Definition of Hypothetical Impact Scenarios for CO_2 Storage Sites: An Input to the RISCS Project

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Facilities for the geological storage of carbon dioxide (CO_2) as part of carbon capture and storage (CCS) schemes will be designed to prevent any leakage from the defined 'storage complex'. However, developing regulations and guidance throughout the world (e.g. the EC Directive and the USEPA Vulnerability Evaluation Framework) recognize the importance of assessing the potential for environmental impacts from CO_2 storage. RISCS, a European (FP7) project, aims to improve understanding of those impacts that could plausibly occur in the hypothetical case that unexpected leakage occurs.

RISCS is concerned with the potential impacts that might result should CO_2 leak from a storage complex, however unlikely. Unintended displacements of natural formation fluids such as brines might also impact upon sensitive environments, but are not a priority for the work because the processes leading to these impacts are relatively well understood. Pipeline failures during operations could lead to impacts similar to those associated with some forms of CO_2 leakage and therefore are not considered separately.

To help focus RISCS research on feasible CO_2 storage concepts and to provide a framework for communicating the results, a set of reference European receptor environments and associated high-level impact scenario descriptions were defined. Here, a scenario is: 'A plausible description of the potential evolution of a system according to the nature of the features, events and processes (FEPs) that might act within and upon it.' Scenarios were developed jointly by all project partners at an expert workshop, and subsequently during reviews of the workshop report. The workshop outcomes were audited against established lists of Features, Events and Processes (FEPs) relevant to storage systems, and compared with issues and uncertainties identified for other project activities. The work produced a small number of scenarios that broadly represent the main types of impacts that could occur. A distinction is made between marine and terrestrial environments (Table 1). Within each type of environment, receptor types and habitats will primarily vary according to climate (terrestrial environments) and water depth, salinity and temperature (marine environments), although other factors will also be relevant. For each environment, the developed scenarios are of three main types:

- A 'Normal Evolution' scenario has no CO_2 leakage and the site evolves as designed, as it would in the absence of CO_2 storage. This is by far the 'most likely' scenario and needs to be explored to understand the impacts that could be associated with any leaks, as a deviation from the norm.
- 'Alternative Evolution 'Impact'' scenarios, describe potential low-likelihood CO_2 leakage to be evaluated by the RISCS project (Table 2).

- 'Alternative Evolution 'Impact'' scenarios, describe potential low-likelihood CO_2 leakage that will not be evaluated in detail by the RISCS project, because they are of low priority taking into account the project aims (e.g. displacement of saline formation water), or because their effects would be similar to one of the scenarios that is being considered.

Table 1: Reference environments

Terrestrial Environments	Marine Environments
Maritime Temperate Representative of a northern European, cool climate (e.g. UK, Netherlands etc)	***Cool, temperate, deep*** with deep water (> c. 60 m, typically with depths of several hundred metres) located on the continental shelf remote from shoreline influences (e.g. northern North Sea, or to the west of Norway)
Continental Considers climate associated with northern (but not Arctic) European continental land mass countries	***Cool, temperate, shallow*** with water depth of a few tens of metres, located relatively close to land (e.g. southern North Sea)
Mediterranean Representative of warmer, more arid, southern European climates	***Warm shallow*** with relatively warm water a few tens of metres deep, located relatively close to land (e.g. within the Adriatic)
Generic Urban Specifically designed to explore potential impacts to humans should a storage system be located close to a large urban centre	***Low salinity (saline, but substantially lower than mean ocean salinity)*** with water depth of a few tens of metres, located relatively close to land (e.g. in the Baltic Sea)

Table 2: Impact scenarios

Terrestrial Environments	Marine Environments
Direct release to atmosphere, via a well (high flux for a relatively short time period – e.g. days)	Localised direct release of free CO_2 via the sediment or directly to the water column above the sea bed via a point source
Localised release to soil as a result of wells / faults / fractures, leading to high concentrations of CO_2 in near surface	Diffuse direct release of free CO_2 via the sediment or directly to the water column over a wide area
Localised release to soils as a result of wells / faults / fractures, leading to long-term low concentrations of CO_2 in near surface	Localised release of CO_2-charged water through the sediment or directly to the water column via a point source
Localised release to freshwater lakes via fractures / faults	Diffuse release of CO_2-charged water through the sediment and subsequently to the water column over a wide area
Diffuse releases to surface and near- surface systems	
Localised release to aquifers that may be exploited as drinking or irrigation water resources	
Release to the urban environment	