LONG-TERM SAFETY OF THE PLANNED GEOLOGICAL REPOSITORY AT OLKILUOTO

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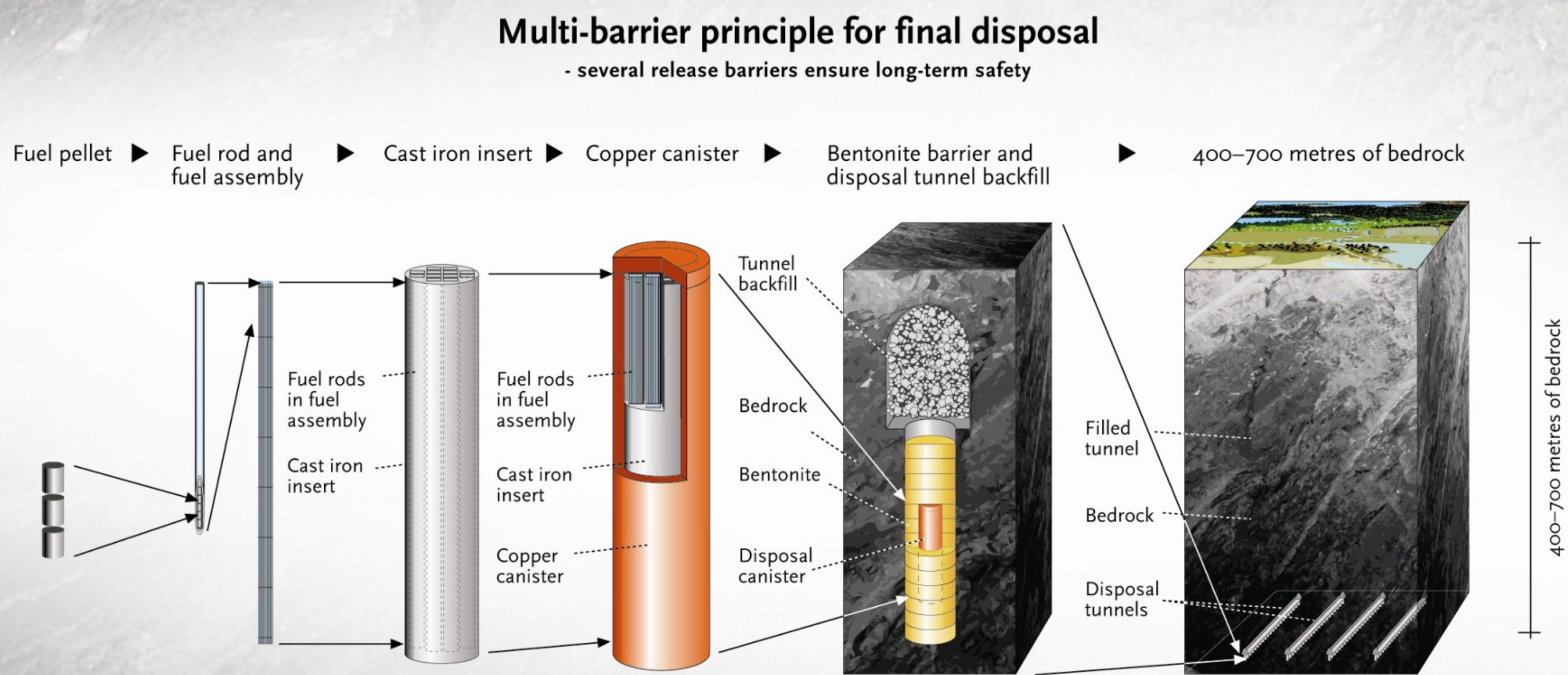
General design premises for geological disposal of nuclear waste

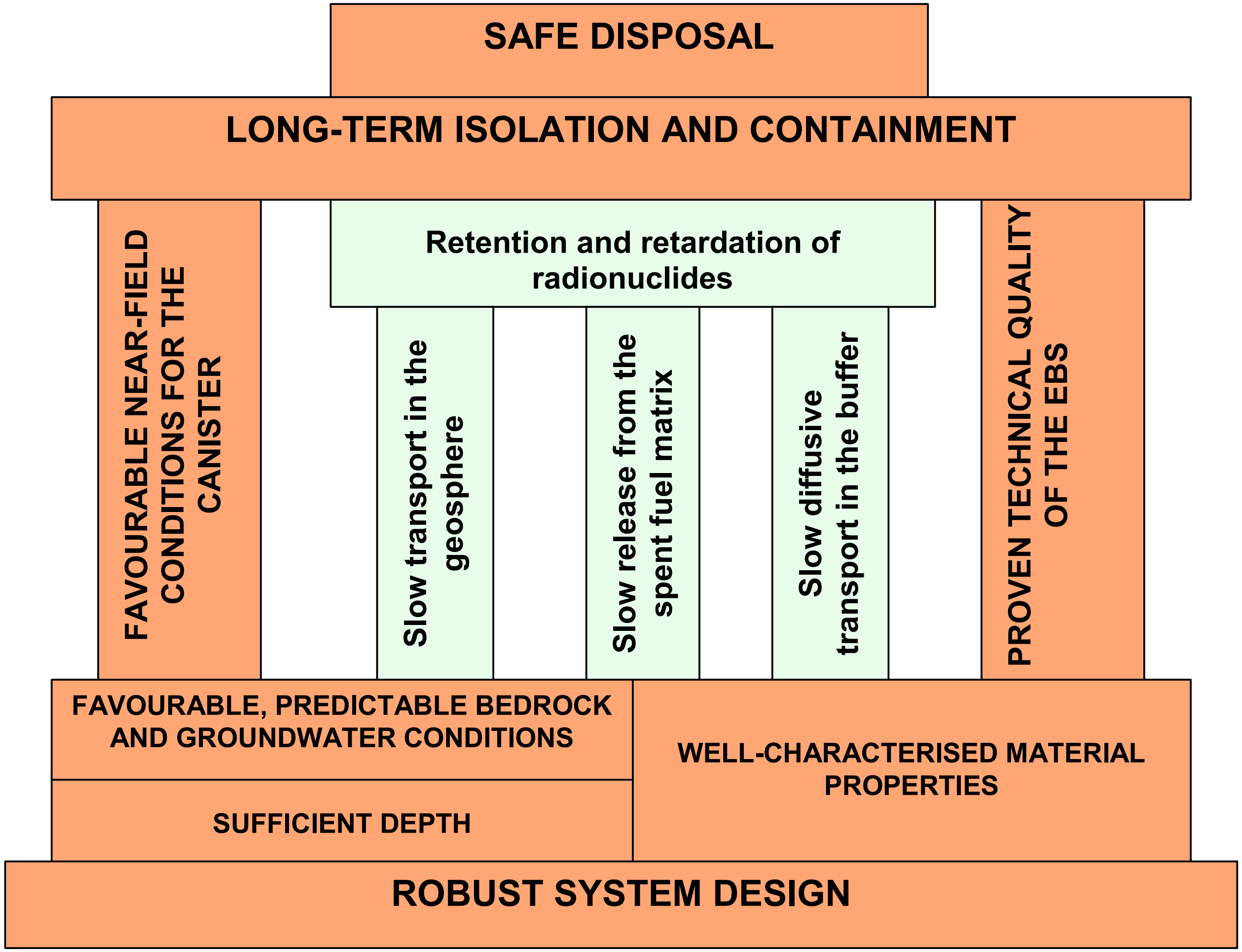
- **Isolation:** Deep in bedrock the waste is decoupled from human activities and natural changes in the surface environment.
  - geological formations show **relatively high stability** over the time scales needed for containment of the radionuclides
- **Containment:** The bedrock can prevent or reduce the access of radionuclides to the biosphere.
  - the most likely carrier of radionuclides to biosphere is groundwater, and, therefore, the efficiency of **containment depends on hydraulic properties** of the bedrock.

European concepts for geological disposal

- disposal in salt formations
  - has been planned in Germany
- disposal in different clay formations
  - high level of containment by the clay itself
  - relatively young geological formations
  - planned, e.g., in Belgium, France, Switzerland
- disposal in crystalline formations
  - potentially high level of containment, but may not be reliable enough as such
  - old geological formations
  - planned notably in Sweden and Finland (in practice the only option available)


Multi-barrier principle for final disposal
- several release barriers ensure long-term safety
Fuel pellet
Fuel rod and fuel assembly
Cast iron insert
Copper canister
Bentonite barrier and disposal tunnel backfill
400–700 metres of bedrock
Fuel rods in fuel assembly
Cast iron insert
Fuel rods in fuel assembly
Cast iron insert
Copper canister
Tunnel backfill
Bedrock
Bentonite
Disposal canister
Filled tunnel
Bedrock
Disposal tunnels
400–700 metres of bedrock

Posiva Safety Concept



The safety concept means that

- a leak-tight and corrosion-resistant canister with a long expected life-time provides the primary containment against release of radionuclides and, therefore, its quality is of key importance for the long-term safety of disposal
- the principal safety function of the bentonite buffer is to protect the canister
- the primary role of the bedrock is to provide stable enough conditions for the engineered barriers to provide the containment over long time periods; its secondary role is to prevent or slow down the transport of radionuclides to biosphere in case some of the canisters start leaking.
- the repository should be closed and sealed in a way that the conditions in the bedrock return to the natural state as soon as possible.

Principal criteria for long-term safety

- for the first 10 000 years: individual dose limit of 0.1 mSv/a
- after 10 000 years: nuclide-specific limits for the radionuclide fluxes from the repository to biosphere
- in the case of unlikely release scenarios the risk (expected value of the dose or flux) has to be assessed and, if possible, quantified and compared to dose and flux limits
- the implementer has to define the performance targets for the multi-barrier system in a way that the EBS system limits efficiently the release of radionuclides at least for the period of 10 000 years
- no cut-off time for the period of concern

Preparing the Safety Case: Several levels of assessments

TRUST: Regulatory review

CONFIDENCE: Assessment of quality, reliability and robustness of the system and the safety assessment

SYSTEM SAFETY: Assessment of the total system performance as regards the safety criteria

SUBSYSTEM PERFORMANCE: Assessment of safety functions

Definition of Safety Case scenarios (according to draft YVL Guide D.5)

Most likely lines of evolution

Base scenario

The performance targets of safety functions are met with incidental deviations from target values

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Variant scenarios

Substantially declined performance of safety functions

Unlikely events or processes

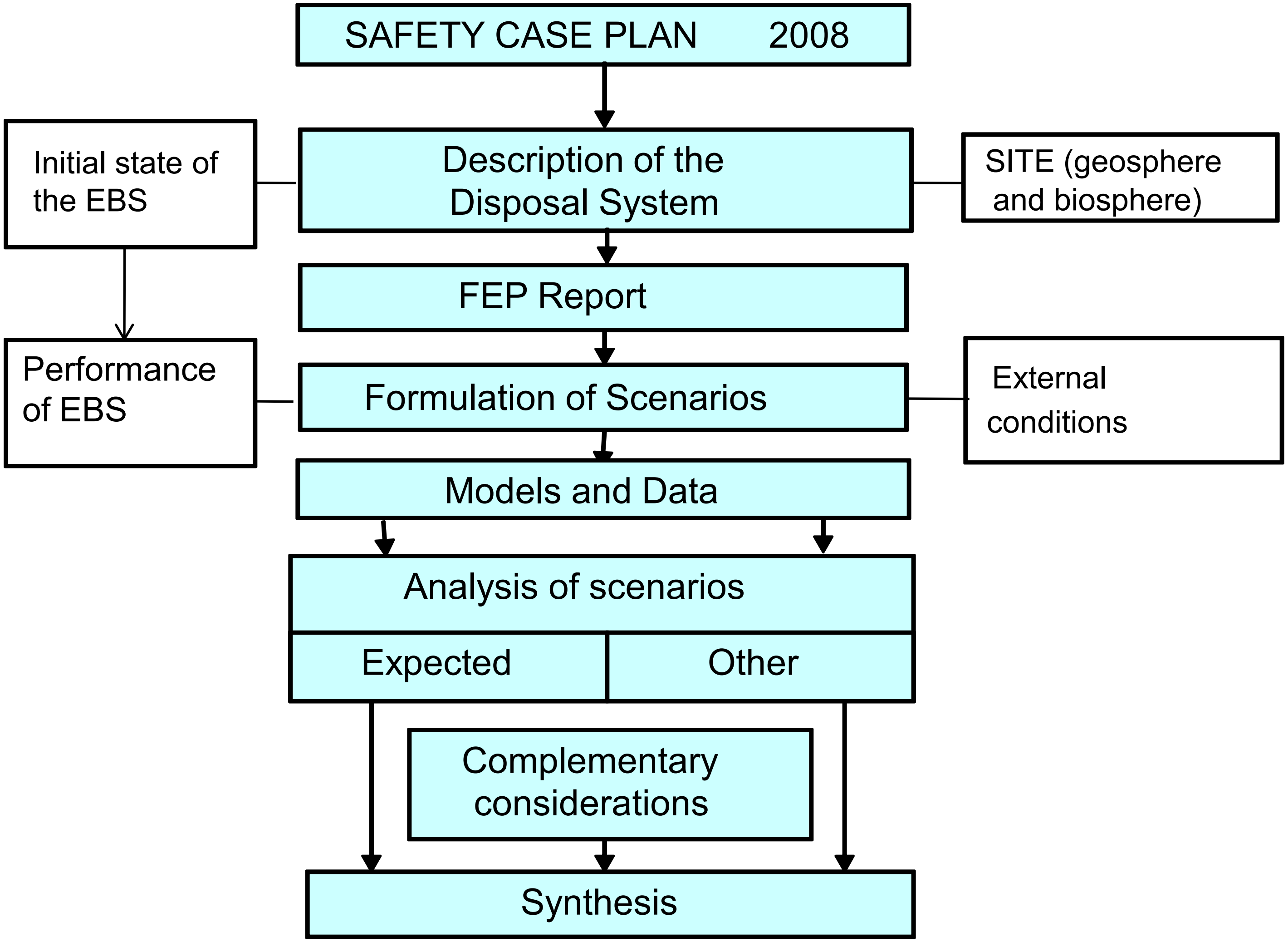
Disturbance scenarios

Long-term safety impaired by unlikely events or processes

Past safety assessments

- TVO-85: generic safety assessment of a KBS-3 repository in crystalline bedrock
- TVO-92: safety assessment with site-specific data from five investigations sites
- **TVO-99:** safety assessment of a KBS-3 repository at Olkiluoto, Loviisa, Kivetty and Romuvaara
  - supporting the application for the Decision-in-Principle (and site selection)
  - with site-specific data from the four candidate sites investigated in 1987-1999
  - **regulatory safety requirements would be met at all the candidate sites studied**
  - **no decisive differences between the candidate sites**
- Safety Assessment for KBS-3H (2008)

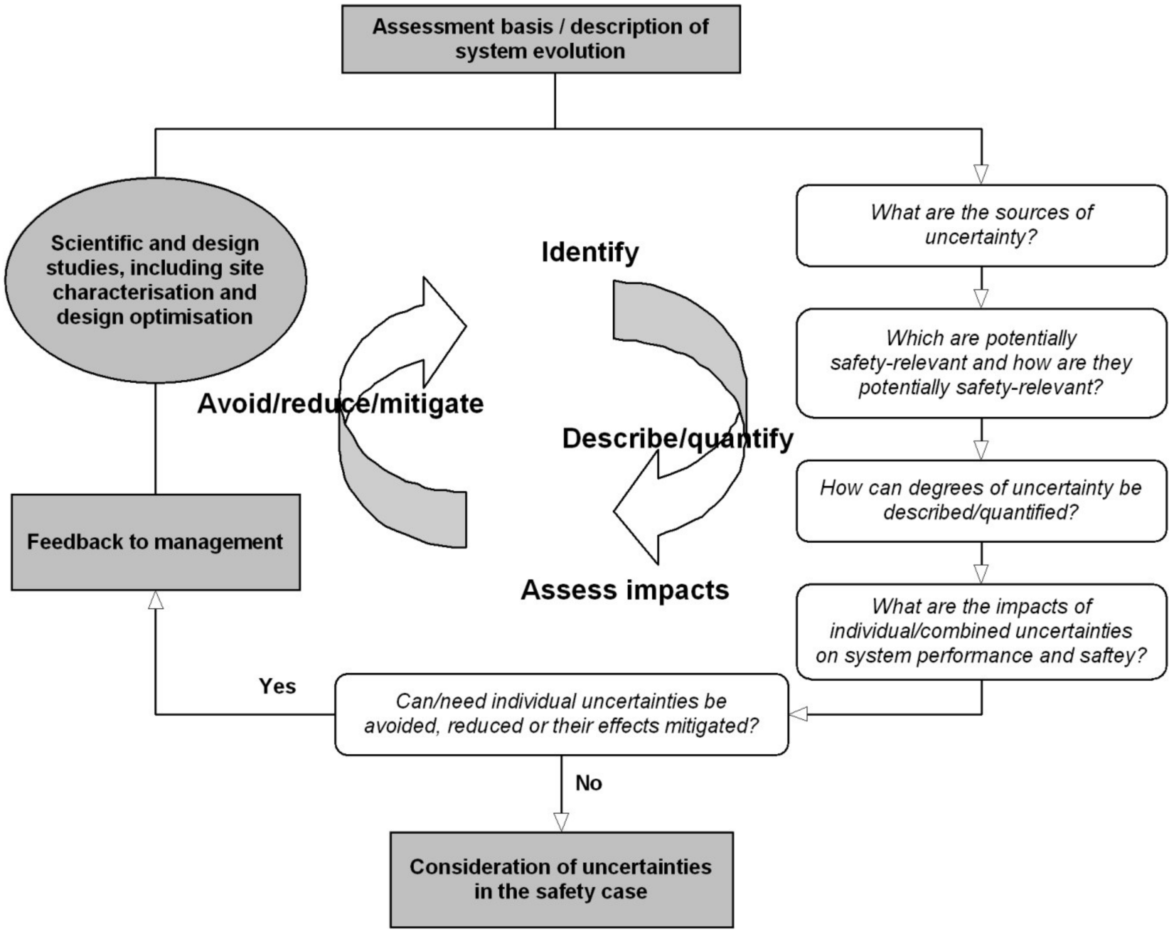
Safety Case 2012 (to support the application for construction license)



Dialogue with STUK

- regular meetings between STUK and Posiva to discuss the progress and outstanding issues in RTD
  - site characterisation and evaluation
  - EBS design and performance
  - safety assessment
- Issue Lists
  - classification of issues according to their meaning for licensing maturity
  - two-step licensing allows incorporation of future RTD results at the stage of operational licensing

Iterative approach to uncertainty management



To conclude: Safety Case is about...

10.1 Confidence in the base scenario

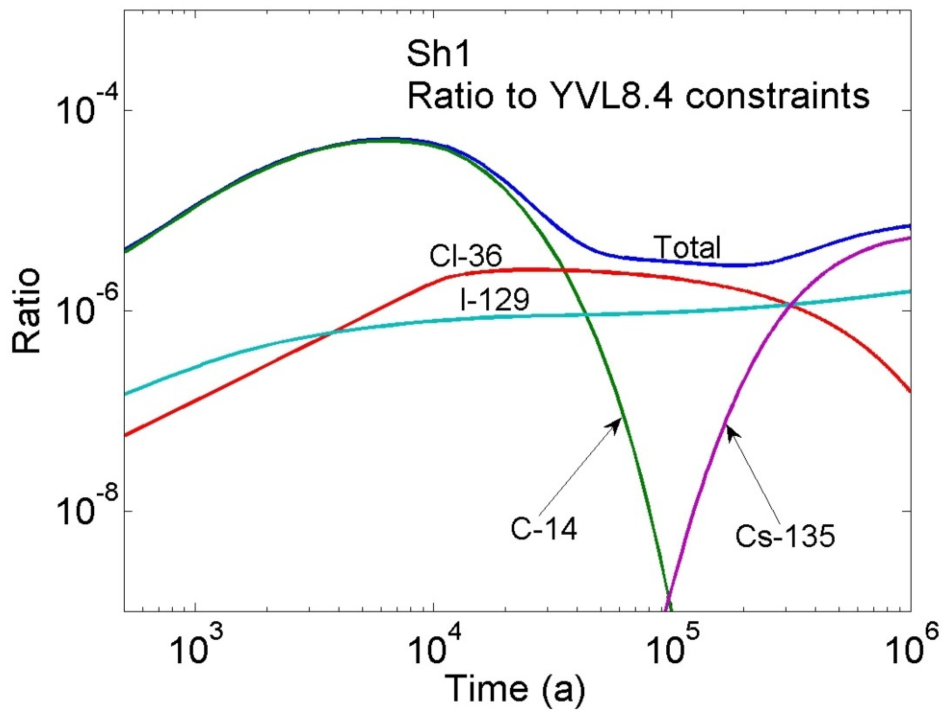
The present report outlines Posiva's preliminary safety case for the final disposal of Finnish spent fuel in a geological repository at the Olkiluoto site. A full safety case will be developed to support the Preliminary Safety Assessment Report (PSAR) in 2012. However, studies to date already indicate that, except for a few unlikely circumstances affecting a small number of canisters, spent fuel is expected to remain isolated, and the radionuclides contained within the canisters, for hundreds of thousands of years or more, as described in the base scenario.

Confidence in the base scenario derives, in the first place, from the intrinsic properties of the main components of the repository that contribute to the safety functions and from the understanding of their evolution over time. This understanding has been gained from extensive site- and concept-specific field, laboratory and modelling studies and from studies, examples of which are given in Section 4.1.2, and from natural and anthropogenic analogues.

The canisters are mechanically strong and corrosion resistant (evidence from natural and anthropogenic analogues for the corrosion resistance of copper is mentioned below). They are also protected by the surrounding bentonite buffer and by their deep underground location in rock that is geologically very stable and lacks resources that might attract deep drilling activities in the future that could disturb the repository.

Conditions around the canisters and at the canister surface will change significantly over the first few hundred years following repository closure, but these changes are not expected to have any significant effects on the integrity of the canisters themselves. For example, the bentonite clay buffer, which is initially only partly water saturated, will gradually take up water from the rock and will swell to fill any small gaps between the canisters and the rock that remain following emplacement of the buffer and canisters. This swelling will cause a pressure to be exerted on the canisters, but the canisters are designed to withstand such pressures with a large safety margin. Some oxygen from the atmosphere will be trapped within the repository following closure, but this will cause only very limited corrosion of the canister surfaces, and corrosion by oxygen will cease once all the oxygen in the repository is consumed by this and other chemical reactions.

The buffer will provide a protective environment for the canisters, particularly once saturated. In particular, the saturated buffer will be plastic and so will protect the canister from any small rock movements occurring following repository construction and, in the longer term, due to seismic activity at the site. Microbes that might otherwise



... argumentation and....

... model calculations ... .

... and building of trust and confidence.