Theme 1 of the BIOMASS project was established with the objective of developing the concept of ‘Reference Biospheres’ into a practical system for application to the assessment of the long-term safety of repositories for radioactive waste. The project involved regulators, proponents of radioactive waste disposal and independent experts gathered from twelve countries. The outcome is the 'BIOMASS Methodology' developed through the construction of a number of ‘Example Reference Biospheres’. The examples illustrate the use of the Methodology and are also intended to be useful in their own right by acting as standard (or reference), stylised biospheres, in the way suggested by the International Commission on Radiological Protection (ICRP).

BIOMASS METHODOLOGY

The BIOMASS Methodology provides a formal procedure for the development of assessment biospheres in general. It was developed through the creation of the BIOMASS Example Reference Biospheres. The BIOMASS Methodology is based on a staged approach in which each stage introduces further detail so that a coherent biosphere system description and corresponding conceptual, mathematical and numerical models can be constructed.

Defining the assessment context is the first stage in the determination of a suitable assessment biosphere. This involves considering: a number of issues that define the overall requirements, principally the purpose of the assessment; the calculational endpoint(s); the site and repository context; the radionuclide source term; the geosphere-biosphere interface; the calculational timeframe; basic assumptions about society; and the assessment philosophy (e.g. the level of conservatism to be applied).

Biosphere system identification and justification is the second stage of the Methodology. Its purpose is to build on the assessment context to identify and justify the assessment biosphere(s) that is/are to be modelled. Identification and justification takes place in three main steps :

1. Identification of the typology of the main components of the biosphere system (e.g. climate type, geographical extent and topography, human activities etc.) using a series of tables.

2. A decision on whether or not the assessment context requires biosphere change to be represented. In deciding this, two components of the assessment context are particularly relevant: the timeframe of the assessment and the geosphere-biosphere interface. At a coastal site, for example, it may be considered necessary to consider the effect of changes in sea level.

3. If biosphere change is to be represented, the third step considers how this should be done. One might, for example, simulate the consequences of radionuclides emerging into a set of separate, unchanging biospheres, chosen to encompass the range of possible futures of interest. Additionally or alternatively, one might wish to consider an inter-related time sequence of biospheres with the interest focussed on the changes from one system to another.

The next stage of the Methodology is to construct a biosphere system description. This should provide enough detail about the biosphere system (or systems) to be considered in the assessment to justify the selection and use of conceptual models for radionuclide transfer and exposure pathways. To begin, the Methodology requires a decision to be made regarding the assumed level of human interaction with the biosphere system (for instance foraging in a natural or semi-natural environment compared to intensive agriculture). Then, for each identified system component, lists of potentially important features events and processes (FEPs) are screened to determine a short-list of those thought to be relevant to the assessment. Working systematically through these lists allows the main features of the biosphere system to be described, alongside the reasons for the various choices. For example, consideration of the socio-economic context of the local human community provides a basis for the subsequent identification of potentially exposed groups for which radiological exposures are to be considered within the assessment model.

The model development stage of the Methodology uses information generated by the second and third stages (system identification & justification and biosphere system description) to construct a conceptual model. The construction of the conceptual model begins by listing the ‘media of interest’ such as water, soil, crops, animals etc. in which radionuclides may migrate or accumulate. The media are not confined to those that make a direct contribute to radiation exposure so that, for instance, subsoil units may need to be included. Next, the radionuclide pathways through these media (and corresponding FEPs) are identified. Cross checks are made to ensure that the conceptual model incorporates – or at least acknowledges – all the FEPs that were identified as being relevant within the system description. As a final check, the contents of the conceptual model (including those FEPs relevant to radionuclide transport and exposure) are audited against an independent FEP list.

A useful tool developed during the course of this work is a 'radionuclide transfer matrix': a matrix that describes the conceptual model by tabulating the interactions between the media of interest. The matrix would typically be developed through several iterations and in its final form, it shows all the relevant radionuclide transfer and exposure pathways.

The conceptual model should describe the system with sufficient detail and clarity to allow the mathematical equations to be constructed for the mathematical model. There may be a number of alternative mathematical models for any one conceptual model. The availability of data to parameterise the model is an important consideration at this point since this may decide the choice of mathematical model. This and the fact that the data need to be fit for purpose are reasons why data selection is seen as an important activity within the Methodology. The combination of data and mathematical model allows the calculation, first of the radionuclide concentrations in the various media of interest and second, of the radiation doses (or other endpoints) resulting from the calculated concentrations in those media.

The Methodology recognises the importance of iteration, which allows for changes to reflect improvements in understanding and insight brought about by the Methodology's application.

EXAMPLE REFERENCE BIOSPHERES (ERBs)

A number of Example Reference Biospheres (ERBs) have been developed. These demonstrate the application of the BIOMASS Methodology while also serving the following three purposes :

1. The ERBs (up to the stage of defining the conceptual model, at least) are relevant to a wide range of assessment contexts. It should therefore be possible to use the examples as 'benchmarks' against which other assessment biosphere calculations may be compared.

2. By adopting a series of progressively more complex examples, the examples show the effect of increasing complexity in the assessment biosphere;

3. By taking the examples all the way through to a numerical endpoint (i.e. using real data), the Methodology is fully exercised. Also, the issue of data selection is addressed though it should be said that the project underestimated the level of effort that would be required to satisfactorily complete the work of data selection.

Three ERBs have been developed that relate to a temperate climate and unchanging biosphere conditions. All three are intended as generic examples: their development is not based on the assumption of a specific location.

1. ERB 1 Drinking water well intruding into a contaminated aquifer.

2. ERB 2A Agricultural irrigation well intruding into a contaminated aquifer.

3. ERB 2B Natural discharge from a contaminated aquifer into a number of different habitats, including arable, pasture, semi-natural wetland and lake.

The project has also produced three further ERBs that have been used to develop the BIOMASS Methodology to allow it to be used to address biosphere conditions changing with time. These three examples are based on two actual locations, Harwell (southern UK) and Äspö (Sweden), for which useful environmental data exist, and a generic site based on the initial biosphere system corresponding to ERB 2A (above). All three examples incorporate changing biosphere conditions and these have been taken through to the 'biosphere identification and justification' stage of the BIOMASS Methodology.