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PROTECT

Protection of the Environment from Ionising Radiation in a Regulatory Context

(Contract Number: 036425 (FI6R))

Workshop: Approaches to demonstrate protection of the environment from ionising radiation (second workshop) (28th-30th January 2008, Oslo, Norway)

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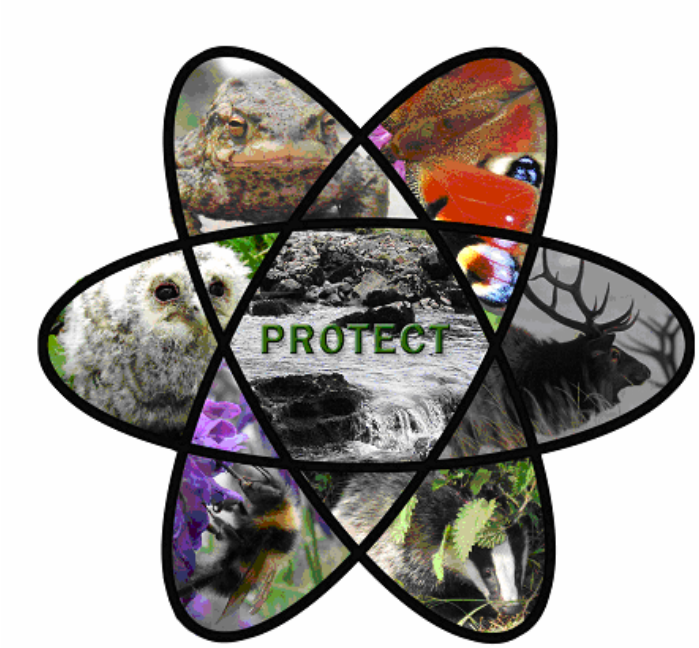
The EU EURATOM funded PROTECT project (FI6R-036425) will evaluate the different approaches to protection of the environment from ionising radiation and will compare these with the approaches used for non-radioactive contaminants. This will provide a scientific justification on which to propose numerical targets or standards for protection of the environment from ionising radiation.



Project Co-ordinator: Natural Environment Research Council, Centre for Ecology & Hydrology

Contractors:

Natural Environment Research Council, Centre for Ecology & Hydrology	(CEH)
Swedish Radiation Protection Authority	(SSI)
Environment Agency	(EA)
Norwegian Radiation Protection Agency	(NRPA)
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1. Purpose of workshop

The workshop was initially intended to continue work package 2 activities (evaluation of approaches to demonstrate protection of the environment from ionising radiation) begun during an earlier workshop held in Vienna June 2007 (Beresford et al., 2007a). Whilst some time was devoted to reporting back on follow-up activities by the PROTECT consortium and discussion of the application of available tools to radiological environmental impact assessments, the scope of the workshop was expanded to allow: (i) consideration of the recently available relevant publications including the draft report released by ICRP Committee 5 (http://www.icrp.org/draft_animals.asp); (ii) approaches suggested by PROTECT work package 3 to propose levels of environmental protection; (iii) comparison of human and non-human biota exposure assessments.

1.1 Workshop and report format

The workshop combined presentations by: (i) the PROTECT consortium presenting project outputs and activities; (ii) ICRP Committees 5 (C5) and 4 (C4), and IAEA representatives; (iii) attendees with experience of applying available tools in assessments. These presentations can all be viewed on-line by clicking on the relevant links from the agenda and appropriate report sections below. The subsequent sections of this report summarise these presentations and associated discussions where appropriate. The final sections of the report are devoted to a scenario application conducted during the workshop (Section 6) and the final discussion session of the workshop including 'take home messages' for the PROTECT consortium formulated by participants (Section 7). Aims of the scenario application (and associated presentation) were: (i) to begin the discussion of the use of the available numeric values within assessments; and (ii) compare results for humans and biota.

Discussion sessions are recorded anonymously, points made during these discussions do not necessarily reflect the views of members of the PROTECT consortium. Points of clarification are presented in parenthesis using italicised text.

1.2 Agenda and on-line presentations

When reading this document from the PROTECT website (see page http://www.ceh.ac.uk/protect/pages/workshops.html), presentations made at the workshop can be accessed by clicking the title within the agenda below and links within the appropriate sections of text. All presenters have agreed to make their presentations available in this way, however, many of the presentations outline 'works in progress' and should not be considered to be finalised reports.

Monday 28th January 2008	
Welcome, workshop objectives and PROTECT overview	Brenda Howard (CEH)
Recommendations of work package 1	David Copplestone (EA)
Screening tier comparisons	Nick Beresford (CEH)
Application of Spatial Analysis and Decision Assistance (SADA) Freeware	Tom Purucker (USEPA)
Review of WNA and OECD-NEA publications	Deborah Oughton
Lunch	
Presentation of ICRP draft report - *Environmental Protection: the Concept and Use of Reference Animals and Plants*	Per Strand (ICRP C5)
Application of the ICRP RAP approach	Kirsti-Liisa Sjöblom (ICRP C4)
IAEA plans with respect to environmental protection	Diego Telleria (IAEA)
General discussion of ICRP report	Chair: Brenda Howard
Tuesday 29th January 2008	
OSPAR Radioactive Substance STRATEGY: Draft Assessment on Impact of Anthropogenic Sources of Radioactive Substances on Marine Biota	Karine Beaugelin-Seiller (IRSN)
Demonstration assessment of doses to non-human biota from Olkiluoto repository and general considerations for waste repository assessments	Carol Robinson (ENVIROS)
Assessing the impact of radioactive disposals and discharges at the Low Level Waste Repository (LLWR) on the ecosystem	Mark Willans (Nexia Solutions)
Work package 3 overview: Requirements for protection of the environment from ionising radiation	Pål Andersson
PROTECT: First proposed levels for environmental protection against radioactive substances	Jacqueline Garnier-Laplace
Group discussion of Work package 3	Chair: Deborah Oughton
Terrestrial assessment: Comparison of human and non human dose assessments for prospective new nuclear power stations	David Copplestone
Group Breakout: Scenario application – marine assessment comparing human and biota assessments (Introduction)	Justin Brown
Wednesday 30th January 2008	
Feedback on scenario application & open discussion	Chair: Nick Beresford
Open discussion including future intentions of interactions PROTECT- ICRP C4 – IAEA EMRAS BWG	Nick Beresford/Brenda Howard

2. PROTECT – update of activities

2.1 PROTECT overview (B.J. Howard)

A short overview of the objectives and progress of the PROTECT CA was presented (link to presentation).

2.2 Recommendation of work package 1 (D. Copplestone)

The work package 1 deliverable (*A review of approaches to protection of the environment from chemicals and ionising radiation: Requirements and recommendations for a common framework*) is now available from the PROTECT website (Hingston et al. 2007). An overview of the report was presented concentrating on the recommendations and their implications for PROTECT (link to presentation).

2.2.1 Discussion

Optimisation was discussed. The message from work package 1 was that optimisation of discharges should remain central to environmental/human radiological protection (and it was commented that this was in agreement with ICRP recommendations). It was noted that optimisation should be related to the object of protection, not to discharges.

Regarding harmonisation of radiological protection of the environment with that for other hazardous substances, it was questioned if genotoxic chemicals were treated the same way as others within the EU Technical Guidance Document ('the TGD') (2003)[1] document. There was a view that expert judgement was often applied when setting benchmarks. It was noted that the harmonisation was needed at the higher level (i.e. what we want to achieve in the end, whereas the methodology and technological details to achieve this might differ). It was also stated that the majority view from PROTECT consultations was that expert judgement alone should not be the approach taken to derive benchmark values for radiological environmental assessments.

A difference in the legislation on chemicals (REACH) and radioactive substances (Euratom) within the EC was suggested. Whereas Euratom promotes the use of nuclear technology and does not mention environmental protection, REACH is in place to make sure that the use of chemicals will not harm the environment or human health.

Regarding methodologies to derive numerical values that should be considered within PROTECT, AF (assessment factor) and specifies sensitivity distribution (SSD) methodology, a question was asked whether PROTECT could consider field studies of observed effects coupled to concentrations/dose rates (e.g. as for the Canadian approach where benthic invertebrate communities and corresponding sediment concentrations were evaluated (*c.* 21 000 data points) to derive sediment concentration thresholds corresponding to low effects and severe effects respectively). However, it was suggested (by PROTECT participants) that data of sufficient quality and quantity would be difficult to identify.

2.3 Screening tier comparisons (N.A. Beresford)

Actions on work package 2 of PROTECT following the earlier Vienna workshop (Beresford et al. 2007a) included a comparison of the screening tiers of the three freely available assessment tools and a

[1] See http://ecb.jrc.it/home.php?CONTENU=/DOCUMENTS/TECHNICAL_GUIDANCE_DOCUMENT/

consideration of the degree of conservatism within the tools. An overview of the screening tiers of the ERICA-Tool, RESRAD-BIOTA and the England and Wales Environment Agency's R&D128 was given concentrating on where each is deemed to be 'conservative' and differences between the models (all three models can be accessed from http://www.ceh.ac.uk/protect/pages/env_protect_radio.html).

Risk quotients for all radionuclides common to RESRAD-BIOTA and the ERICA-Tool estimated using the three models assuming 1 Bq unit^{-1} media were compared for terrestrial and freshwater ecosystems (link to presentation). Many estimated RQs varied by more than one-order of magnitude between the models with some varying by two to four orders of magnitudes. A number of reasons for this variation were identified including the reference organisms considered and the application of screening dose rates to different organisms. However, the most common reason for variation was the transfer (CR and K_d) parameters used by each model. The presentation also highlighted some incompatibility between the outputs of the different tiers of the ERICA-Tool when considering sediment as the contaminated media.

2.3.1 Discussion

There was a question about the freshwater K_d value for ^{3}H used in RESRAD-BIOTA ($1x10^{-3}$ l kg^{-1}). The value appears to have been taken from that used within other elements of the RESRAD code used for human assessment. It was justified on the basis that since ^{3}H is not associated with the particulate phase then the K_d should be zero, but to allow calculations a nominal value is set to just above zero. However, it was suggested if the sediment has a high water content, the *in-situ* sediment concentration would be similar to water, i.e. *in-situ* K_d= 1.

In discussion it was said that the default RESRAD K_d values for the freshwater ecosystem may be taken from soil-soil water partitioning data (*confirmed subsequent to the workshop*). This value of K_d may not be appropriate to use as within the presented comparison (i.e. to estimate water concentrations and resultant dose rates from an input of sediment concentrations only).

The basis for K_d values was discussed. It was stated that, as defined, they should be based on suspended material, but often they are actually based on deposited sediment data. For the purpose of calculating sediment concentration from water concentrations (or *vice-versa*) and external dose rates as used in the models, this might be more appropriate (than if derived from suspended sediment data).

It was commented that numerical values like the K_d discussed above are often used as published from the literature without critical review or evaluation against field observations. When used many times they tend to become accepted as definitive immutable values. A critical review of the origin of the numbers might in many cases lead to the conclusion that they are not applicable. Such a review may therefore be needed.

The IAEA are in the process of updating transfer values for freshwater aquatic environments and this will be compiled in a new 'Tecdoc.' and thereafter (as part of) a Technical Report Series (an update to TRS364; IAEA1994). These values are used as the defaults in the ERICA-Tool. However, it was commented that there needed to be more information on how to use numbers given in the IAEA handbook since as supplied to the ERICA consortium they were difficult to interpret (*following the workshop an updated version of the Tecdoc. chapter has been made available – the values are now more readily interpreted but are the virtually the same as the ERICA-Tool defaults although some questions remain*).

It was stated that the very high variability in calculated risk quotients for ^{210}Po and ^{226}Ra is unacceptable as these radionuclides would be very important in some situations such as sites involved in uranium mining.

2.4 Application of Spatial Analysis and Decision Assistance (SADA) freeware (T. Purucker)

One objective of PROTECT work package 2 is to consider available tools used in chemical assessments (see http://www.ceh.ac.uk/protect/pages/env_protect_chem.html). One such tool identified during the work of work package 1 was the Spatial Analysis and Decision Assistance (SADA) freeware that incorporates tools from environmental assessment fields into an effective problem solving environment. These tools include integrated modules for visualisation, geospatial analysis, statistical analysis, human health risk assessment, ecological risk assessment, cost/benefit analysis, sampling design, and decision analysis. A fully functional freeware version is available from: http://www.tiem.utk.edu/~sada/index.shtml. An overview of the capabilities of the SADA tool was presented (link to presentation).

2.4.1 Discussion

On the question how SADA deals with very local pollution within an area of interest, it was answered that dual level exposures (i.e. hotspots as well as larger areas) could be considered within the tool.

It was questioned how the 20 featured species were chosen. These were intended to be representative of different trophic levels across the USA. Parameter values for these species were taken from various EPA handbooks[2].

It was asked what the default soil screening value for uranium is in the model (*the model contains numerical target values from various sources*). For environmental protection there is no such value, although for human health the value is 5 mg kg^{-1} dry weight.

It was asked whether own benchmark values could be added to the database of available benchmark values. In theory the answer is yes, but it is not easy for the end user. Instead the tool developers should be contacted to include new benchmark values.

2.5 Review of WNA and OECD-NEA publications (D.H. Oughton)

There is a requirement for PROTECT to be aware of, and take into account, relevant on-going developments (especially that of international bodies). In response, a review of three selected relevant OECD-NEA and WNA publications (see http://www.ceh.ac.uk/protect/pages/env_protect_radio.html) was presented, for discussion (link to presentation). A summary of the presentation can be found in Appendix A. The three reports considered were:

- OECD (2007) Scientific issues and emerging challenges for radiological protection.
- Browless, G.P. (2007) Issues around radiological protection of the environment and its integration with protection of humans: promoting debate on the way forward. J. Radiol. Prot. 27, 391–404.
- SENES Consultants Limited (2007) Overview of representative ecological risk assessments conducted for sites with enhanced radioactivity.

[2] See http://www.tiem.utk.edu/~sada/SADA_4_1_Usersguide.pdf for details

2.5.1 Discussion

OECD-NEA publications

It was commented that whereas a periodic review of any system for environmental protection is needed, as proposed by George Brownless in his paper, a system first needs to be developed. It then needs to be decided who is going to be responsible for the review process.

SENES-WNA report

It was commented that with regard to the Canadian uranium mines the report was 'selective', those sites considered are the most modern with good effluent treatment etc.. In general, new sites are acceptable whereas older sites might be much worse than the ones assessed. It was also commented that the spatial scale is of great importance. If effects are evident within a very limited area, possibly only on-site, does it matter?

A point was made that for many of the cited cases, the objectives had not been to provide a definitive assessment of environmental risk rather it was to test a methodology under development (e.g. assessment of the FASSET methodology). It was therefore inappropriate to draw any robust conclusions concerning environmental impact from some of the cited studies.

It was commented that the Sellafield assessment did not cover the ERICA marine assessment, although during the workshop it was suggested that the final ERICA case study report (and hence Sellafield marine assessment) may not have been available to be considered (*note the report considering the marine assessment (Beresford et al. 2007 b) is referenced in other areas of the WNA report*). In the marine assessment, some dose rates had been found to be above the screening levels.

It was remarked that the report was produced for one stakeholder, reflecting its view. Although it was commented that SENES would look upon themselves as independent, and thus producing an independent report. It was further suggested by one participant that 'it is not wrong to demonstrate that the ICRP 60 statement 'works' at the 'best' sites'.

It was questioned as to why the report had not compared the assessments to one set of dose benchmarks rather than quoting those used by the original authors.

It was noted that within reviewed assessments, dose rates to various organisms were reported from $<10\mu Gy\ h^{-1}$ to $>400\mu Gy\ h^{-1}$. The opinion was stated that this review is not an evaluation of whether the current (human based) system is effective for protection of the environment or not.

3. International developments

3.1 ICRP Committee 5 draft 'Reference Animals and Plants' report (Per Strand)

The draft report by ICRP C5 *Environmental Protection: The Concept and Use of Reference Animals and Plants* (RAPs) (ICRP 2008) has been available for consultation since early 2008. The deadline for comments on the draft is 28th March 2008. A summary of the report and future intentions of C5 was presented for discussion (link to presentation).

3.2 ICRP Committee 4 – application of the ICRP RAP approach (K-L. Sjöblom)

ICRP C4 has the responsibility for 'application of ICRP recommendations' and a Working Party to consider the recommended system for protection (i.e. the RAP report) has been initiated (link to presentation). At the November 2007 IAEA meeting it was suggested that PROTECT and the EMRAS BWG could assist the ICRP C4 Working Party. The Working Party will report to C4 in September 2008.

3.3 IAEA plans with respect to environmental protection (D. Telleria)

An overview of the IAEA activities and intentions with regard to protection of the environment was presented (link to presentation).

3.4 Discussion

Questions were raised over the application of the reference animals and plants, particularly the idea that the RAPs are only representative of a limited set of organisms. It was pointed out that the IAEA EMRAS BWG has demonstrated that the dosimetry calculations which are being used by different groups are comparable (*see Vives i Batlle 2007*) and should allow dose conversion coefficients to be generated for any shape etc.. Therefore, there was a suggestion that ICRP should provide a list of absorbed fractions for all sizes/shapes for the most important radionuclides. How representative the current RAPs are of different geographical regions of the world was also questioned. This reflects the lack of clarity within the RAPs report on how RAPs should be used.

The selection of RAPs as a resource was felt to be a reflection of our anthropogenic view of these organisms and how they might be used as a resource (e.g. for food consumption) for humans. Some of the criteria used to justify the selection of RAPs were further questioned. For instance, for most RAPs there was felt to be little radioecology data available (e.g. it was felt unlikely that there were significant data on the accumulation of radionuclides by bees – despite the suggestion that there are as many data as for grass in the report).

The lack of consideration of prey-predator interactions of the RAPs was also felt to be problematic because effects on prey species in particular might give rise to indirect effects on the RAPs that will not otherwise be detected. It was noted that whilst the report provides no information on transfer it listed some very specific pathways (e.g. contamination of feathers) which C5 were suggesting for consideration by a transfer Task Group - how would such specific pathways be used? In response it

was stated that this was an initial list of pathways/parameters to begin the required discussion which would ultimately be filtered down to those which are actually required.

It was asked whether the dose coefficients presented are weighted or unweighted – in response, they are unweighted but this should be clearer. It was also unclear what level of secular equilibrium was being considered within the ICRP RAPs report. It was suggested that as the approach developed for the ERICA-Tool had been adopted by the ICRP, this was likely to be 10 days but that this needs to be specified.

It was also highlighted that there are differences between chemicals and radioactive substances toxicity assessments on the biological effects because surrogate species are used within chemical toxicity testing/assessments. This does not occur in radioactive substances. However, it was suggested that the chemicals field could perhaps learn from the concept of reference animals and plants.

There were questions over how uncertainty is dealt with in respect to the effects information tables that are used for the derived consideration levels. What levels of uncertainty are acceptable (especially when combined with other uncertainties such as transfer)?

The question was asked 'with the sliding scales of the effects information, how accurate are we being?'. The questioner suggested that this linked back to the previous comment on uncertainty but is related also to what actually happens if alpha particles are ingested.

Members of the group understood that C5 was due to provide information on the similarities and differences between chemicals and radioactive substance assessments. However, this information does not appear in the RAPs report and it was unclear how this will fit in with the application of RAPs as currently proposed by ICRP.

It was asked if the ICRP would consider changing the list of RAPs for the final report? In response it was stated that C5 would consider any good cases for this made in response to the consultation.

With regard to the plant RAPs, questions were raised over the application of pine trees versus tropical species and why there are differences in approach (trees modelled as ellipsoids, grass as a semi-infinite layer?). These points need more explanation and justification.

Inhalation of gaseous radionuclides was raised as an issue that is missing from the ICRP report but it was pointed out that this is important because, for example, there is a natural background link for some radionuclides such as radon.

It was asked if the derived considerations levels (DCLs) were really based on background exposure rates as the text implies. In response it was said they are not, they are based on effects observations, but that background provides a point of reference.

It was also asked if the ICRP would identify priorities for research, for instance the DCL for 'duck' is based on no data. It was answered that observations such as this would help to focus research.

There was confusion over the use of the effects tables and text and there seems to be a mismatch between the text and the tables. The comment was made that there were c. 40-50 pages of text on effects but that this read as a compendium with no critical review: where was the added benefit compared to previous publications of the IAEA and UNSCEAR. There was thus a question of what are UNSCEAR doing in their current review (*due 2008*)? The ICRP output is tables of DCL derived by expert judgement and this was considered to represent a 'great leap of faith'. It was also noted that projects such as ERICA had put considerable effort into quality control of effects data and interpretation using species sensitivity distributions (SSDs) – this is missing from the ICRP report. In response it was stated that a lot of work, by different groups, is on-going and that effects data should

be input to the ICRP by UNSCEAR. The RAP report tries to link available data to the selected RAPs as a first step to see what is available.

Whilst the RAPs report provides a framework for assessment there was a general feeling that the consequences following the assessment are open ended and of limited assistance to the user in making decisions based on the assessment results.

The report was generally felt to be missing recent references and not reflective of current thinking and scientific progress in this field. It was suggested that the ICRP should try to create harmonisation and highlight gaps etc..

4. Tool applications

The main objective of PROTECT work package 2 is to evaluate the practicability of the available assessment tools. A number of workshop participants were invited to discuss recent assessments.

4.1 OSPAR: Draft assessment on the impact of anthropogenic sources of radioactivity on marine biota (K. Beaugelin-Seiller)

A presentation was given on the application of the ERICA-Tool to the OSPAR area considering seven radionuclides (link to presentation).

4.1.1 Discussion

It was asked what the source of the data used was. This was measurement data from different member countries in OSPAR (environmental monitoring).

Information on the outcome of the comparison of ERICA-Tool results with RESRAD-BIOTA and EA R&D was requested with the comment that RESRAD-BIOTA does not consider the marine environment. In response it was said that the three approaches were compared in terms of organism properties (mainly size), available radionuclides, concentration ratio and K_d values. The ERICA tool appeared the most appropriate tool to meet the needs of the OSPAR evaluation.

In response to a request for clarification of the 'limiting factor' mentioned in the talk when running the ERICA-Tool - it was stated that it was easier to copy the ERICA parameters and run the calculations separately in dedicated MS Excel spreadsheets. This was quicker and it was less complicated to deal with the results.

It was noted that the assessment considered only one compartment per marine area – many organisms inhabit much smaller areas. Later models (e.g. Poseidon) have more boxes. Both water and sediments represent large areas. In response, it was stated that the assessment needed to be consistent with earlier studies and models applied in the OSPAR framework. Marine areas are defined by the previous work conducted for OSPAR.

Clarifications with regard to the input data were requested: (i) how did the assessment deal with the problems of having different concentrations over large boxes?; (ii) were water concentrations and/or concentrations in biota used?; (iii) how were concentrations determined to be below detection limits used in the assessment? In response in was stated that average concentrations were used and inputs were predominantly water data with concentration ratios (CRs) applied to estimate concentrations in biota. A decision was made to include 'less than' data in the input means.

It was asked, bearing in mind that Po-210 exposures represent a significant contribution, are there any plans for a sampling campaign to measure concentrations in marine biota (e.g. birds and fish rather than water/sediments)? Whilst none were known it was suggested that this could be included in the assessment recommendations.

4.2 Demonstration assessment of doses to non-human biota from Olkiluoto repository and general considerations for waste repository assessments (C. Robinson)

A consideration of requirements for waste repository assessments and the demonstration assessments process conducted for the Olkiluote repository (Finland) was presented. The findings and plans of the BIOPROTA group were also considered (link to presentation). A report on the Olkiluote assessment is available from http://www.posiva.fi/englanti/tietopankki.php?page=nayta&id=10.

4.2.1 Discussion

It was asked which domestic animals were considered in the assessment? These were agricultural animals, pets were assumed to be eating the same foodstuffs as humans.

Clarification of the transport mechanisms and processes for getting from release to the point of exposure was requested. It was explained that the present assessment used the same inputs as for human assessment provided as activity concentrations in sediments, water and soil. The geological modelling was another part of the assessment; a worst case scenario of a single capsule being total destroyed with subsequent discharge to the groundwater table was assumed.

It was asked if one could therefore conclude that all other scenarios will lead to even lower exposures? In response it was acknowledged that there could be scenarios of more than one capsule breaking at once. One participant commented that it should be remembered that waste disposal has both geological and engineering challenges - the canister design is a central aspect.

It was commented that similar types of assessments are carried out in Canada, and there are a number of sceptics. There are concerns about the level of knowledge and whether there is sufficient information about the geological situation. For example, fractures could increase transport by many orders of magnitude. The selected Ontario site in Canada has only just started to become well characterised and there is some public concern. A question was raised on the general public opinion in Finland, to which it was answered that some people are concerned in Finland too. However, there is an ongoing surveillance programme, which is undertaken by Posiva with STUK, as the regulator, evaluating the programme with the help of international experts. There was a vote in the Finnish parliament and from 200 members, only three voted against the repository and five abstained.

It was asked how the estimated dose rates for the biota assessment compared to those from the human assessment? In reply, it was said that estimated human dose rates, from an initial report, were higher than those estimated for biota.

It was stated that the Olkiluoto assessment was on-going and that the work described was unlikely to represent the final biota assessment.

4.3 Assessing the impact of radioactive disposal discharges at the Low Level Waste Repository (LLWR) on the ecosystem (M. Willans)

An initial assessment to feed into the LLWR (located in west Cumbria, England) environmental safety case was presented (link to presentation).

4.3.1 Discussion

It was asked if there was any explanation for the discrepancies between the (ERICA) Tier 1 and Tier 2 assessments. In response it was suggested that this could be because the ERICA prototype had been used and there were some suspected inconsistencies in model data for each Tier.

It was asked how much confidence there was in the climate/landscape change modelling: are these worst-case scenarios? It was explained that the assessment has to address a number of climate/landscape change scenarios as part of addressing uncertainty. For example, erosion and also the fate of eroded sediments are uncertain issues. The probabilities of various climate/landscape change scenarios occurring is difficult to quantify which is leading to a more "risk informed" analysis for assessments.

5. PROTECT work package 3

The objective of work package 3 is to derive and propose numerical target values for an extended list of ecological targets and protection levels, designed to assure compliance with environmental protection goals. In achieving this consideration will be given to the appropriate recommendations of work package 1:

- consider use of screening value;
- consider the need for a 'standard' equivalent to 1 mSv a^{-1} for public;
- provide advice on the implications of exceeding any suggested numeric values;
- protection should focus at the population level (although rare/protected individuals may need to be considered);
- methods of demonstrating compliance should be evaluated;
- clearly document derivation, limitations and inherent level of conservatism of any suggested numeric values.

A draft deliverable will be available for comment in April 2008 and a workshop will subsequently be held 14th-16th May 2008 (Aix-en-Provence, France) to discuss the draft deliverable.

Following an overview of work package 3 (link to presentation) a second presentation summarised derivation methods for determining numeric values, available effects data and preliminary results (link to presentation).

5.1 Discussion

The suggested protection goal includes the phrase '…. Special attention should be given to keystone species and other species of particular value'. Clarification of what was meant by 'particular value' was requested – was it always an anthropogenic value? In response it was said that this may include factors such as biodiversity or economic value. It was commented that considerations of what is 'valuable' have, and will continue, to change with time. It was also suggested that consideration of 'habitat' was key for sustainability and how this fitted the suggested protection goals was queried.

With respect to the 'low degree' of conservatism which would be in-built into any regulatory trigger value suggested by PROTECT, it was queried if this was in contravention of the precautionary principle. It was answered that any suggested regulatory trigger would have 'lower' conservatism than a generic screening value.

It was questioned as to if PROTECT had properly thought out a 'two value system' – what happens between the screening value and any threshold? It was acknowledged that such advice would be required.

It was commented that the suggested numeric value did not take into account uncertainty. In response it was answered that the screening value and screening assessments aim to be conservative. There may be considerable uncertainty within the exposure assessment – but refined assessment can take this into account.

It was asked what effects were considered for the SSD analyses? The data used included effects related to mortality, morbidity and reproductive success as the intention was to protect at the population level. In response to a further question it was confirmed that data for all life-stages (e.g. amphibian eggs) would be included. One member of the workshop questioned if genotoxic chemicals were considered differently within chemical assessments. In response it was said that the TGD approach encompasses all effects including genotoxicity.

The use of the same or lower assessment factor (AF) to define the taxonomic specific and screening values was questioned. In response it was reasoned that for the taxonomic value application of an AF in the range 1 to 5 could be justified from the guidance within the TGD. An application of an AF of 5 to the larger dataset to derive a generic screening value was to ensure a conservative value was generated. The reason for suggesting the taxonomic values was because within assessments the most exposed organism may not always be the most radiosensitive (e.g. phytoplankton in aquatic assessments).

It was pointed out that the range in taxonomic values were within the confidence limits estimated for the generic value.

There was some discussion as to the use of species based geometric means within the SSD analyses especially as for some species there is only one data point. It was suggested that individual data should be used (not the geometric mean): this would give useful information on the effect of using geometric mean data; is less prone to being skewed by outlying date; is a more defensible approach. The use of a 'jack-knife' statistical approach to looking at the effect of individual data points was also suggested.

There was a question proposed with respect to data from one study of a cyano-bacteria species which had the lowest EDR_{10} value within the data assessed – should this be removed from the analyses as it seemed contradictory to what is known about the high radiosensitivity of single-cell organisms. An opinion was expressed that the data could not be removed unless PROTECT could justify that the species was not important to the functioning of the ecosystem.

It was commented that there are 1000's of papers with effects data and that the total number of values used for the SSD analyses (*88 EDR_{10} values*) therefore looked small. This is because data have had to be rejected as they do not meet the statistical requirements of the SSD analyses (*see Garnier-Laplace 2006*). It was requested that if there are other suitable data then please pass on the details to the PROTECT consortium.

The data included in the SSD were also criticised as not including secondary effects (e.g. parasitism) reported to have been observed at field sites in the former Soviet Union. In response it was stated that there is a lack of good quality published data from field studies.

It was suggested that PROTECT should consider total life-time dose as well as dose rate in derivation of numeric values. However, it was suggested that there are too few data to do this.

It was observed that values of 1 m Gy d^{-1} (c. 40 μGy h^{-1}) or 10 mGy d^{-1} (c. 400 μGy h^{-1}) as 'dose rates to protect populations' had been suggested for many years by different organisations. These approximated to the 5^{th} and 95^{th} confidence interval on the combined ecosystem screening level (if the cyano-bacteria data are excluded) and could be proposed as the screening and action levels.

There was discussion around the concept of potentially having a different action value for contaminated land (existing exposure situations) compared to planned exposure situations which was suggested within the PROTECT presentations. For instance, what would happen if a new practice (planned activity) was planned for an existing site? In response it was stated that already contaminated sites were a different issue (to planned exposure assessments) and that in human assessment we have

different standards to trigger remediation than are used for planned activities. Do we want a similar trigger for environmental assessment of contaminated land?

However, it was argued that optimisation to meet ALARA principles should be used. For protection of the ecosystem we need to assess if we are achieving more good than harm. There was general agreement that regulatory limits which led to ecosystems being 'destroyed' were not required/would not be used.

It was asked if different weighting factors for environmental components were included in the SSD analyses. They are not, but EDR10 data may be weighted for use in SSD for example, on the basis of ecosystem structure, biomass etc.. However, this requires assumptions or knowledge about the ecosystem to determine the weights to apply.

There was some discussion as to the validity of organism specific numeric values and it was noted that (e.g.) USEPA have organism, area and water body (dependent upon chemistry, flow rate etc.) specific screening values for some chemicals.

The workshop was asked if PROTECT had justified the use of a screening value (if not an action/trigger) – nobody responded negatively.

It was suggested that the SSD analyses to identify a HDR_5 value did not necessarily imply protection of a population, but that such values would identify if you had an area of concern.

It was requested that in the PROTECT deliverable it would be important to highlight the lack of data for specific groups and where additional work was required.

It was suggested, by a PROTECT consortium member, that PROTECT may not necessarily be able to define all the numeric values, but would be able to outline a practical approach. Values which cannot be justified should not be given. However, it was commented that we have to make judgements and PROTECT was asked to recommend conservative values if taxonomic specific ones cannot be derived. In response it was commented that PROTECT was considering the use of acute exposure data to aid the selection of values for organism types for which no chronic exposure data are available.

6. Comparison of human and biota assessments

To begin a discussion of the use of available numeric values within assessments two hypothetical release scenarios were considered with results being compared for humans and biota. The scenarios were also suggested as something which could be built upon to assist ICRP C4 in its assessment of the RAP report.

6.1 Terrestrial assessment (D. Copplestone)

Screening level assessments of planned discharges from a nuclear power station into the terrestrial environment for both humans and biota were presented (link to presentation). The major component of the discharges was ^{41}Ar, unfortunately the ERICA-Tool does not include noble gases and whilst the Environment Agency R&D128 model does it was not possible to obtain the input in the correct form (using the IAEA SRS19 models embedded within the ERICA-Tool). Therefore, ^{41}Ar was modelled as ^{14}C in both the human and biota assessments. Note the assessment will be re-run including ^{41}Ar and a summary will be made available on the PROTECT website.

6.1.1 Discussion

Much of the discussion was centred on the contribution of ^{14}C (surrogate for ^{41}Ar) to the overall doses as the nuclide dominated both the human and non-human assessment.

It was suggested that the assessment was biased to giving humans a comparatively higher dose rate than likely to be the case in reality. It was assumed for humans that inhalation dose were received at 100 m from the site and all food obtained from 500 m which was likely to be overly conservative. Whereas it was considered that the consideration of biota at 500 m was more realistic. It was also noted that many nuclear sites have protected ecosystems in close proximity whereas people generally live > 1km away (although this is not always the case).

It was commented that new build assessments would probably soon be conducted in Canada and the United Kingdom.

The level of detail in the scenario and in particular the degree of realism needs to be considered further and the assessment rerun.

6.2 Marine scenario – breakout sessions (J.E. Brown)

Following a short introductory presentation (link to presentation) workshop participants were divided into four groups and asked to run the ERICA-Tool and ICRP derived human assessment parameters (provided in an MS Excel file) for a hypothetical marine release. The scenario was loosely based on peak (1970's) discharges from a regulated nuclear complex to a coastal marine environment in Western Europe. The scenario instructions and question/answer template can be found in Appendices 2 and 3 respectively.

6.2.1 Feedback and discussion

The various groups reported back following their running of the marine scenario.

Group 1 provided details on assessment context – defaults were used with the 400 μGyh^{-1} screening value. The non-human assessment exceeded the screening criteria for most of the reference organisms. The group felt that the 400 μGy h^{-1} benchmark was most appropriate because the assessment

concerned populations, but if 10 μGyh^{-1} was used, then obviously more results would exceed the screen. Dose-rates fell below the ICRPs suggested DCLs but it was noted that no guidance was provided by ICRP for phytoplankton (the ERICA reference limiting organism). The screening level would need to be set to 220 μGyh^{-1} to obtain an RQ of 1. However it was noted that changing the distance where the dose rates were determined would affect the RQ. It was felt appropriate to account for uncertainty and the use of the uncertainty factor within ERICA was a start. The effective committed dose to human of 0.92 mSv a^{-1} was considered unacceptable. Furthermore, it was not possible to say which assessment provided the limiting criteria because this depends on the context. The human dose constraint of 0.3 mSv a^{-1} might be appropriate to apply and the concentration of some radionuclides in fish were above intervention levels for humans. There was a need to move to a more realistic assessment especially with regard to the assumptions included in the assessment. The group felt that the ICRP-60 statement was not supported by this particular scenario assessment and that it was inappropriate to compare sites at the same distance for the human/non human assessment and that the assessments should be made at the most appropriate location (e.g. the non human species at 10km, the humans at 100km). The screen of 10 μGy h^{-1} for the non human assessment might be used to flag a potential problem but the 400 μGy h^{-1} might be used in a more detailed assessment.

Group 2 took a slightly different approach applying different uncertainty factors, changing occupancy factors for the non-human assessment and selecting different source to receptor distances for human and non-human assessments (a distance of 70km for fishery and 10 km for the Marine Protected Area). For the non-human assessment RQs exceeded 1 except for bird and mammal; a number of reference organisms also had RQs > 1 when assessed at 70 km. This group considered that there was no rationale to select a 400 μGy h^{-1} screening value having first selected a value of 10 μGy h^{-1}. Although a comment from outside the group was made that in view of the different radiosensitivity of different groups, different benchmarks might be appropriate. There was a brief discussion concerning phytoplankton and use of a 400 μGyh^{-1} screening value because this might be a 'population issue', but a value of 10 μGyh^{-1} should be used where individuals might be important.

Group 2 was unsure how to apply the ICRP DCLs – no advice is provided within the relevant "box" within the ICRP report tables. Furthermore, whilst the ICRP report is clear in saying what DCLs do not mean this does not help when it comes to trying to apply them. With regard to the PROTECT approach, it seemed reasonable to have a generic value for the aquatic system and then to apply more specific/targeted values following a more in-depth assessment. The group felt that it was important to know why values were being changed – changes should not be made just so the assessment "looks good". It was important to establish what the screening level was and what should be done in follow-up. The Group felt that uncertainty factors were applicable because of large uncertainties. Because the human effective dose fell below the 1 mSv a^{-1} value it was considered acceptable. However, it was noted that this is not the single source discharge constraint. There was then a brief discussion of the potential importance of sea to land transfer.

Group 2 clearly felt that the limiting criteria were provided by biota and that the ICRP-60 statement was not supported by this assessment – at least it was not possible to conclude that by protecting humans in this case you were indeed protecting the environment. In view of the source to receptor distance it was not appropriate to select the same distance in both cases.

Group 3 applied the ERICA-Tool default values and results were similar to those previously given by other groups. Phytoplankton were identified as the limiting organism. In view of the different radiosensitivity of phytoplankton and other reference organisms, the group felt that there may be some merit in providing organism group based values. The application of the 400 μGy h^{-1} benchmark was considered problematic because this relates to the most exposed individual within a population (*see*

IAEA 1992) – within this scenario it was difficult to predict or say anything about this. Various non-human and human RQs could be derived based on which non-human biota benchmarks were applied or whether for humans, dose constraints or dose limits were being applied. Because of the various combinations of results it was not in fact possible to say whether human or biota provided the limiting criteria. Group 3 felt that from this scenario there was no evidence to suggest that the ICRP-60 statement was not true but neither was there evidence to support the statement. In considering the source to receptor distance it would probably be necessary to consider a range of distances. The protected area would need to be considered explicitly as would the area where fish are caught for human consumption.

There was a comment that the regulator might not want to be overly restrictive in setting screening levels – if for example a screening level was set at such a low level that many sites failed this might cause difficulties – some flexibility and "calibration" for existing sites might be desirable. Cost benefit analyses might also be a useful tool to help elucidate the situation. There was a view that an action/trigger level might be a way to move forward. In the US in human radiological protection there is flexibility – for example with nuclear clean-up an alternative to termination of licence for breach might be institutional control. Another view was made that many of these issues were of a managerial nature and that the criteria upon which subsequent managerial decisions are made still need to be agreed.

It was considered that future developments in the scientific field could have consequences for the setting of thresholds and thereby the managerial decisions made. It is clearly important to have continual review of information. In view of the fact that the regulator will consider high level tiers in detail and utilise site specific information, PROTECT might be best providing the quantitative analysis for use as a basis for assessment (i.e. a means of answering whether the impacts are significant). The benchmarks should also be provided with confidence limits and other statistical summary information.

The view was expressed that we should be aiming for a true action level or threshold for decision making "proceed or not to proceed". This should be related to a likely significant adverse effect level. If this was breached a practice would not be approved. The procedure needs to be scientifically based and legally easy to defend. There was a view that the draft ICRP approach was too vague. Essentially, there was a leap of faith between the information on effects and the DCL values. Instead regulators require defendable, justifiable, scientifically-backed values. It should be recognised in many cases there are very few data and these can be interpreted in quite different ways – this leads to 'discomfort' for the regulator.

The process of optimisation was considered important. For existing exposure cases, the situation might be best left as it is. There is a requirement for regulatory discretion. A view was forwarded that a strong position was required in the case, for example, where a company is being forced to reduce discharge levels. When tough decisions are required it is useful to have a method and values with an authoritative stamp of approval. PROTECT might have a role in providing a robust way of interpreting data. With regard to the setting of a benchmark/limit, the process is often hampered by relatively few data. There was a question over whether the limit needs to be a hard limit or a value with incorporated flexibility. In view of the data limitations some inherent flexibility might be desirable. The terminology was discussed – the term "action" level might not necessarily translate to "stop releases" it should rather be a signal that "there is risk here". The term "significant" was also discussed - is 5 % of species affected at the 10 % effect level indicative of significant harm? Should similar values be applied to all organism groups? In some countries there is no standardisation and values are continually debated. It was considered that currently we have a simple straight forward screen but that

at the second tier of an assessment you may be required to reformulate your problem, change parameters etc. - there is then a question of what you compare exposure estimates to.

There is some precedent for using the 5 % species, 10 % effect level but selection of other values might be more contentious. An example was cited from human radiological protection where different bands of dose-rates are often applied in an overall managerial framework, i.e. there is some inherent flexibility. It would be useful to define what an acceptable level of detriment is. A point was made that conservationists may need to be involved in the process and a link to population models might also be desirable.

With regard to the SSD approach a comment was made regarding an acknowledged limitation. A population effect is difficult to interpret because the SSD treats all effects the same whereas some may have greater effects on population dynamics than others. There was a view that it was desirable to avoid expert judgement as far as possible. There was a clear requirement to 'interrogate' with the SSD approach and clearly describe what the screening level actually means.

A proviso was placed on the concept of monitoring programmes to prove or disprove environmental impact: many of these studies could lead to further complexity and confusion as oppose to elucidation.

It was suggested that we should look back at the protection goals – once these are clear we can move forward.

Group 4 used a screening value of 10 μG h^{-1} benchmark and an uncertainty factor of 5. Some modifications were made to the reference organism occupancy factors. Phytoplankton was the limiting organism. With regard to their interpretation of theTier 2 results, an objective was to avoid false negatives therefore a conservative screen was appropriate. The ICRP DCLs were considered to be less precautionary than the ERICA screening value. Dose rates for humans and non-humans were derived for various source to receptor distances. Although the realism of the scenario was questioned it was concluded from this case that the environment would need to be considered along with potential human detriment. No clear conclusion could be drawn concerning the applicability of the old ICRP-60 statement: it basically depends on the environment and underlying assumptions. More details would be required before this might be answered robustly. With the information provided source to receptor distances might have been selected to be different for human and non-human assessments. In any case, using present day practice, authorisation would not have been given.

There was a discussion concerning whether it was sensible to treat all species the same by the application of a generic screening level. Some considered that e.g. phytoplankton might be treated differently to e.g. mammals.

It was concluded that the ICRP-60 statement was not necessarily correct and that it needs to be looked at further.

7. Concluding discussion

Following a brief update on intended activities of the EMRAS BWG (link to presentation) there was an open discussion of each of the above workshop sessions. The workshop concluded with the formulation of 'take home messages' from the workshop for the PROTECT consortiums future consideration.

Screening level assessment tools

There was general agreement that the level of disparity between predictions was unacceptable and that there is a clear need to review the underlying parameters. This emphasises the importance of the 'biota transfer handbook' being suggested by the IAEA. It was noted that the ICRP are also considering transfer although this would be specifically for their list of RAPs.

SADA model

The SADA model was considered to be potentially useful especially with regard to the utility relating to spatial concentrations.

WNA/SENES and OECD-NEA reports

The suggestions of Brownless seemed to have some common features with the PROTECT approach. Clearly any developed system needs to be exposed to periodic review (as suggested). The WNA/SENES report, despite its deficiencies was considered to provide a useful overview (if not critique) of radiological environmental risk assessments performed.

ICRP C5 RAP report

There was still confusion about how the RAP methodology would be applied.

PROTECT approach – protection goals and numeric target values

A screening level was generally considered to be appropriate and useful. There were concerns that data were insufficient to define action/trigger values. There was general agreement that the SSD approach provided scientifically reasoned values, was underpinned by the TGD, was similar to that used for chemicals, and could be updated. There was a concern that not all available, good quality, data were used in the SSD approach because of incompatibility. The opinion was expressed that within the agenda for the in Aix-en-Provence workshop there should be a presentation detailing the positives and negatives of the SSD approach. There was general agreement that a two-tier system would be useful and that optimisation might be used between the second tier level ('action/trigger or something else level') and the screening level.

There was a view that scientists need to "bite the bullet", i.e. provide a defined number for scrutiny. Otherwise a more vague approach could lead to poor management decisions. A problem was identified that a limit would be too high to optimise against and a screen too low to optimise towards, so something was required in between but there was no agreement on exactly what.

There appeared to be consensus on the need for a numeric value(s) beyond the screening level. However, there was a discussion over what the action levels actually mean, what types of action would be taken etc.. It was suggested that it would be better to have a set of numbers which, if above, could be used to help with optimising the discharges to reduce the dose rate to the organisms to the currently stated action levels. The discussion then continued over the need to identify, as a robust regulatory action level, the point at which significant harm might be incurred.

A suggestion was made to split the data into component SSD relating to biota groups and use the lowest value from these groups as the screen if the quantity and quality of data allowed. At the second tier the various taxonomic SSD values would come into play. There was also a suggestion to put the values coming out of the effects analyses into population models.

The use of the precautionary principle, associated with the risk/likelihood of significant harm, needs to be considered by PROTECT. In particular we should be more precise with our use of this principle and ensure that we include guidance on how it should be applied in PROTECT outputs.

The discussion suggested that, from a regulator's perspective, it is important to get a realistic number for decision making (e.g. the action level) and that a quantitative approach was needed such as that proposed by PROTECT which uses the SSD type approach. The discussion emphasised that expert judgement should be avoided where possible. The source of any action value(s) should be based on a reasonably authoritative analysis of the available data and that confidence levels should be determined to assist in determining the level of risk. One question that needs to be addressed however is what is a significant ('unacceptable) effect and easy to defend if action is needed. It was generally felt that the ICRP RAPs approach does not currently go far enough.

The question of whether by taking action we are doing more good than harm was also raised. With prospective assessments it's perhaps easier to apply an approach which if you exceed certain limits you cannot continue or action can be taken. However if you are undertaking a retrospective assessment using say, 5 as the limit, but the predicted dose rate is 6 does this automatically mean we should remediate the site as the action to remediate may be more damaging? Finally for existing sites the use of monitoring after the decision has been made should be encouraged to see if the decision was right.

A point was made about the reliance on the linear no threshold theory and PROTECT should confirm that there is no issue here with respect to what are likely to be threshold effect types (i.e. we will need to determine whether this is an issue for the types of effects data available in the SSDs). PROTECT should review the effects data and then document those used in the SSDs.

The opinion was expressed that the use of any numbers for screening or action levels need to be tested against existing assessments, data sets etc. (*this will be an activity within work package 2 of PROTECT*).

7.1 Take home messages for PROTECT

1) Large (unacceptable) range in screening assessment results as consequence of transfer components
    - demonstrated importance of proposed IAEA handbook and ICRP Task Group;
2) There are other models (non-radiological) which could be useful and should be considered by PROTECT;
3) There are important points (transparency, periodic review) from the OECD-NEA documents which PROTECT should consider;
4) Significant reservations with regard to the clarity of the application of the ICRP RAP approach within the draft report;
5) Various applications of the available tools (e.g. see Section 4) have demonstrated the importance of the need for clear problem formulation and the importance of sensitivity analyses;
6) General agreement on need for/use of a screening level dose rate for use in assessments;

7) General agreement on use of SSD for the derivation of a screening level (consistent with chemicals and allows updating as new data become available);

8) General agreement that there is a need for an 'action level(s)';

9) Lack of agreement on how an action level is derived nor what it actually is although it was recognised that the procedures used to set it should be scientifically defensible and it should be easy to defend legally (but this relies on knowing what a level of significant harm actually is);

10) PROTECT needs to consider the implications of including in environmental management the precautionary principle, optimisation etc.. In particular it was felt that the differences between the screening and action levels could be related to how optimisation might be applied to environmental protection although it was noted that any action that is taken must be proportional to the risk and should do more good than harm;

11) The ICRP-60 statement could not be supported or repudiated and further work is required on this.

7.1.1 Additional points for consideration

In addition to the 'take home messages' discussed at the workshop the PROTECT consortium has identified a number of additional points to be considered from discussions at the workshop:

- PROTECT should test any numeric values that it derives as a standard or screening value. This should include a critical review and/or evaluation against field data on biological effects caused by exposure to ionising radiation where possible to ground truth the number;
- PROTECT should make it clear on what values are being applied within the suggested protection goals that have been proposed by PROTECT WP3;
- PROTECT should highlight, in an open and transparent manner, where data gaps exist, what the implications of these data gaps are in terms of deriving standards, thresholds or action limits and recommend what further work is required to address these issues;
- PROTECT needs to be clear about what data is being included in the SSDs and should consider how the data points used are constructed (for example using jack-knife type procedures to select data points for input into the SSDs);
- PROTECT should continue to request and highlight the need for others to indicate and enter papers which describe biological effects in non human species resulting from exposure to ionising radiation;
- In the final workshop in Aix, PROTECT should arrange for a presentation on the 'pros and cons' of using a SSD;

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Appendix 1 – Review of WNA and OECD-NEA publications – summary

A1.1 OECD-NEA (2007)

The OECD-NEA report has been prepared by the Expert Group on Radiological Protection Science and addresses a range of topical issues, one of which is radiological protection of the environment.

The discussion of scientific issues represents a good summary of the state-of-the-art, albeit with the main focus on human risks. However, a number of the scientific challenges may have implications for the assessment and management of doses to biota. The section on radiological protection of the environment gives a concise overview of the issue and some of the challenges. They acknowledge there is international consensus on the need to protect the environment, but stress that research needs to be well-targeted and aimed towards concrete results to assist policy makers. They also raise the question of the suitability of the current ICRP approach, noting that: '*The data published to date have led to the finding that no significant harmful effects that could put whole species at risk or promote irreversible balances between species have been observed for radiation exposures below 1 mGy day*$^{-1}$,' (p.14). However, they conclude that there is still an obligation to demonstrate that the current system gives an adequate level of protection to the environment, and they also stress a number of complexities such as the lack of data on chronic exposure. Other issues discussed include the challenges of linking measurement data to protection of the environment, the identification of pertinent endpoints, need for simple models and a 'Fit-for-purpose approach'. These points are elaborated in more depth in the Brownless paper. They also discuss the reference organism approach, highlighting the benefits of having a pragmatic approach, the strengths and weaknesses of having a simple approach, and the problems with addressing life-cycle differences. The general conclusion is that despite the problems, and a wish to demonstrate ecosystem health, the reference organism approach is better developed than the alternatives. The main action proposal is to set up an international network (or "Observatory") that allowed researchers to co-ordinate and understand research in relevant fields.

In conclusion, the report appears to be complimentary to PROTECT work, noting a number of the same challenges, and not appearing to raise any serious objections to the work being undertaken. In their own words:

> '*Today, under controlled practice and in normal operation of facilities, there seems to be not indication of any significant or visible harmful effect on the health of ecosystems that can be attributed to radiation. But given the complexity of the situation (e.g. natural background, relationships between individual and ecosystems, many simultaneous stresses), the research necessary to scientifically answer questions regarding the well-being of ecosystems must be well targeted and based upon the social choices at the international, national and local levels depending on the situation being considered*' (p. 94)

A1.2 Brownless (2007)

The paper has been published as a peer reviewed journal article, with the approval of the NEA's CPRRH. The aim is to promote debate on the topic, and particularly to explore the challenges of integrating protection of the environment into the current system of radiological protection. The paper gives a good summary of the problem and makes a number of interesting and useful proposals. It starts

from the position that the current approach is generally effective (namely that protecting humans will protect the environment) and explores the implications of directly and explicitly integrating protection of the environment into that approach. Two important concerns are identified:

1. *'**Lack of transparency of the current system**. It is not immediately obvious how protecting humans gives good protection to the rest of the environment, since the system does not give any direct protection or means of measurement or comparison'.*
2. *'**Lack of comprehensiveness of the current system**. Currently, radioactivity accumulated in the environment is only controlled insofar as humans are exposed to it. Therefore it is in principle possible that isolated, sensitive parts of the environment may be inadequately protected.'* (p.392)

Brownless proposes a 'three-banded scheme' that fits well with tiered assessment approaches and 'screening and action values' proposed within PROTECT (Figure A.1). However, it is less clear whether or not such an approach could be used to give a general evaluation of the entire philosophy of the current ICRP approach ('if humans are protected so is the environment') - does one only have to show one case where exposures exceed 400 uGy hr^{-1} to reject outright the philosophy? Surely a 'philosophy' needs to be universally applicable? Nevertheless, the approach can be used to address on a case-by-case whether or not the current system would be sufficient for that particular context, and to identify situations where the approach would be problematic.

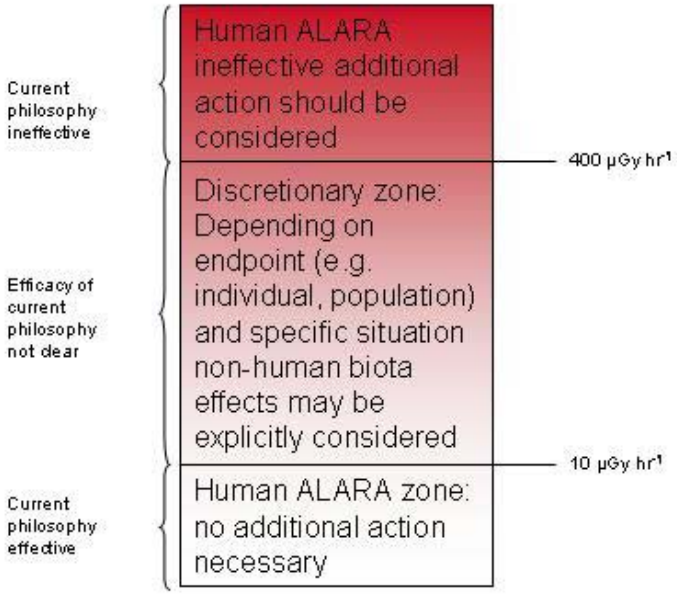

Figure A.1 Three banded scheme for environmental protection as proposed by Brownless (2007).

The paper advocates that it would be useful to have generic estimates of 'dose rate per unit concentration' values for reference ecosystems, organisms and radionuclides. It also suggests that this could be done once and then subjected to periodic review as new data becomes available, and notes that as a starting point such a table is possible to extract from the ERICA-Tool. Of course, this is a lot of work (and undoubtedly complicated by the variability and lack of consensus on parameters), but the spirit of the idea is in line with the work ongoing in PROTECT and the EMRAS Biota Working Group (BWG) on model and parameter comparison. Finally, the paper also notes that the assumption that a

limited set of organisms is representative of an ecosystem needs to be explored and that information on background is desirable to give a sense of scale.

In conclusion, this is a very helpful paper for PROTECT. It makes clear the difference between the problem of merely assuming that protecting humans will protect the environment, and the advantage of actually having tools and procedures to demonstrate that the environment is protected. This is a distinction that is not appreciated in the following report.

A1.3 SENES (2007)

The SENES report was prepared for the WNA, and there are two aspects that can be addressed here: the report itself and the WNA response to the report. We can start with the WNAs press release accompanying their publication of the report:

> '***Reassurance on environmental protection from nuclear site releases:*** *By examining the effects of ionising radiation in the environment, an independent expert overview has confirmed that both people and nature have been adequately protected from radioactive releases from all kinds of nuclear sites, old and new*' (WNA November 2007).

Firstly, SENES made no evaluation of whether or not people have been adequately protected; secondly, there is a problem with extrapolating from the few cases to an assessment of 'all sites, old and new'; and, thirdly, the criteria for demonstrating adequate protection are debateable. Leaving aside the WNA interpretation, we can first turn to what the SENES report has done.

SENES has taken a number of published ecological risk assessments and summarised their conclusions. These include: uranium mining sites (McArthur River, McClean Lake); nuclear power plants (Pickering Generating System, Loire River); nuclear fuel reprocessing plants (La Hague, Marcoule, Sellafield); management and disposal sites (Hanford, Bear Creek, Chalk River); the Chernobyl accident; NORM sites (Komi, North Sea oil and gas off-shore platforms).

The assessments use a range of methodology and screening or reference dose values. They include RESRAD, FASSET, the DOE Graded Approach and IAEA/NRCP. Quoted reference doses range from 1 mGy d^{-1} to 24 mGy d^{-1}, and include one of 0.13 mGy hr^{-1} to a trumpeter swan. Leaving aside the Chernobyl accident, of the 12 remaining assessments, four had dose rates well below the assessment screening value used in the specific assessment, nine had dose rates greater than the suggested ERICA screening value of 10 uGy hr^3, and seven had dose rates to individual organisms above the actual assessment screening values (including three greater than 10 mGy d^{-1}). In all cases, the conclusion was that the effects would not be significant on the population level. Reference was made to the limited areas and species affected, and the fact that despite breaching reference values, the exposures were below those at which significant population effects would be observed.

There are a number of strengths in the SENES report. It gives an illustration of the type and range of organisms needed to carry out the evaluation and highlights some of those organisms most at risk, and to which radionuclides. It underlines (indirectly) the problems with the lack of consensus on reference values between the different assessments. Finally, it provides a useful overview of the range of dose rates that might be observed from nuclear facilities.

There are however, a number of problems with the SENES report. Firstly, the representativeness of the assessments selected. There are many good assessments, but do they give the full picture? One could contend that sites with the potential to give higher doses had not been included. On the other hand, one could question the relevance of the few cases where organisms were shown to be potentially exposed

[3] Note that SENES made no direct comparison with the ERICA screening value.

to high doses. It should also be stressed that the FASSET assessments were carried out to test the methodology as an input to the ERICA developments and were not intended to represent a comprehensive site evaluation. Second, the report uses no upfront criteria to determine whether or not the environment has been adequately protected. There is an arbitrary reference to the reference dose rates applied by the various assessments, without acknowledging the lack of compatibility.

Applying the 'Brownless scheme' one might easily conclude that the 'philosophy' was not effective, or at the least that the efficiency was not clear. Nevertheless, while many of the reviewed assessments showed a potential for concern, the more realistic and detailed data analysis showed that the exposures were not likely to have caused significant effects at a population level. While one could claim that there was no evidence that the environment had been harmed, it would seem still debatable whether or not the environment had been adequately protected.

The conclusion draw by SENES is as follows and has been repeated and endorsed by WNA:

> '*The representative ERAs considered in this review show that the application of the current system of radiological protection, which includes a variety of standards protective practices for containing radioactive sources, controlling and limiting radioactive releases to the environment, and protecting people, have in fact also provided an adequate level of protection to populations of non-human biota*.' SENES p4-2

WNA goes further and adds that:

> '*This overview provides reassurance against the concern expressed in this decade by part of the international expert community, which suggested that the environment may not have been adequately protected from exposure to ionising radiation and that the system of radiological protection was incomplete*.' WNA Press Release

One can contend that the system of radiological protection was clearly incomplete as it would have never been possible for the WNA to make this claim (however contentious) without the help of the models and tools developed.

Appendix 2 – Marine Scenario for the PROTECT Meeting 29th January 2008

Introduction

The following assessment is loosely based on a period of peak discharges from a regulated nuclear complex to a coastal marine environment in Western Europe for the sake of providing some degree of realism. The results should not be considered as an authoritative assessment of impacts on man or biota for any actual existing site.

The objective of the scenario involves conducting assessments for biota and for humans in parallel in order to consider how this procedure might be undertaken in a practical sense and how the results and their interpretation may impinge on the decision making process. This can be seen as an initial test into the practicability of following the ICRP (ICRP, 2003) suggestion of providing a common approach to protecting humans and other living organisms (Figure 1).

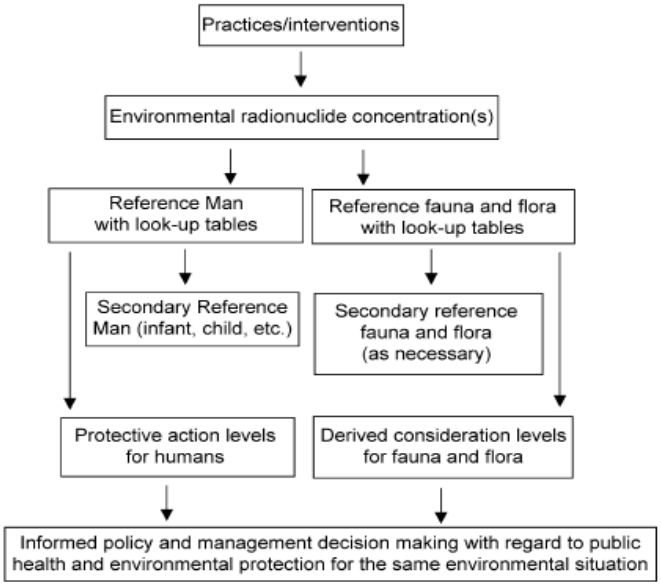

Figure 1. A common approach to protect humans and other living organisms (reproduced from ICRP, 2003).

The assessment can be run at Tier 2 in the ERICA Assessment Tool in order to generate the detail of information required to help address a number of discussion points. A supporting spreadsheet has also been provided to aid you in conducting the human radiological assessment.

Scenario description

A marine protected area is located with a boundary that crosses at a distance of 10 km from the discharge outlet at its nearest point. The main commercial fishery (fish and crustaceans) is located approximately 100 km from the discharge point (Figure 2). The ecology of the area is typical of boreal marine ecosystems.

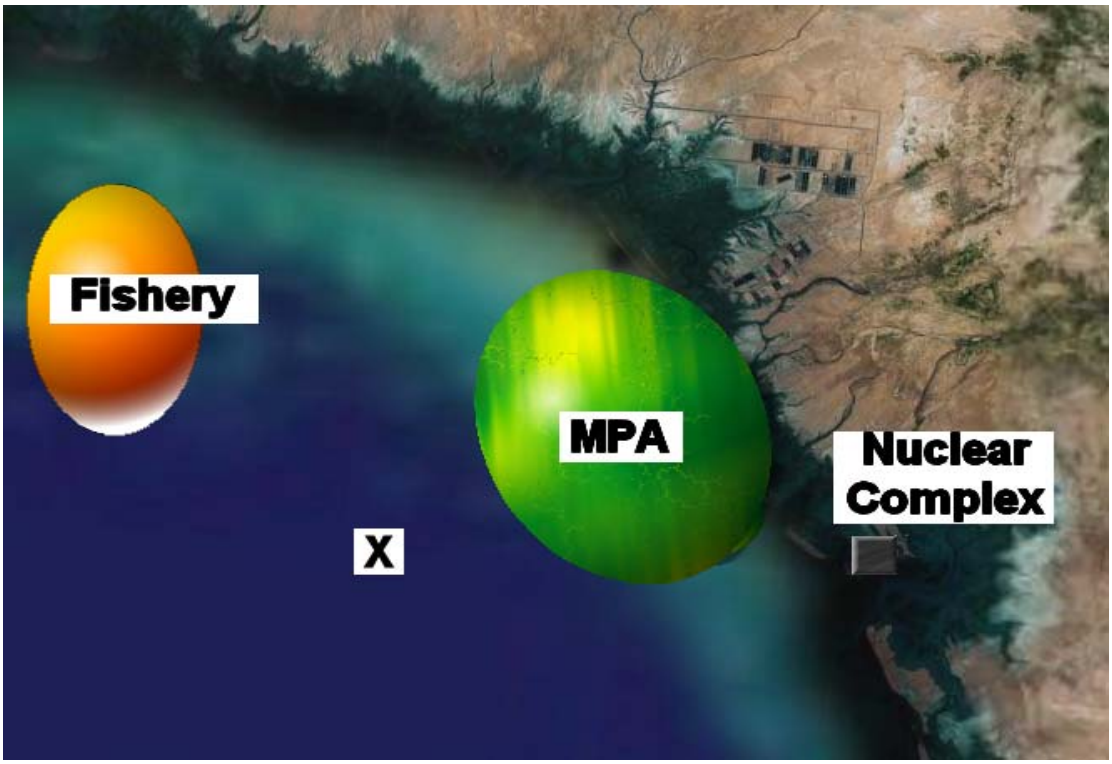

Figure 2. Overview map of scenario. X marks the location for which the predictions from the generic model apply (see text description below).

Low level liquid effluents arising from a number of sources are discharged to a shallow Sea area via pipelines extending approximately 2.5 km from the high water mark.

Running the Generic model

Assume initially that, the information you have is limited to annual discharge data (Table 1) and basic bathymetric-hydrographic information (Table 2). This allows you to run a simple conservative screening assessment, i.e. information provided should allow you to parameterise and run the generic IAEA SRS-19 Coastal model that can be accessed in the ERICA Tool.

In order to provide <u>best estimates</u> of activity concentrations in the assessment area, you decide to run the coastal model for a discharge point to receptor distance of 70 km.

Table 1. Discharge data for the nuclear complex

Radionuclides	TBq/y	Bq/s
^{3}H	2.00E+03	6.34E+07
^{60}Co	1.00E+00	3.17E+04
^{90}Sr	5.00E+02	1.59E+07
^{99}Tc	1.00E+02	3.17E+06
^{106}Ru	5.00E+02	1.59E+07
^{134}Cs	5.00E+02	1.59E+07
^{137}Cs	5.00E+03	1.59E+08
^{238}Pu	1.00E+00	3.17E+04
^{239}Pu	5.00E+01	1.59E+06
^{241}Am	1.00E+01	3.17E+05

Table 2. Hydrographic-bathymetric data for running the scenario

Parameter (units)	Value
Average water depth, (m)	50
Distance between release point and shore, (m)	2500
Distance between release point and receptor (m)	70 000
Coastal current, (m sec-1)	0.1

Environmental radiological assessment

The risk to non-human biota can be derived directly from the ERICA Assessment Tool. These values should be noted in the accompanying answer sheet. **Please answer questions 1 to 6.**

The ICRP are considering an approach whereby derived information relevant to each type of animal and plant could be simplified into bands of dose rates relevant to their individual background radiation dose rates in order to set out 'Derived Consideration Levels (DCLs)'. The purpose of the DCLs would be to serve as points of reference at which one should consider what is known about the effects of radiation on particular types of animals or plants alongside other relevant information.

Please refer to pages 88 to 96 of the ICRP Draft report "Environmental Protection: the Concept and Use of Reference Animals and Plants". **Thereafter answer questions 7 to 9.**

Human radiological assessment

At this stage you have no direct information on activity concentrations in seafood and therefore must rely on Concentration Ratio (Concentration Factor data) to allow you to derive these values from activity concentrations in seawater (see answers to Qu. 5). The standard dataset used in routine human radiological assessments from IAEA Technical report series 422 (IAEA, 2004)[4] is provided in Table 3 and the accompanying EXCEL spreadsheet.

Table 3. Concentration factors (l kg^{-1}) for different categories of marine organisms consumed by humans.

Radionuclides	Fish (l/kg)	Crustaceans (l/kg)
H-3	1.00E+00	1.00E+00
Co-60	7.00E+02	7.00E+03
Sr-90	3.00E+00	5.00E+00
Tc-99	8.00E+01	1.00E+03
Ru-106	2.00E+00	1.00E+02
Cs-134	1.00E+02	5.00E+01
Cs-137	1.00E+02	5.00E+01
Pu-238	1.00E+02	2.00E+02
Pu-239	1.00E+02	2.00E+02
Am-241	1.00E+02	4.00E+02

Assume that site-specific habit surveys have been conducted for the area of interest, the critical pathway has been identified as arising from the consumption of seafood only as oppose to external exposure from contaminated inter-tidal sediments or a combination of pathways. Consumption rate data have been interpreted to identify groups of high-rate consumers. These data (loosely based on actual data reported in RIFE-5[5], 2000) are presented in Table 4.

Table 4. Consumption rate of seafood for a 'critical' (High rate consumption) group

Seafood	kg/y
Plaice and cod	90
Shrimps (crustaceans)	30

The (Annual) Committed effective dose, E_{int} can be derived using the following equation :

$$E_{\text{int}} = \sum_i e(\tau)_i \times I_i \qquad (1)$$

Where : $e(\tau)$ = Dose conversion factor (Sv Bq^{-1}) for radionuclide "i"
I_i = Annual Intake of radionuclide "i", (Bq y^{-1})

Dose conversion factors are provided in Table 5 and also in the accompanying EXCEL spreadsheet.

[4] IAEA's Technical Report Series has been developed with human radiological assessment in mind – data often pertain to edible species and the edible parts of these species. No "correction" is made to derive equivalent whole body concentrations whereas such a data manipulation is performed for the ERICA dataset where practicable.
[5] UK assessment

The annual intake of radionuclide can in turn be derived from the following equation :

$$I_i = \sum^{p} C_{ip} \times V_{ip} \times K_{ip} \qquad (2)$$

Where : C_{ip} = activity concentration of radionuclide "i" in foodstuff "p", Bq/kg
V_{ip} = Annual consumption rate of foodstuff "p", kg/y
K_{ip} = factor accounting for loss of activity of nuclide "i" during cooking or storage of foodstuff "p", unitless

K_{ip} can be assumed to be 1 (i.e. no loss) for the purposes of these calculations.

These equations are implemented for you in the accompanying EXCEL-spreadsheet.

Table 5. Dose conversion factors $e(\tau)$, Sv Bq^{-1}, for adults from ICRP-72 (ICRP, 1996).

Radionuclide	Sv per Bq (Adult)
H-3	1.80E-11
Co-60	3.40E-09
Sr-90	2.80E-08
Tc-99	2.00E-09
Ru-106	7.00E-09
Cs-134	1.90E-08
Cs-137	1.30E-08
Pu-238	2.30E-07
Pu-239	2.50E-07
Am-241	2.00E-07

For this particular scenario we will assume that the individual dose limits as recommended by the ICRP for members of the general public are most appropriate to apply. The ICRP recommends an annual limit on effective dose of 1 mSv (ICRP, 1991). The individual dose limits are normally taken to apply to the mean dose received by the critical group. The dose limit for the general public also appears in the new recommendations from the ICRP that includes planned situation (including practices in operation).

Alternatively, the single source dose constraint[6] of 0.3 mSv/year can be applied in line with the ICRP's recommendations on relevant constraints for prolonged exposure.

Please answer questions 10 and 11.

The following text concerning environmental protection is taken from the old version of the basic ICRP recommendations (ICRP-60) :

"*The Commission believes that the standard of environmental control needed to protect man to the degree currently thought desirable will ensure that 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 imbalance between species*."

Please answer questions 12 to 15.

[6] Normally applied in conjunction with the optimisation of protection to restrict individual doses

References

IAEA, 2004. Sediment distribution coefficients and Concentration Factors for biota in the Marine Environment, Technical Reports Series No. 422. International Atomic Energy Agency, Vienna.

ICRP Publication 72: Age-dependent Doses to the Members of the Public from Intake of Radionuclides Part 5, Compilation of Ingestion and Inhalation Coefficients. Annals of the ICRP Volume 26/1

ICRP (1991). ICRP Publication 60: 1990 Recommendations of the International Commission on Radiological Protection. Annals of the ICRP Volume 21/1-3.

ICRP (2003). A Framework for Assessing the Impact of Ionising Radiation on Non-human Species, Annals of the ICRP, 91, pp. 201-266.

Radioactivity in food and the environment , 1999 (RIFE-5). (2000). Food Standards Agency & Scottish Environmental Protection Agency. ISSN 1365-6414.

Appendix 3 - Question and answers sheet for Marine scenario

Group number and names	
1. Please note basic "assessment context" information, i.e. screening level, selection of reference organisms, uncertainty factors.	Screening level = Reference organisms = Uncertainty factors =
2. Please note if you have used other occupancy factors and/or radiation weighting factors than default values.	
3. Note down the Total dose rate per organism group.	*Suggest – copy and paste into EXCEL spreadsheet*
4. Do the dose-rates exceed the screening criteria (are RQs expected and/or conservative > 1) ? For which organism/organism groups ?	
5. Note down the activity concentrations in water (Results – Tables) : <u>these will be used in the human radiological assessment</u>.	*Suggest – copy and paste into EXCEL spreadsheet*
6. Regarding the interpretation of the RQ results at Tier 2 Do you feel that it is more appropriate to use the ERICA default screening value of 10 µGy h^{-1} or the 400 µGy h^{-1} screening value that is considered to be protective of populations of aquatic organisms?	

Questions concerning interpretation of environmental assessment results

7. What implications (to decision making) would deliberation upon (a) the ICRP derived consideration levels and (b) PROTECT's proposed levels have on the assessment?	
8. Consider how the choice of screening level might influence the decisions made, e.g.: • If estimated RQ ≥ 1 for the most exposed organism and chosen screening level what screening level would be required for RQ = 1? • If estimated RQ<1 for the most exposed organism and chosen screening level what screening level would be required for RQ=1?	
9. Do you feel that it is appropriate to account for uncertainty in the dose-rate estimate through the application of an uncertainty factor (*you may want to come back to this question after considering the subsequent human radiological assessment*)?	

Questions concerning human radiological assessment

10. Specify the Annual committed effective dose (mSv) derived for the human critical group.	
11. Are the calculated doses for humans unacceptable?	

Questions concerning the parallel assessments

12. Which assessment (environmental or human) provides the limiting criteria?	
13. Is the statement from ICRP-60 quoted in the main text of the scenario description supported by the assessment?	
14. What screening level would result in the environmental assessment becoming the more restrictive?	
15. Is it appropriate to use the same values for distance from discharge point to receptor in both assessments?	