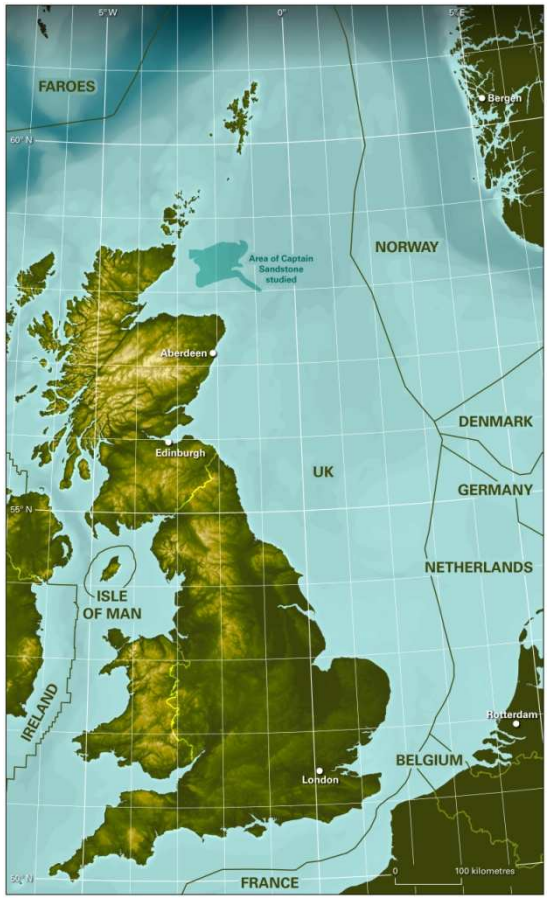
Characterisation of European CO_2 storage

Licence application for a multi-store site, UK North Sea

Maxine Akhurst
British Geological Survey (NERC)

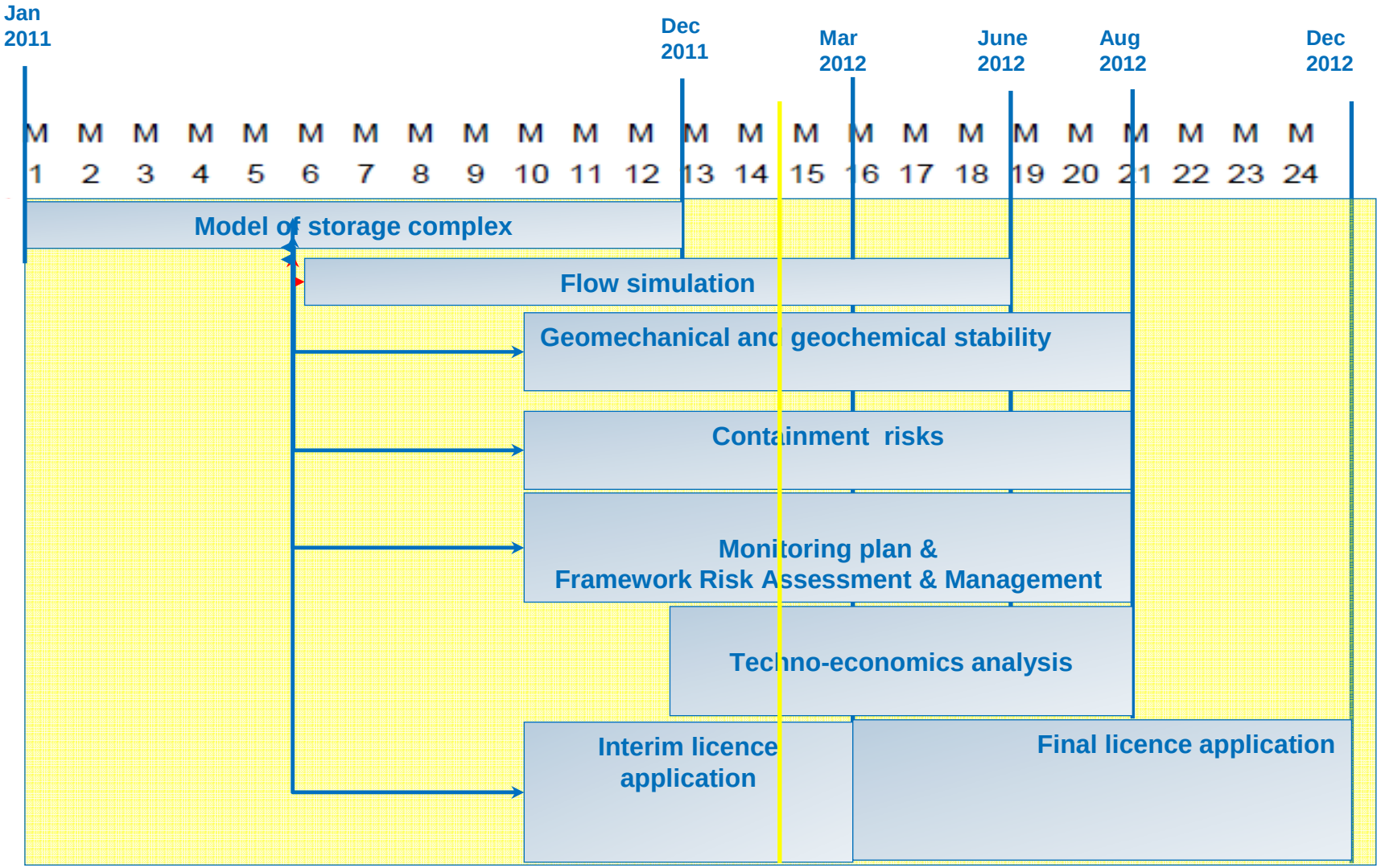
Overview of UK multi-store site

- **Objective of WP3**
  - **To provide sufficient information on a multi-store site in the UK North Sea for a 'dry-run' storage permit application to Scottish Government**



- **Why a multi-store site?**
  - **Hydrocarbon fields are planned as stores for demonstrator projects**
  - **Sandstones containing salt-water (saline aquifers) are anticipated for commercial-scale storage**
  - **The SiteChar multi-store site investigates the Captain Sandstone and a field hosted within it**

SiteChar WP3 Gantt Chart



Storage Permit Application content	Interim Mar 2012	Final Dec 2012
1. Name and address of proposed operator	✓	
2. Appraisal term	✓	
3. Project description		
i. Injection parameters and project concept	✓	
ii. Storage development plan incl.		✓
Injection & Operating plan		✓
Storage Performance Forecast		✓
4. Site description		
i. Boundaries	✓	
ii. Site geology, hydrogeology…	✓	
iii. Past development history	✓	
iv. Storage capacity estimate	Draft?	✓
5. Measures to prevent significant irregularities		
i. Risk register	✓	✓
ii. Plan of risk mitigation	Draft	✓
iii. Dialogue with stakeholders	Draft	✓
6. Monitoring plan		✓
7. Corrective measures plan		
i. Key Performance Indicators	✓	
ii. Corrective measures plan (provisional)		✓
8. Post-closure plan		
i. Key Performance Indicators	✓	
ii. Post-closure plan (provisional)		✓
9. Environmental Impact Assessment		
i. Description of relevant features	✓	✓

Site Character-isation

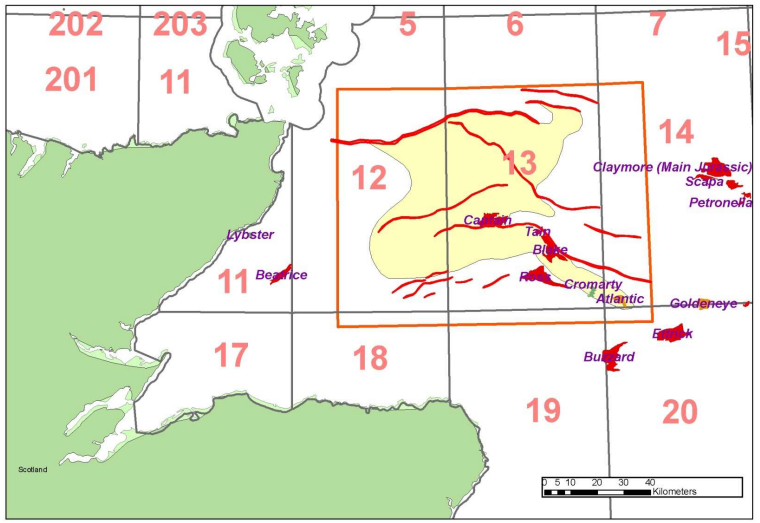
Risk Assessment

Key Performance Indicators

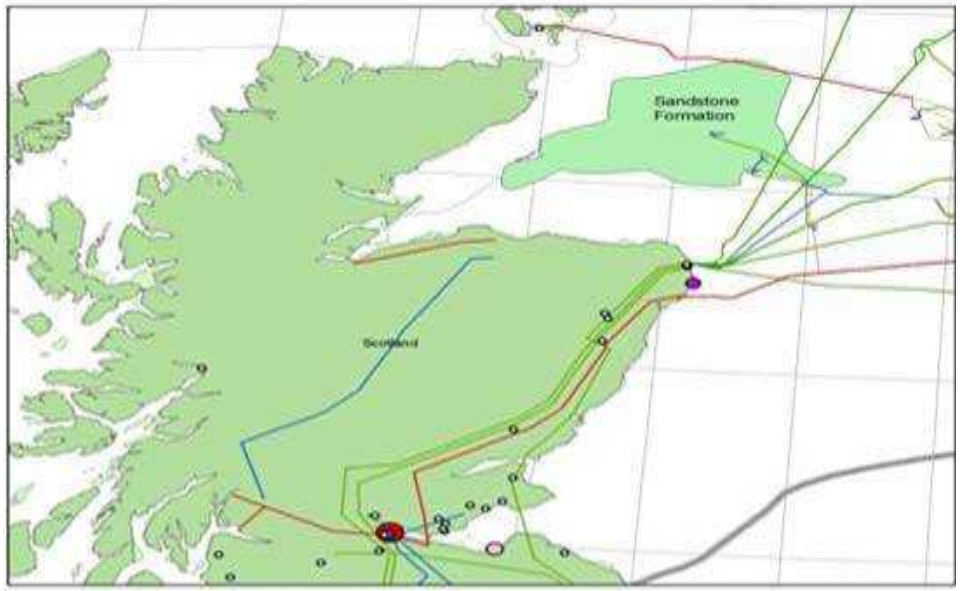
WP3 Research to inform the dry-run licence application

Characterisation of a multi-store site

- Construction of the static model of the multi-store site
- Flow simulation of CO_2 injection into hydrocarbon field and saline aquifer and evaluation of well integrity
- Geomechanical and geochemical stability assessments
- Assessment of containment risks
- Design of a monitoring plan and Framework for Risk Assessment and Monitoring
- Economic analysis
- Dry-run licence application



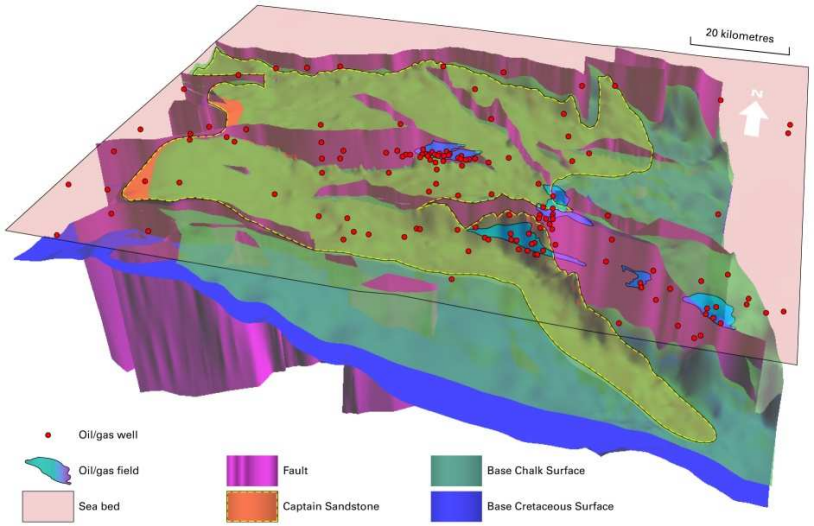
WP3 Research to inform the dry-run licence application



- **A multistore site, comprising hydrocarbon field together with associated saline aquifer**
  - **Development of a credible CO_2 storage injection history over a 25 - 50 years term, compatible with likely current and future industrial sources**
  - **Full-chain techno-economic assessment to reach readiness for storage permit application**
  - **Investigation of the relationship between a hydrocarbon field and the associated saline aquifer store**

WP3 Research to inform the dry-run licence application

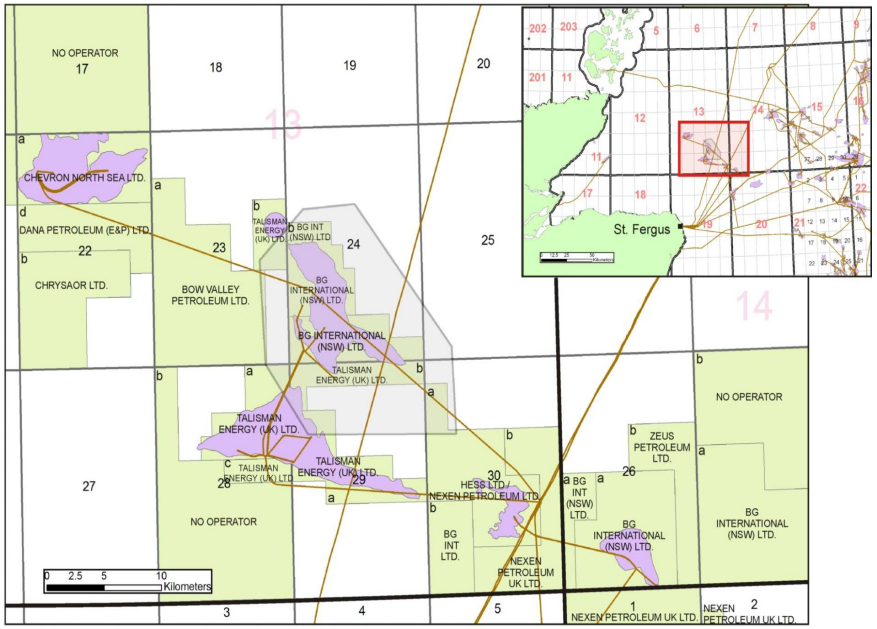
WP3 UK northern North Sea multi-store site



- **Construction of the geological model of the storage complex**
  - **Method for construction of the multi-store site model agreed and implemented**
  - **Method for model attribution proposed, tested and implemented**

WP3 Research to inform the dry-run licence application

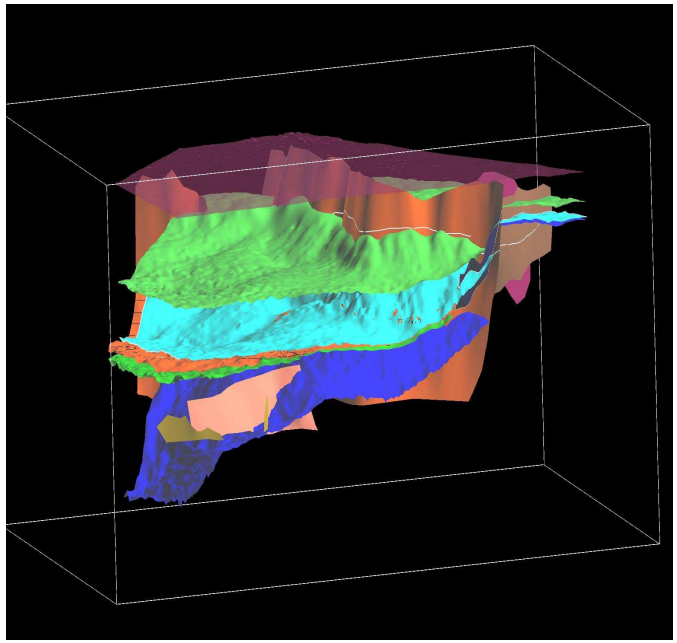
WP3 UK northern North Sea multi-store site



- **Selection of one of the hydrocarbon fields hosted within the Captain Sandstone**
- **Based on geological and non-geological criteria**
  - **Depth**
  - **Storage capacity**
  - **High-quality data**
  - **Availability of data**

WP3 Research to inform the dry-run licence application

WP3 UK northern North Sea multi-store site

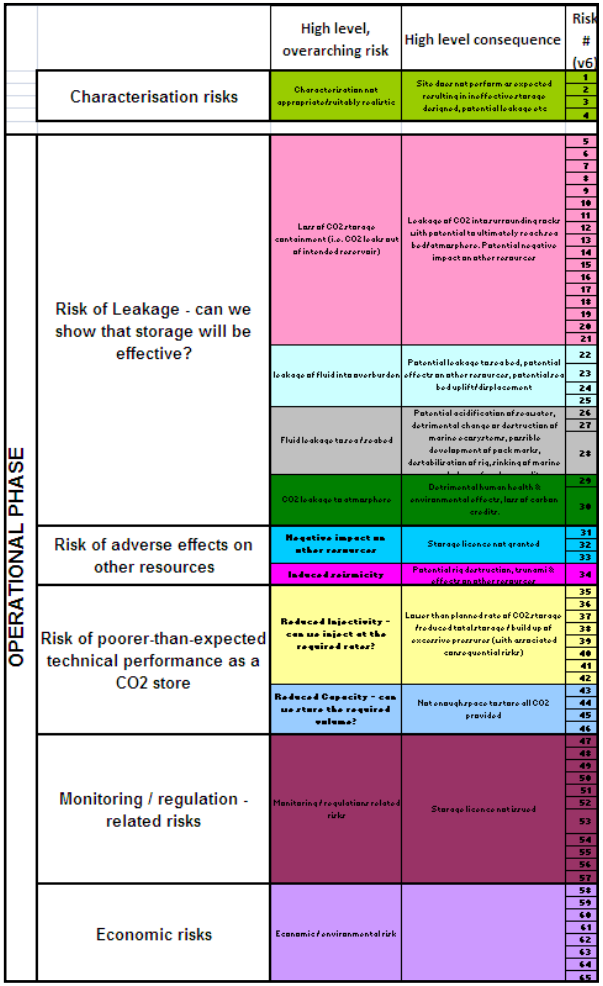


- **Flow simulation of CO_2 injection in the multi-store site**
  - **Basin-scale aquifer, hydrocarbon field and merged multi-store model**
  - **Attribution with reservoir properties**
- **Two scenarios for dynamic modelling of CO_2 injection**
  - **Into the field and 'spilling over' into the aquifer**
    - **– demonstrator project**
  - **Into the aquifer and then migrating up into the field**
    - **- commercial-scale store**

WP3 Research to inform the dry-run licence application

- **SiteChar is a research project**
- **The Moray Firth storage project, though a feasible realistic target for future storage, is a concept:**
  - **Freedom to explore more challenging aspects of site characterisation and storage permit application than actual demonstration projects in the near-future**
  - **Reduces the risks associated with developing 'dry-run' storage permit applications and allows us to 'learn by doing'**
  - **Very resource-constrained and recognise the limitations this will place on the depth of the characterisation and associated storage permit application**

WP3 Research to inform the dry-run licence application



		High level, overarching risk	High level consequence	Risk # (v6)
	Characterisation risks	Characterisation not appropriate/routinely realistic	Site does not perform as expected resulting in ineffective storage designed, potential leakage etc	1 2 3 4
OPERATIONAL PHASE	Risk of Leakage - can we show that storage will be effective?	Loss of CO2 storage containment (i.e. CO2 leaks out of intended reservoir)	Leakage of CO2 into surrounding rocks with potential to ultimately reach sea bed/atmosphere. Potential negative impact on other resources	5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21
		leakage of fluid into overburden	Potential leakage to sea bed, potential effects on other resources, potential sea bed uplift/displacement	22 23 24 25
		Fluid leakage to sea/sea bed	Potential acidification of ecosystem, detrimental change or destruction of marine ecosystems, possible development of pack marks, destabilisation of rig, sinking of marine	26 27 28
		CO2 leakage to atmosphere	Detrimental human health & environmental effects, loss of carbon credits	29 30
	Risk of adverse effects on other resources	Negative impact on other resources	Storage licence not granted	31 32 33
		Induced seismicity	Potential rig destruction, tsunamis effects on other resources	34
	Risk of poorer-than-expected technical performance as a CO2 store	Reduced Injectivity - can we inject at the required rates?	Lower than planned rate of CO2 storage / reduced total storage / build up of excessive pressures (with associated consequential risks)	35 36 37 38 39 40 41 42
		Reduced Capacity - can we store the required volume?	Not enough space to store all CO2 provided	43 44 45 46
	Monitoring / regulation - related risks	Monitoring / regulations related risks	Storage licence not issued	47 48 49 50 51 52 53 54 55 56 57
	Economic risks	Economic / environmental risk		58 59 60 61 62 63 64 65

- **Assessment of containment risks**
  - **Risk Assessment workshop of WP3 researchers**
  - **Risk register of individual risks within 11 categories of overarching risk grouped into 6 operational phases of risk**
    - **Characterisation**
    - **Leakage**
    - **Adverse effects on other resources**
    - **Technical performance of CO_2 store**
    - **Monitoring and regulation**
    - **Economic risks**
  - **Individual risks are assigned to tasks of WP3 site characterisation research for investigation of mitigating activities**

Risk categories & consequences

Containment risks	Migration / leakage of injected CO_2
	Loss of injected CO_2 to biosphere
	Displacement or alteration of brines
Adverse effect on other resources	Hydrocarbon fields
	Others
Reduced technical performance	Reduced Injectivity
	Reduced capacity
Monitoring / Regulatory	Monitoring issues
	Regulatory issues
Economic / Environmental	Socio-economic
	Storage costs
	Environmental

Risk categories & consequences

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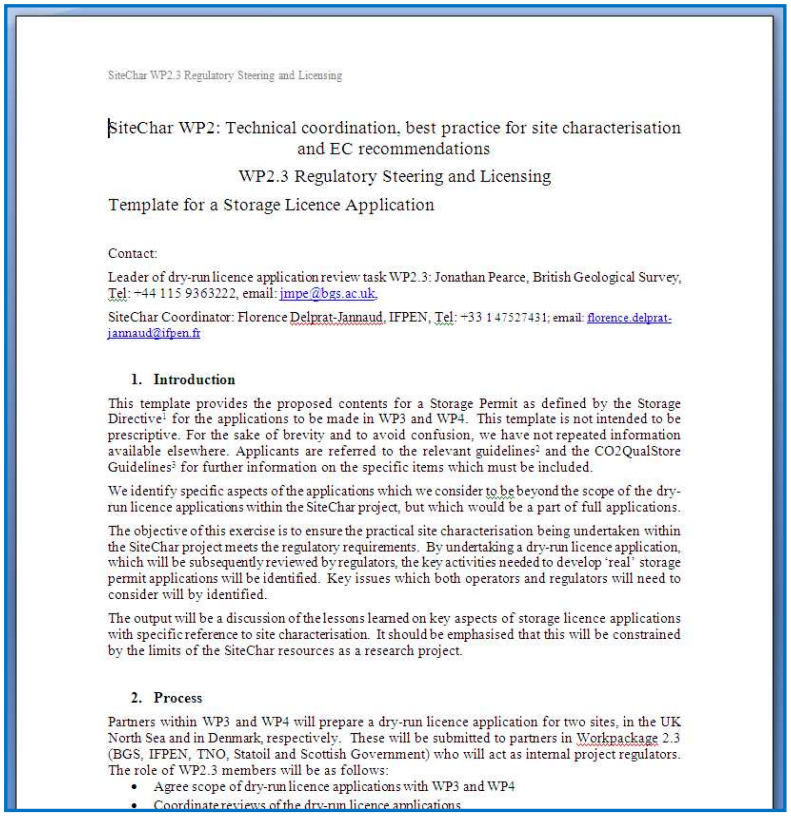
	Reduced capacity
Monitoring / Regulatory	Monitoring issues
	Regulatory issues
Economic / Environmental	Socio-economic
	Storage costs
	Environmental

- ~ 80 risks have been defined
- This will reduce with mitigation measures
- Key findings to date:
  - Mainly uncertainties due to data gaps at this stage
  - However, as this is a theoretical project, many of the risks may have high remaining uncertainty at the end of SiteChar

WP3 Research to inform the dry-run licence application



SiteChar WP2.3 Regulatory Steering and Licensing

SiteChar WP2: Technical coordination, best practice for site characterisation and EC recommendations

WP2.3 Regulatory Steering and Licensing

Template for a Storage Licence Application

Contact:

Leader of dry-run licence application review task WP2.3: Jonathan Pearce, British Geological Survey, Tel: +44 115 9363222, email: jmpe@bgs.ac.uk;

SiteChar Coordinator: Florence Delprat-Jannaud, IFPEN, Tel: +33 1 47527431; email: florence.delprat-jannaud@ifpen.fr

1. Introduction

This template provides the proposed contents for a Storage Permit as defined by the Storage Directive[1] for the applications to be made in WP3 and WP4. This template is not intended to be prescriptive. For the sake of brevity and to avoid confusion, we have not repeated information available elsewhere. Applicants are referred to the relevant guidelines[2] and the CO2QualStore Guidelines[3] for further information on the specific items which must be included.

We identify specific aspects of the applications which we consider to be beyond the scope of the dry-run licence applications within the SiteChar project, but which would be a part of full applications.

The objective of this exercise is to ensure the practical site characterisation being undertaken within the SiteChar project meets the regulatory requirements. By undertaking a dry-run licence application, which will be subsequently reviewed by regulators, the key activities needed to develop 'real' storage permit applications will be identified. Key issues which both operators and regulators will need to consider will by identified.

The output will be a discussion of the lessons learned on key aspects of storage licence applications with specific reference to site characterisation. It should be emphasised that this will be constrained by the limits of the SiteChar resources as a research project.

2. Process

Partners within WP3 and WP4 will prepare a dry-run licence application for two sites, in the UK North Sea and in Denmark, respectively. These will be submitted to partners in Workpackage 2.3 (BGS, IFPEN, TNO, Statoil and Scottish Government) who will act as internal project regulators. The role of WP2.3 members will be as follows:

- Agree scope of dry-run licence applications with WP3 and WP4
- Coordinate reviews of the dry-run licence applications

- **Dry-run licence application**
  - **Reviewed the template licence application with WP3 researchers**
  - **Advised WP3 researchers of their contributions from their site characterisation research to inform the licence application**
  - **Arranged presentations to the Scottish Government regulatory group to:**
    - **Introduce SiteChar research January 2012**
    - **Present preliminary licence application April 2012**
  - **Preparation of the interim licence application is in progress**

WP8 Research to inform the dry-run licence application

Storage Permit Application content	Mar 2012	Dec 2012
5. Measures to prevent significant irregularities		
i. Risk register	✓	✓
ii. Plan of risk mitigation	Draft	✓
iii. Dialogue with stakeholders	Draft	✓

- **Advancing public awareness at UK North Sea site in WP8**
  - **Social site characterisation in Moray Firth area**
  - **Unobtrusive surveys**
  - **Focus conferences**
  - **Site-specific information**
  - **Repeat surveys**
  - **Emerging findings will be incorporated into the dry-run storage permit applications**

Key Performance Indicators (KPIs)

- **KPIs define limits to site behaviour which, if exceeded, indicate that a significant irregularity or leakage has occurred. This will trigger corrective measures accordingly**
  - **Identified through Risk Assessment (5)**
  - **Inform the Monitoring Plan (6)**
  - **Lie in Corrective Measures (*7.i)* and Post Closure Plans (*8.i)***

- ***(Section #s refer to template for a Storage Permit Application" document).***

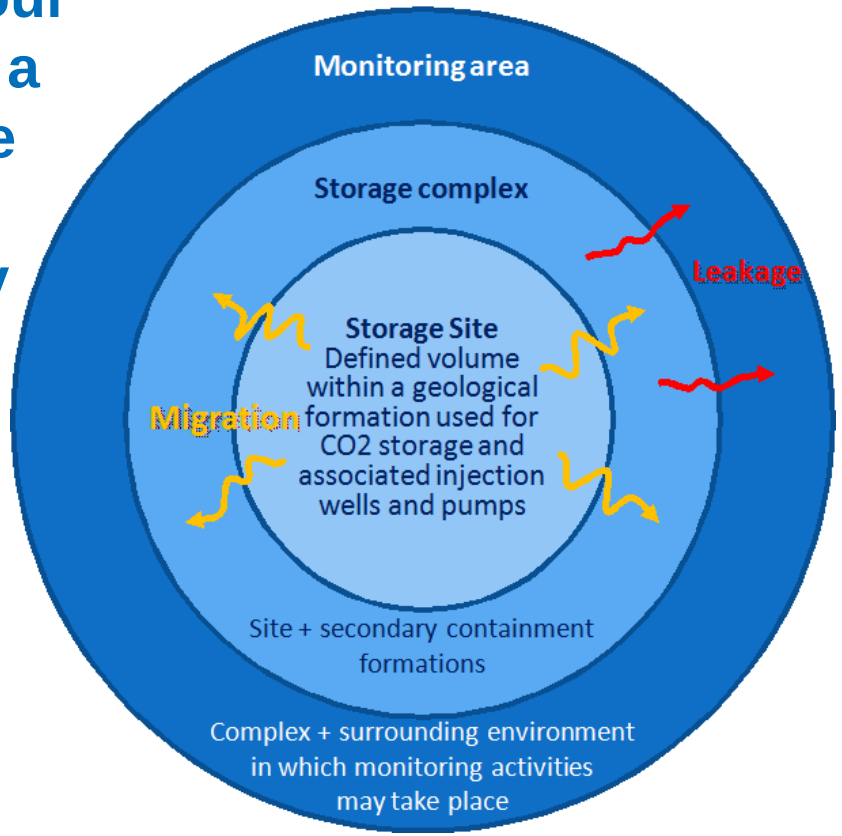
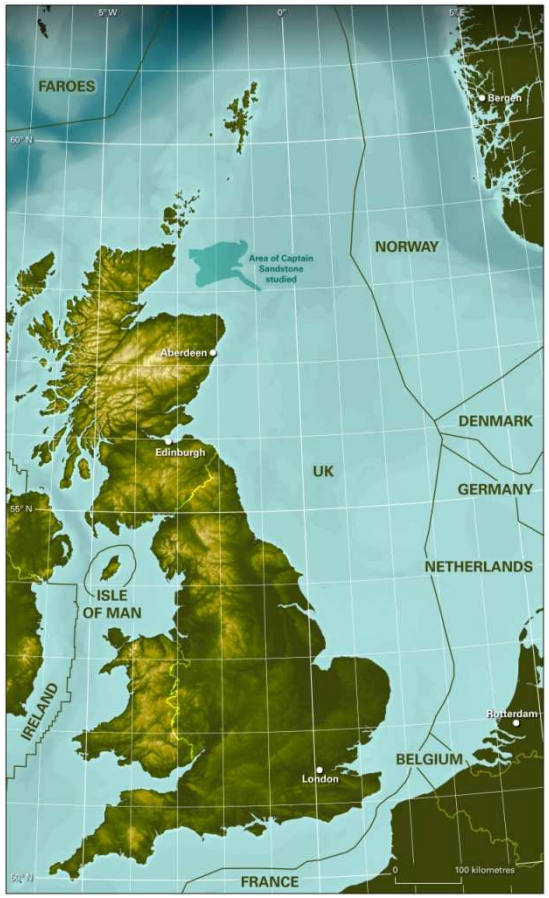


Figure 1: Schematic defining key terms based on CCS Directive (Adapted from Figure 3, p26 of Implementation of Directive 2009/31/EC on the Geological Storage of Carbon Dioxide **Guidance Document 2**)

WP3 Research to inform the dry-run licence application

Characterisation of the UK North Sea multi-store site



- Inform the SiteChar workflow for characterisation of offshore sites
- Define and test a licence application that conforms with the requirements of the CCS Directive
- Considers credible scenarios for storage of CO_2 by demonstrator and commercial-scale projects
- Investigates the relationship between depleted hydrocarbon fields and associated sandstones used for CO_2 storage