

BIOPROTA

Key Issues in Biosphere Aspects of Assessment of the Long-term Impact of Contaminant Releases Associated with Radioactive Waste Management

Report of Third Workshop

Paris, 22-24 September 2003

Hosted by ANDRA

Version1.0

29 October 2003

**Report of Third BIOPROTA Workshop
22-24 September 2003
Hosted by ANDRA, France**

History

Draft report Version 0.1 prepared by Enviros Consulting Ltd, distributed to Workshop Participants.

Comments received from participants, Final Version 1.0 prepared by Enviros Consulting Ltd, distributed to Workshop Participants and filed on the BIOPROTA Business Collaborator Workspace.

Preface

The report is presented as working material for information. The content may not be taken to represent the official position of the organisations involved.

Contents

1	INTRODUCTION.....	1
2.	DISCUSSION OF THE THEMES AND TASKS.....	2
	2.1: THEME 1: SPECIALISED DATABASE FOR KEY RADIONUCLIDES AND PROCESS DATA.....	2
	2.2: THEME 2: MODELLING	3
	2.3 THEME 3: SITE INVESTIGATION, EXPERIMENTS AND MONITORING.....	10
3	WORK PROGRAMME AND SCHEDULE.....	11
4	ACKNOWLEDGEMENT	11
5	REFERENCES.....	11
	APPENDIX A: BIOPROTA: THIRD WORKSHOP	A1
	APPENDIX B: WORKSHOP PARTICIPATION LIST	B1

1 Introduction

Key issues in biosphere aspects of assessment of the long term impact of contaminant releases associated with radioactive waste management were identified at a Preliminary BIOPROTA Workshop, hosted by Andra in June 2002 [BIOPROTA, 2002a]. Common issues and a way forward were set out in a BIOPROTA Concept and Definition Document [BIOPROTA, 2002b].

Previous meetings have included the Preliminary Workshop in Paris, the First Workshop in Oslo, October 2002, and the Second Workshop in May 2003, at the invitation of Nagra. A Third Workshop was arranged in Paris to be hosted by ANDRA to discuss the first year progress and deliverables, and the Work Plan for 2003-04. The Agenda is reproduced as Appendix A and the participants list is in Appendix B.

IUR Task Force on Waste Management and Radioecology

The next workshop for the IUR Radioecology and Waste Task Group will be held in Madrid, 3-4 November. There are several members of BIOPROTA that will be present at this Workshop. The agenda can be found on the IUR website: <http://www.answeb.net/~iuruir/>. The presentation material and workshop report will be uploaded to the BIOPROTA Business Collaborator workspace after the Workshop http://cobweb.businesscollaborator.com/bc/explogin_ie5.cgi/0/13590068.

EMRAS

Among other things, IAEA EMRAS is revising TRS 364¹, using a Task Group under the chairmanship of Pascal Santucci, IRSN, France. A revised report is anticipated in 2007, and the focus will remain doses to man. (Protection of the environment and non-human biota are the focus of other collaborations.)

Revisions to TRS364 include aquatic environments (but with a freshwater focus as the marine environment is considered in a separate report) and atmospheric deposition, and additions will include co-factors to help the user to select a recommended value, plant classification (grouping species into useful categories), biological half-lives, a section on analogues, pathways or processes for irrigation, tropical and subtropical systems, inhabited environments, and statistical distributions of parameter values.

The TRS364 revision is related to BIOPROTA Theme 1, the Specialised Database and the IUR Waste Task Force. There has been concern that that Theme 1 and EMRAS are investigating the same data requirements, however the Table below illustrates that there are differences.

¹ IAEA (1994). Handbook of Parameter Values for the Prediction of Radionuclide Transfer in Temperate Environments. Technical Report Series 364, IAEA, Vienna.

TRS364	BIOPROTA
All nuclides	Key nuclides
Paper document	Electronic database
Recommended values ready to use	Provide information needed to select a value in specific circumstances

The next EMRAS meeting is scheduled to take place in April 2004, Cadarache followed by a plenary meeting in Vienna in September/ October 2004. The TS and Elisabeth Leclerc-Cessac will contact IAEA and Pascal Santucci to discuss collaboration with BIOPROTA.

2. Discussion of the Themes and Tasks

The workshop provided a setting for some lively debate for the Themes and Tasks within BIOPROTA. The following note does not document all arguments, rather the most important issues and the agreed decisions regarding how the Themes and Tasks should proceed.

Tasks were introduced with a presentation by the Task Group Leader (TGL) or the Technical Secretariat, (TS). Where available, these presentations have been filed on Business Collaborator

http://cobweb.businesscollaborator.com/bc/explogin_ie5.cgi/0/10655593 .

2.1: Theme 1: Specialised Database for Key Radionuclides and Process Data

The objective of the database is to be a source of information that includes justification and background information to allow the user to make an informed choice of parameter value for their PA. We cannot include all background information to the parameter values for all references and experiments, but neither do we want an overly simplistic 'look up book' of recommended values that is similar to IAEA TRS364. Whilst primary data is preferred and is the priority, extrapolations will be included if there are no primary data available. The database can also include parameter values that are used for assessment purposes now, if technically supported, e.g. animal transfer factors computed using biokinetic models based on primary data. Generic suggestions, for use within long term assessments could be included. However, generic data is probably more within the remit of EMRAS.

Action: TS to send latest version of the database (that does not have 'Nirex' on the front end) and the report to participants requesting comments on structure and requesting information, which should be primary ('raw') data or assumed (or extrapolated) values including justification.

Deadline: 31 October 2003

Action: Each organisation to submit information on ‘raw’ data and what is actually used and how it is justified within existing assessments. The TS will filter out the repeat references, to avoid multiple use implying authority.

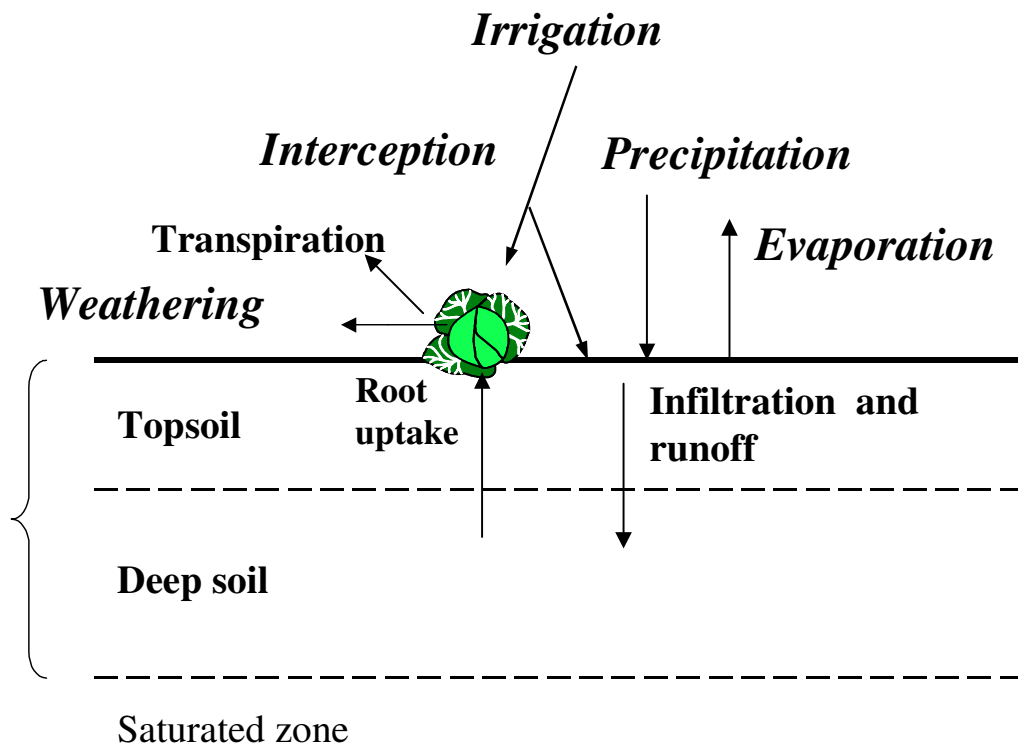
Deadline: 26 March 2004

When more data is received, another version of the database will be circulated to participants. If appropriate the database structure can be changed to list the data for assessment purposes.

2.2: Theme 2: Modelling

2.2.1. Task 1: Develop guidance on irrigation modelling

The objective of this Task is to investigate the calculation of doses arising from interception by growing crops using contaminated irrigation water and the consequent contamination of the food consumed by humans. There are 8 participating organisations in the test calculation: ANDRA, CIEMAT, EPRI, JGC, Nirex/MTA, Studsvik RadWaste, University of Veszprem, and YMP. The results and comparisons were discussed briefly and are considered in more detail in the working material report to be produced before the end of October.



Some issues worth noting are:

- that the time of irrigation and last irrigation before harvest were not specified;
- ANDRA used a specific activity model which was different to the others, although there are probably some relationships to the Nirex model.

Further analysis is needed before we can establish whether a unified approach can be suggested. Each organisation is requested to forward additional information to the TGL and the TS to better describe the conceptual models and parameter values in more detail.

A number of ideas were discussed for consideration in 2003-04. In future, the models could be applied to different biosphere systems. BIOPROTA could then determine the circumstances in which root uptake or surface deposition is more important.

Action: Participants to provide the TGL with better descriptions of the conceptual model and provide parameter values.

Deadline: Mid October

Action: TGL and TS to prepare V1.0 working material report

Deadline: End of October

2.2.2. Task 2: Develop guidance on the inhalation pathway for actinides accumulating in soils/sediments

The objective of this Task is to investigate further the calculation of doses arising from inhalation of particles suspended from soils within which long-lived radionuclides, particularly alpha emitters, have accumulated. As for Task 1, the models were developed independently for different environments and processes then applied to the BIOMASS ERB2A System Description. The participants are: ANDRA, Ciemat, EPRI, Nirex/MTA, NUMO, Studsvik, UKAEA and YMP.

The models will be analyzed to determine whether there are any differences conceptually, mathematically or in the parameter values to show the uncertainty. This will highlight whether any processes have been treated substantially differently or excluded. The results and conclusions were discussed briefly and are to be considered in more detail in the working material report to be produced before the end of October.

From this, the 2003-04 work programme may take account of soil profiles over time, consider a fixed activity level in the soil (not specified originally because of the different accumulation processes considered, but now appropriate), and sensitivity information.

There are several other issues that may be considered in the 2003-04 work plan: the amount of activity attached to small particles; consideration of a resuspension factor instead of dust loading as more appropriate to accidental releases; consideration of the period following deposition and the amount of time the contamination is deposited over; the depth of soil and the importance of the time when ploughing takes place subsequent to deposition; and when is it necessary to take account of soil structure.

An issue discussed during this Task but of interest to all of the others is the problem of terminology. We need to agree the definitions of terms such as porosity and translocation. It was recommended to use ICRU65² and SI units where possible.

Action: participants to provide better description of conceptual models and parameter values in more detail.

Deadline: mid October

Action: TGL and TS to prepare V1.0 working material report

Deadline: End of October

2.2.3. Task 3: Model Review for C-14 Dose Assessment

At present there is less consensus on how to model C-14 than other radionuclides and the Task started later than the others so there has been less progress. In addition, the Task involves the whole biosphere system, so it is more difficult to model and as carbon is not a trace element it is not appropriate to use trace element models.

The TGL has reviewed several papers and has found that most organisations are moving towards using specific activity models. However, there is uncertainty regarding the appropriate level required when considering C-14 modelling for PA and there are many problems and unanswered questions:

1. Should kinetics and the whole biosphere be considered?
2. What carbon pools should be considered?
3. What degree of mixing is there between pools?
4. How does the carbon reach the biosphere?
5. What atmospheric exchange is there?
6. What proportion of C-14 is fixed (unavailable) in soils?
7. What stable carbon and C-14 is in the waste inventories and what assumptions can be made about the physical and chemical form of both the stable carbon and C-14?
8. How will it escape from a repository?
9. How much food can humans take out of the system?

Into 2003-04, the Task Group will address how organisations model C-14 now and the shortcomings of these models. It might be obvious when one model is better than others and a test calculation may be considered at a later date. It may be possible to conduct a C-13 experiment under field conditions to validate the conceptual model. The Task Group can then consider what are the key processes (such as isotopic mixing) and what information is required to be able to model them more accurately.

There are some examples of buried wastes that contain C-14 (such as West Valley, USA) that may provide details on the movement and behaviour of C-14 that are relevant to a PA, and can be included in a review.

Action: TGL to draft a technical note on model information acquired to date with support from the TS as necessary.

Deadline: End October 2003.

² Quantities, Units and Terms in Radioecology. Journal of the International Commission on Radiation Units and Measurements. Volume 1 No 2, 2001

Action: Participants requested to provide references to the TGL.

Deadline: January 2004

Action: TGL will describe a conceptual model to be agreed with other participants and will continue to review papers of relevance.

Deadline: April 2004

2.2.4. Task 4: Model Inter-Comparison Exercise

The comparison of this Task involves the process of radionuclide accumulation in soil that may arrive from several pathways. The comparison is not concerned with doses from inhalation or consumption of crops contaminated by irrigation water because they are the subject of Tasks 1 and 2. The participants in this Task are: BNFL, UKAEA, EPRI, NUMO, ANDRA, EdF and Nirex/MTA.

Not all participants have provided full parameter values which are used to calculate the nuclide concentration in soil. However, the TGL has considered the test cases and there are some similarities within the models. Where there are differences they can be attributed to the use of specific activity models in some cases and compartmental models in others. For example, the ANDRA CI-36 specific activity model results in higher concentrations, but if transfer factors were used the results would be more similar to those from other organisations. Differences can also be attributed to the different values of Kd chosen.

It was apparent that some of the models had encountered errors that had not been corrected before the workshop. These errors will be addressed for the working material report due before the end of October, where further analysis and comparison can be found.

Nirex can consider the 3-D dispersion of radionuclides or other contaminants (such as nitrate) in a surface-water catchment, incorporating the growth cycle of plants over a catchment depleting concentrations from soil and can average contaminant concentrations in soils and plants over any specified 3-D subvolume of the catchment. However, this work is probably more specialised than some organisations require. References for this work are available³ and further reports are in preparation and will be made available to BIOPROTA participants over the next few months.

Action: Participants to forward corrected results or parameter values to the TGL. In addition provide details of rate constants and all other transfers.

Deadline: Mid October.

Action: ANDRA draft working material for the well and river scenarios. The working material should include comments on radionuclides for which there is good agreement in the results and consideration of any processes or parameter values that may be the source of the differences.

Deadline: End of October.

³ Thorne MC, Degnan P, Ewen J and Parkin G (2000). Validation of a physically based catchment model for application as a post closure radiological safety assessments of deep geological repositories for solid radioactive waste. *J Radiol Prot* **20**: 403-421.

Parkin et al (1999). A physically based approach to modelling radionuclide transport in the biosphere. *J Radiol Prot* **19**: 319-331.

Action: Steering Committee will advise on publication issues in response to the ANDRA offer to draft a technical note to be published.

Deadline: End of October

The task may continue by combining the test calculations for root uptake and the irrigation pathway scenarios with soil accumulation. It may also be useful to include loss rates, which may highlight where differences occur. The continuing work programme may consider seasonality in a second test calculation with appropriate values for irrigation, precipitation, evapotranspiration etc. However Nagra have done this type of calculation before and did not find a significant difference and it would probably only be relevant for nuclides with low sorption. Such a calculation could be made more complicated by considering oxidised and redox zones in more detail. It may also be appropriate to consider sensitivity analysis.

For the other scenarios (capillary rise and groundwater discharging into a water body via a sediment layer) fewer organisations participated. However some observations could be made. Differences may have resulted from the retardation factor or distribution coefficients used. In future we need to ensure that 'like with like' parameter values are used in Test Calculations to be able to compare the mathematical equations. For capillary rise, if there is no percolation and only evaporation (or evapotranspiration) then the loss rate depends on decay constants not on the K_d of soil. Seasonality is again an issue.

Sweden considered groundwater entering a surface water body in detail (see SKB 2003, TR-03-06 for further details).

2.2.5. Task 5: Update and review use of analogue data to resolve the key issues identified

The objectives of this Task are to list the relevant analogues, review and identify relevant processes, identify qualitative and quantitative information for PA, and suggest analogues suitable for use in testing models. Ideal analogues for the requirements of BIOPROTA have spatial and temporal contexts of relevance to a PA and also involve lots of processes. The information gathered will be used to populate the Theme 1 Database, parameterization, calibration or testing (validation) of numerical models, build confidence through process understanding, and to improve communication. The Task is very closely linked to the EC Project NANet which is concentrating on non-biologically influenced analogues.

It is difficult to separate analogue studies into those that are biologically and non-biologically influenced because many examples in the literature relates to the whole-system. Within BIOPROTA, the Task should concentrate on biotic transfer and accumulation mechanisms involving natural radioactivity, atmospheric deposition, groundwater/surface water pollution, although BIOPROTA could include physical data (assuming no contractual difficulties with the EU). Examples of processes to include:

- Plant uptake including nutrient analogues
- Microbial mediation of redox conditions
- Volatilization due to biological mediation
- Aging effects on bioavailability

- Build-up of irrigation/evapotranspiration residues
- Food-chains

The TGL has compiled a database of over 300 analogue studies using contributions from Posiva, Japan and the TS. This database is for both BIOPROTA and NANet: i.e. until now they have not been separated due to the problem of distinguishing between biological and non-biologically influenced analogues and because not all the literature describes analogues that are closely related to PA requirements.

Some examples include:

Studies of micro- and macro-nutrient uptake as analogues of molecular-level mechanisms, e.g. Transport proteins associated with:

- Sulphate
- Phosphate
- Nitrate
- Chloride,

e.g. Crawford and Glass, 1998

Microbial mediation of redox conditions

e.g. Muramatsu and Yoshida, 1999 (fate of iodine in the soil environment)

Some other examples offered through discussion include:

- Plutonium from bombs in Japan that has shown up in pre-1945 tree rings
- Studies relating to lead migration in soils following long-term contamination by leaching of lead roofs
- Elemental K_d and concentration ratio data.
- Leaching of heavy metals from Roman metal smelter slags.

From the data collection already undertaken for this Task, the preliminary conclusions are:

- Site-specific investigations at proposed localities for hosting repositories are the 'best' sites for deriving analogue information and/or carrying out field experiments
- More effort is required to understand mechanisms of plant uptake at a molecular scale
- Specification of processes of interest as a means to rationalize the literature
- Extensive database to add to, now need to investigate and draw out the lessons learnt.

Action: Ulrik Kautsky to circulate objectives and methodology of the SKB report that investigated plant uptake, and Mike Thorne to circulate information on a similar University of West of England project.

Deadline: End of October

Action: TGL to distribute the electronic database of literature.

Deadline: End of October

Action: TGL to draft Working Material with support from the TS.

Deadline: End of October

Task 6: Environmental Change

This Task is concerned with environmental change as a result of human influence. Unfortunately no significant progress has been possible in this Task. As mentioned below, this Task may be combined with Task 7 in the future work programme. It is important that it should not be forgotten because, for example, if a lake was dredged subsequent to sediment accumulation, the doses would be different. It may not be modelled in detail but should be mentioned at least because the doses are higher than without the human influence.

2.2.6. Task 7: Geosphere Biosphere Interface Zone

The objectives of this Task are to be able to account for the treatment of the GBIZ and the related accumulation/dispersion/dilution processes which have to be explored to help in the completion and the confidence of "safety assessment scenarios" on this important issue.

Illustrative calculations were not performed, but a number of reports were reviewed. It was concluded however that accumulation in the future is dependent on the exposure pathway, and changes in the biosphere can affect the geosphere, and vice versa.

Some of the problems raised with the GBIZ are that whilst the hydrological processes are fairly well known, the biogeochemical processes are not. There is also a lack of consistency between the geosphere and biosphere models, and a lack of understanding as to how to transfer data from one to the other. Also, the geosphere models used in PA are often 1-D (stream tube or stream network), but are typically supported by 2-D or 3-D flow and transport calculations. The 2-D calculations are often, but not always, in the vertical plane. Biosphere models are often 0-D (multiple compartments). However, the user may have a 2-D or 3-D interpretation of those compartments, as in BIOMASS Example 2B, for example.] The biosphere models are usually investigating a 1m² area which is a normalization. The loss of information can often be attributed to a failure of considering water balance and a lack of representation of near-surface hydrology, or of its coupling to deep hydrology. The timescales of the geosphere and biosphere are very different and can also cause problems when considering the GBIZ. The dynamics of each should be taken into account.

Action: TGL and TS to prepare V1.0 working material report

Deadline: End of October

Future work could include a simple test calculation involving a small number of relevant nuclides and taking into account ingrowth of daughters. The source term would be defined and the transport times considered. There are also possibilities of using SHETRAN models in the context of this Task to address considerations of hydrology, topography and soil properties.

In addition to the above suggestion for further work, it was proposed that the Scope of the Task be amended in the 2003-04 work programme to incorporate Task 6 and to consider the possibility of a wider project involving experts from the many disciplines concerned

with the GBIZ. Further details will be made available in the 2003-04 work programme. Provisionally, a meeting is planned for 15-16 December, in ANDRA.

2.3 Theme 3: Site Investigation, Experiments and Monitoring

2.3.1. Task 1: Develop guidance on biosphere site specific characterisation

In most countries long-term site characterisation for PA is distinguished from that used in support of an EIA, although in Sweden the approach is more holistic. It is recognised that consistency is needed, as many of the same questions need to be asked, however, the different timescales and the possibility of different regulations must be taken into account.

There has not been a lot of progress within this Task in comparison to those in the other Themes. However, inputs have been received from Posiva, Numo, SKB and ANDRA. From this information, and inputs from other experts (such as key parameters and FEPs of interest) as a result of this Workshop, the TGL will determine the most appropriate method of presentation (by ecosystem compartments (atmosphere, soils, plants), by pathway (inhalation), by key calculations (soil activity)). The BIOMASS system description was suggested as a format to start with. This would not be exclusive and site characterisation information not readily represented in the BIOMASS primary system components can be added. This would combine all the information that site characterisation experts require to measure and biosphere modellers require to model. The system description could also be expanded to take account of other environments, e.g. marine.

Action: Working material report produced by the TGL with support from the TS

Deadlines: End of October

2.3.2. Task 2: Research Protocols

The TGL, Mike Thorne circulated a briefing note to participants discussing experimental research and field research protocols. It is closely related to Task 1 above. Such protocols are relevant so that current monitoring and site characterisation data are applicable in the future and it would be useful if there was a global standard.

The Task aims to document the protocols that are used in each country and to consider the agreement between them. The aim is not to replace existing protocols, but document what techniques are used for different processes, and determine what is sufficient for purpose and in agreement with regulations. Subsequent to the review, the Task Group can determine what is appropriate for PA purposes. With such a bank of information, the Task Group can develop a standard set of parameters that require measuring/ monitoring in the field or laboratory so that we have confidence in the results.

If a repository has been constructed correctly, site characterisation should show that the natural variation around the site is to do with other environmental issues and not the impact of the repository. This implies the need to consider monitoring everything that could potentially be impacted upon. A combination of baseline surveys and time-series monitoring of selected indicators of environmental change may be appropriate, taking resource and time constraints into account.

Action: Participants to provide information on what protocols are used in research and site characterisation programmes and why, e.g. is it a requirement to build public confidence or is it safety related.

Deadline: End February 2004

Action: TGL will review and comment on the participant information.

Deadline: April 2004

3 Work Programme and Schedule

Before the Work Programme can continue into 2003-04, the first year requires 'finishing'. This will involve the completion of Working Material reports (or technical notes if appropriate) for each of the Tasks, to be completed by the TGL with assistance from the TS before the end of October. In addition, the TS will draft a summary report on technical progress of the 1st Year of BIOPROTA, also before the end of October; this will also set out the objectives, scope and work plan for 2003-04.

Some of the Working Material may be of sufficient quality and interest that the Steering Committee chose to publish it. The Steering Committee is responsible for decisions on publication of BIOPROTA material.

At the Steering Committee meeting held on 23 September, Elisabeth Leclerc-Cessac decided to step down as Chairman of BIOPROTA. Paul Degan was appointed as her replacement to take on the role. It was also decided that there should be an interim Workshop in April or May 2004 (the location of which is to be decided (probably Oxford or Stockholm)). A Workshop will also be arranged for September 2004.

4 Acknowledgement

All participants expressed their thanks to ANDRA for hosting the Workshop and providing excellent facilities and hospitality.

5 References

BIOPROTA (2002a). BIOPROTA Key Issues in Biosphere Aspects of Assessment of the Long-Term Impact of Contaminant Releases Associated with Radioactive Waste Management, Report of Workshop 12-14 June 2002, hosted by Andra, Chateney-Malabry.

BIOPROTA (2002b). BIOPROTA Key Issues in Biosphere Aspects of Assessment of the Long-Term Impact of Contaminant Releases Associated with Radioactive Waste Management, Project Concept and Definition Version 2, September 2002.

IAEA (1994). Handbook of Parameter Values for the Prediction of Radionuclide Transfer in Temperate Environments. Technical Report Series 364, IAEA, Vienna.

ICRU (2001) Quantities, Units and Terms in Radioecology. Journal of the International Commission on Radiation Units and Measurements. Volume 1 No 2.

Parkin et al (1999). A physically based approach to modelling radionuclide transport in the biosphere. *J Radiol Prot* **19**: 319-331.

Thorne MC, Degnan P, Ewen J and Parkin G (2000). Validation of a physically based catchment model for application as a post closure radiological safety assessments of deep geological repositories for solid radioactive waste. *J Radiol Prot* **20**: 403-421.

APPENDIX A: BIOPROTA: Third Workshop Paris, 22-24 September 2003 Draft Agenda

Monday 22 September

9.30AM

Introduction

Aims and Objectives of the Meeting, Elisabeth Leclerc-Cessac
Review of agenda, TechSec

Theme 1: The Specialised Database: discussion of structure and content
demonstration, TechSec

Theme 2: Task 1: Spray irrigation modelling. Review of contributions, model
descriptions/ differences; calculation results/ differences and lessons
learnt. U Bergstrom

12.30PM

Lunch

Theme 2: Task 2: Inhalation Exposure Modelling. Review of contributions, model
descriptions/ differences; calculation results/ differences and lessons
learnt. TechSec (on behalf of YMP)

Theme 2: Task 3: Discussion of C-14 Modelling, S Sheppard

5.30PM

Close of Day One

Tuesday 23 September

9.00AM

Theme 2: Task 4: Discussion of Model Intercomparison Exercise, Review of
contributions, model descriptions/ differences; calculation results/
differences and lessons learnt. A Albrecht/ H Yoshida

12.30PM

Lunch

Theme 2: Task 6: Environmental Change. TechSec (on behalf of Ciemat)

Theme 2: Task 7: Geosphere Biosphere Interface Zone. I Simon

Theme 3: Task 1: Site Characterisation, E Leclerc-Cessac & TechSec

5.30PM

Close of Day Two

Wednesday 24 September

9.00AM

Theme 2: Task 5: Natural Analogues. Review of contributions and lessons learnt, P
Degan

Theme 3: Task 2: Research Protocols, M Thorne

Future Work Programme:

Continuing Work Programme from October 2003

2.30PM

Close of Day Three

APPENDIX B: September Workshop Participation List

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