Programme Area: Carbon Capture and Storage

Project: Storage Appraisal

Title: Web-enabled Database and GIS Specification

Abstract:

The Web-enabled database and GIS (WDG) will be the key deliverable from the UK Storage Appraisal Project. This document provides a summary of the agreed specification for the WDG. The proposed functionality for the GIS front end to access the database is shown in Section 5.3.

Context:

This £4m project produced the UK's first carbon dioxide storage appraisal database enabling more informed decisions on the economics of CO2 storage opportunities. It was delivered by a consortium of partners from across academia and industry - LR Senergy Limited, BGS, the Scottish Centre for Carbon Storage (University of Edinburgh, Heriot-Watt University), Durham University, GeoPressure Technology Ltd, Geospatial Research Ltd, Imperial College London, RPS Energy and Element Energy Ltd. The outputs were licensed to The Crown Estate and the British Geological Survey (BGS) who have hosted and further developed an online database of mapped UK offshore carbon dioxide storage capacity. This is publically available under the name CO2 Stored. It can be accessed via www.co2stored.co.uk.

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survey & geoengineering

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Web-enabled Database and GIS Specification

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1 Introduction

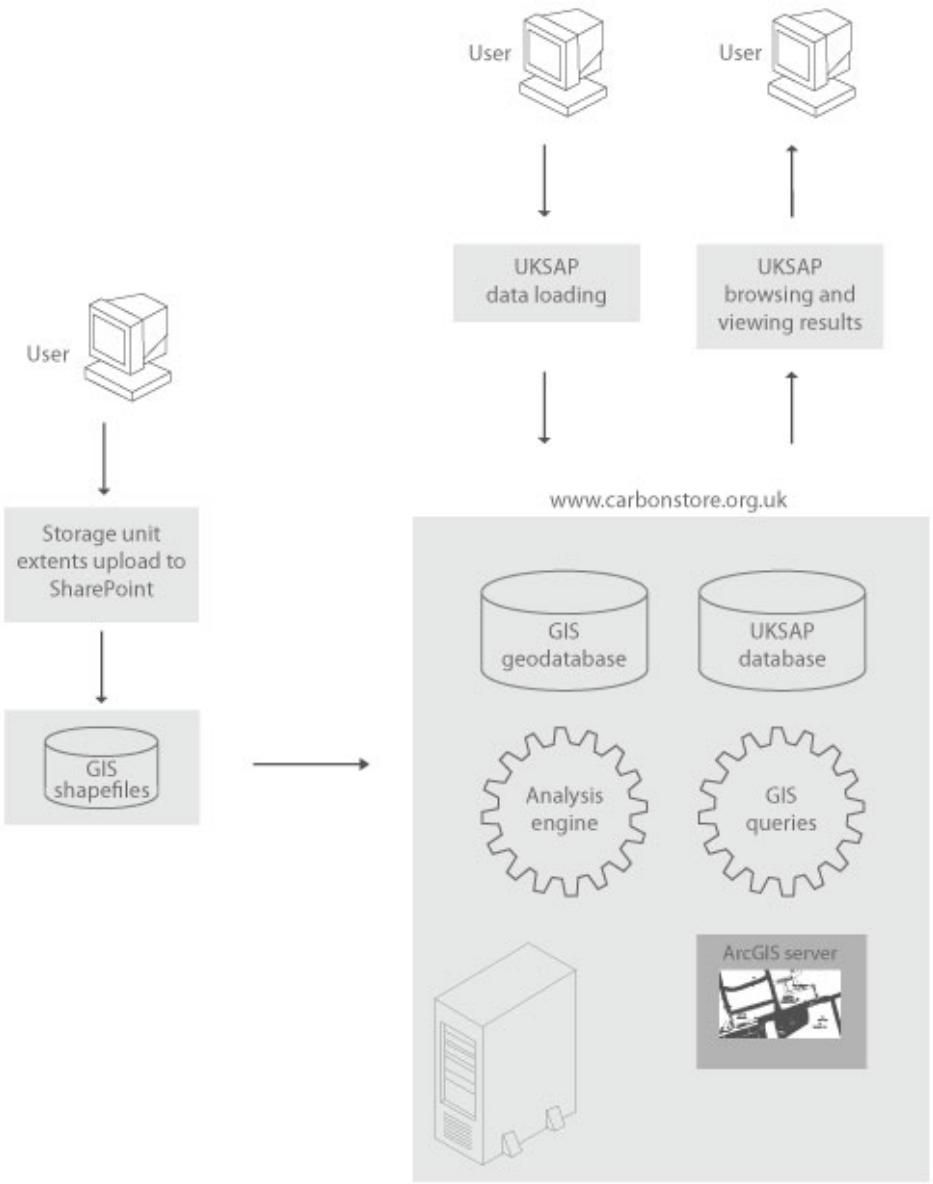
The Web-enabled Database and GIS application ('WDG') to be developed under UKSAP Work Package 5 plays a primary role in the collection and management of data associated with the ETI UKSAP Carbon Storage project. The correct definition and specification of this product is therefore critical, to optimise overall project progress and end-user benefits.

Although the basic concepts and requirements for the WDG were developed prior to completion of the main Technology Contract for the project in Q2-3 2009, the detailed specification evolved during the early months of the project as participants from the different project teams began work on their respective packages.

This document details the specification of the WDG, as envisaged at March 2010, as a deliverable for Milestone 5.1. Some aspects of the later project stages are not fully known at this stage, and will be clarified in subsequent versions of the project specification or other appropriate documentation.

The current version of the WDG website can be seen in its ''live' online form at *www.carbonstore.org.uk.*

WDG Concept


User
User
UKSAP
data loading
UKSAP
browsing and
viewing results
User
Storage unit
extents upload to
SharePoint
GIS
shapefiles
www.carbonstore.org.uk
GIS
geodatabase
UKSAP
database
Analysis
engine
GIS
queries
ArcGIS server

2 Database Design

2.1 General

The design of the WDG spatial database (DB) and its relational links has been based on the requirements of primarily Work Package 1 and liaison with the other appropriate UKSAP Consortium members. The resulting data worksheet developed within WP1 and the explicit DB design specification can be seen in Appendix 1, comprising Data Sheet v4.1 plus later amendments up to early Dec 2009.

The purpose of the DB is to enable entry of all data relevant to UKSAP that relates to each identified 'Storage Unit' (SU), as identified and assessed by the WP1 to WP4 teams. Functionality in the associated 'Analysis Engine' (AE) will then facilitate the accurate interpretation of carbon storage capacity and associated risks for each spatially defined 'Storage Unit'.

The input of data into the database will be handled via the 'Data Loader' (DL) element of the WDG website (http://www.carbonstore.org.uk/), where users will enter Storage Unit data via the online data loader.

Users will require read/ write access to the DB via the online Data Loader to allow addition, revision or deletion of previously inputted data during the data collection phase of the project.

The DB will then be required to store additional information relating to the results generated by the AE as discussed in Section 5.

The database will then be accessed by the web-enabled GIS application using ArcGIS Web Server.

2.2 Database Administration

A suitable database management system is to be implemented, managed by a database administrator (DBA).

The role of the DBA will be to implement a number of proactive processes that will ensure that the ETI Carbon Storage database remains in a healthy condition while minimising downtime. For the duration of the Project, Senergy S&G will act as the DBA.

2.2.1 Database Performance Monitoring and Tuning.

The performance and tuning of the ETI Carbon Storage database will be essential to ensure efficient working of the whole WDG. The following factors will influence performance of the database and as such will be prioritized by the DBA:

- Workload
- Throughput
- Resource
- Optimisation

2.2.2 Security and Authorisation

Authorization to access the website has a tiered approach, starting with a request for a username and password. Once this request has been approved by the project managers or client then an account will be set up. The user account can either be “read only”, “read\write” or “administrator”. Each level of access gives a user a different level of permissions within the application and also a different level of functionality. This method will allow guests to be welcomed onto the site in the knowledge that they cannot edit, perform mass downloads or amend the underlying databases.

As the Data Loader and rest of the WDG website are ‘online’ a suitable method of security and authorisation is required. The focus of security and authorisation will be to prevent the following:

- Unlawful security/ confidentiality breaches
- Improper data modification

Preventative security measures are to include:

- Forcing the user to change their password at intervals
- Encouraging a user not to share their username and password
- Not promoting or showing anything of interest with respect to the site to the public
- Ensuring firewalls are secure and only relevant ports are open.

2.2.3 Backup and Recovery

A backup and recovery strategy is to be established in order to prevent loss of data. The data recovery strategy will need to account for the following factors:

- Software error
- Human Error
- Hardware failure

A suitable backup routine will be operational in time for release of the online Data Loader. The backup routine will be sufficiently robust to enable the recovery process to retrieve all data from potential loss. Although regular backups will be performed on the Data Loader server, the emphasis is also on users of the Data Loader to back-up their own data locally as a further security measure.

2.3 Modification to the Database Design

As the project progresses, if the Database is seen by the Project teams to be suboptimal, then the design may need modification. Depending on the nature of such modifications, such changes may be inclusive within the WP5 workscope or require additional funding to implement.

3 Input Website- Data Loader

Due to the geographically diverse nature of the Project teams, a bespoke online Data Loader application is required for all parties to upload relevant UKSAP data. An online web-based data loader application will be developed to support data upload and direct transfer to the database.

3.1 Data Loader Website Design

The design of the Data Loader website will facilitate upload of carbon storage data by all pertinent consortium members.

The website design directly reflects the data requirement governed by outputs of Work Package 1.

An auditable QC trail to ensure traceability and consistency of data entry is required. Traceable commenting is also required to enable capture of peer review of entries by other consortium members. The website will also be required to perform 'online' QC checks on the data.

The QC checks will indicate if all pertinent data parameters have been entered for each storage unit. The pertinent data parameters consist of the minimum items to be able to compute Pore Volume and CO2 storage capacity, and to complete associated risk and economic analysis. Checks will be made to ensure that for all parameters entered there is a corresponding Reference Source. For each Storage Unit it will show the number of parameters entered for each database table.

Prior to submitting the data to the DB the information will be subject to a number of validation checks. The check system will ensure that gross errors in data entry are trapped and also that the user is provided with an opportunity to correct.

Data units will follow the international system of units (SI); these will be specified at point of data entry.

The basic structure of the website as seen at the issue of the final Data Loader data sheet spec is set out in table form in Appendix 2. The current up-to-date implementation can be seen at www.carbonstore.org.uk.

3.2 Management and Maintenance

The data loader application is managed by Senergy S&G on a dedicated third party server. Senergy S&G has full administrative control over the server and is able to perform all software updates and backups autonomously.

The database and associated software stored on the server will be backed-up on a regular basis and stored offsite.

The Data Loader application is subject to continuous improvement and evolution to improve functionality, post confirmation of the datasheet design (see Appendix). and a system of bug \ new functionality tracking has been implemented.

The bug reports are submitted via the data loader application or via email and stored in a central database on a local server. The development team has access to this facility and their tasks and priorities are dictated by the reported bug.

New functionality requirements are submitted via email, or via the project SharePoint site. Such requirements are submitted to the project Lead Coordinator for approval. Once approved, the new functionality is acknowledged and a developer assigned for task implementation.

The software application team uses a sub-version application to manage the versioning of the software code. Code is checked into and out of the server and this enables the software to be rolled back in case of technical issues.

3.3 Modification to the Data Loader Design

As the project progresses, if the original Data Loader specification is seen by the Project team to be suboptimal, then the application may need modification. Depending on the nature of such modifications, such changes may be inclusive in WP5 workscope, or require additional funding for implementation.

4 Analysis Engine

A series of formulae and consequent algorithms will be used to analyse the raw input data and generate the required project results. Resulting values will then be stored within the database to allow the web-based GIS to interrogate and present such information, and permit appropriate reports and graphs to be generated.

The required results from the Analysis Engine are presented below, along with database storage information. The actual formulae are given in Appendix 5.

The selected algorithms as detailed in section 5.1.2.2 of the Technology Contract will be used to generate the following key results:

- **"Pressure Capacity", Si**
- **A Static Capacity estimate based on assumed "Storage Efficiency" (E factor), initially = 2% Pore Volume**
- **Maximum Sustainable Injection Rate M_i**

In addition, via an approach as yet to be determined but described in principle in section 5.6.2 of the Technology Contract, the following results will be generated:

- **Dynamic Storage Efficiency**
- **Dynamic Storage Capacity**

The WDG will generate estimates for each Storage Unit initially using the Basic Static Capacity formula, followed later by a Probabilistic Static capacity method (Monte Carlo simulation).

CO_2 density and viscosity values will be obtained via look-up tables provided to the WP5 team.

The calculation of the CO_2 capacity of each Storage Unit will be achieved as follows:

Intermediate results will be computed for the following:

- CO_2 Density at mean depth [te/m^3]
- CO_2 Viscosity at mean depth [cP]
- Hydrostatic Pressure [MPa]
- CO_2 Column Height [m]
- Thickness:Area ratio

These computed parameters will use data as entered by the user in the Data Loader application. The parameters are computed on-the-fly, once pertinent data entry fields

have been populated, and stored in the database. Formulae to calculate the parameters are shown in Appendix 5.

4.1 Basic Capacity Estimate

The initial stage of development of the Analysis Engine will utilize the formulae as described in Appendix 5 to generate preliminary results using only the Most Likely (ML) values in the database for each Storage Unit.

4.2 Probabilistic Static Capacity

The second stage of development will comprise the programming of a probabilistic statistical functional calculation, using a Monte-Carlo simulation algorithm to produce a curve of storage capacity versus probability.

The Analysis Engine will operate on the stored data on instruction from the User, when suitable data have been entered. The Monte-Carlo simulation is processor intensive and will be run as a background process, with user requests being queued. A user will have to wait to view the results.

The Monte-Carlo simulation is likely to utilize the following:

- Log-Normal distribution assumed for input parameters
- Sampling method: Latin hypercube
- Number of iterations = 10,000

This is however subject to further technical discussions and final approval.

The initial result of the simulation (at Stage Gate 1) will be the Static Capacity probability P_{10} – P_{90} values, in intervals of 10%. These results will be stored in a table within the database.

No intermediate probability results will be displayed or stored.

Following Stage Gate 1, Static Capacity distributions will be further modified based on the results of Dynamic Modelling (Work Package 4). The means by which this will be achieved will be defined during Work Package 6.

4.3 Modification to the Analysis Algorithms

As the project progresses, if the algorithms used in the Analysis Engine are seen by the Project teams to be suboptimal, then the algorithms may need modification. Depending on the nature of such modifications, such changes may be inclusive in WP5 workscope or require additional funding for implementation.

5 Web-Enabled GIS

5.1 GIS Functionality

Current GIS and specifically web-based GIS products are designed to offer users the ability to access large volumes of diverse, but spatially related, datasets. Delivering the functionality to query and assess complex spatial analysis, coupled with basic graphical, mapping and visual functions allows the GIS to become a highly effective business intelligence solutions tool.

The functionality of a web based GIS can range from a simple map viewer to a complex and powerful data access and analysis system. Building the correct level of functionality is critical in terms of supplying the user with a tool that meets the project's final requirements and is thus entirely fit for the intended purpose. The following section has graded the WDG GIS application into three separate versions, 'Basic', 'Standard' and 'Advanced', with an increasing degree of functionality that will allow the Client/ Consortium to select the final GIS solution.

The 'Standard' package is as envisaged at the proposal and initial Technology Contract stage. The 'Basic' package will present the opportunity for some financial savings, at the expense of GIS functionality, whereas the 'Advanced' package, although increasing cost, can offer the most powerful set of tools and data to assist the ETI to best assess potential carbon storage sites within the UKCS.

The Advanced functionality presented here is only that envisaged at the current stage of the project. It is likely that modifications will arise as the project progresses.

Additional Advanced functionality could also be programmed into the WDG after UKSAP completion.

To assist selection, example screenshots have been included(see Section 5.5) as envisaged by the UKSAP Technical Director. These illustrate some of the possible features within each level.

The envisaged functions have been assessed as to their availability under Basic, Standard or Advanced functionality A summary of each option can be seen in the table in Section 5.6 below.

5.2 Data Presentation and Information

5.2.1 General

The presentation and information process within the web based GIS will follow the same principles, nomenclature and icon layout as ESRIs ArcGIS Desktop product. This will include all layouts and formatting of any text and 'popup' windows such as the 'identify' box.

The clear and concise presentation of the UKSAP carbon storage spatial data is essential. Resolution of on screen data will be such that single point features can easily be interrogated. As a minimum, the following functions will be made available to aid spatial navigation, and will be bundled into a 'navigation toolbar'.

- Pan
- Zoom in/ out
- Zoom window
- Zoom extents
- Go to last zoom level
- Straight line measure tool
- Curser coordinate position display
- Colour coded \ symbolised data layers
- Enabled switching on\ off of data layers

5.2.2 GIS Layers

The data available in the GIS will be visually represented to the user via layers. Each shapefile and database feature class will have its own specific layer. The control of how data is viewed/ symbolised on a map will be handled on an individual layer basis. As a minimum the user will have control over the following features:

- Allow user to enable attribute labels
- Turn layer on/ off (visible or not)
- Zoom in and out which will turn layers on/ off at scale cut-offs

5.2.3 'Identify' Attribute Information

Users will need access to all attribute information stored within the GIS. Accessing this data will be done via the 'identify' tool. Upon selection of the 'identify' tool, user will have the ability to click on specific area of interest and then be presented with all attribute information (raw and analysed results) related to the selected Storage Units.

Attribute data will be displayed to user via a new window. The data will be sorted according to Storage Unit ID number and displayed in a "drill-down" fashion. Results for a Storage Unit will be shown first and optionally a user will be able to drill-down into the data-entry pages to display the "raw" data relating to a unit.

5.3 Additional Results

As the project progresses, results from other Work Packages will be added as additional entries to the Database, such as the Economic Analysis or Risk packages. These can then be viewed when a given Storage Unit is queried.

5.4 Query Functions

Query functions enable a user to query attribute information and return a sub-set of data.

5.4.1 'Standard' package Query Function Capability

The web GIS in 'standard' form will allow user the ability to perform 'one step' single attribute analysis using the WDG database and shapefiles. More specifically the user will be able to create a sub-set of the data contained in the database using a pre-defined number of parameters. The user interface will show these parameters complete with boxes to enter a range (min – max). The user will be able to generate a query using a combination of these parameters and return a result which satisfies all entered range boundaries.

Examples of such a query are as follows:

- 'Show me the carbon storage units with a storage capacity greater than X tonnes, and where the porosity is greater than Y and less than Z.'

This standard query can be augmented by a geographic query that will be able to create a further sub-set of the results as obtained from the attribute query.

The geographical query can also be run on its own.

The geographical query will be limited to query tools available on the map interface. These will include the "select rectangle" and "select circle".

The resultant output from the above query will be presented to the user on a separate page. From here the output will display the Storage Units that meet the query criteria. The user will see a summary storage capacity together with other pertinent results. The user will be able to select a Storage Unit and see the individual Storage Unit results. The user will then be able to select on the appropriate data entry tabs and see the "raw" data as entered during the data entry stage. A drill down approach will enable a user therefore to see all data for a Storage Unit.

The resultant output from the above query can be exported in comma-separated-variable (csv) format and used externally within Excel, or exported in a printable format (eg Rich Text Format).

5.4.2 'Advanced' Package Query Function Capability

5.4.2.1 SQL style Queries

To enable the user to perform more sophisticated attribute queries on the WDG database a new page could be developed which will enable SQL style queries to be performed. The user would be able to select any parameter in the database (raw and results) and create a "greater than", "less than", "equal to", "not" query. The user would be able to add multiple parameters and conditions to the SQL style query. The user would not have access to the full SQL command set as this could result in the underlying databases being corrupted.

5.4.2.2 Geographical Queries

Stand-alone geographical queries, or queries performed on the results of 5.4.1 would be possible. These geographical queries will be more complex and use existing map layers to query upon.

For example:

- Show me the Storage Units within 150nm of Peterhead. This would require Peterhead to be displayed as a point in a map layer.

- Shown me the Storage Units within 20nm of the 30" Shell pipeline.

This would require e.g. the DEAL pipeline dataset to be displayed as a map layer.

These queries will require a separate webpage / user interface to be developed on which a user can define their geographical query.

5.5 Example Screenshots and GIS Functionality

The following screenshots show possible GIS screens, and the levels of functionality they represent are indicated. The final screen layout constructed may differ.

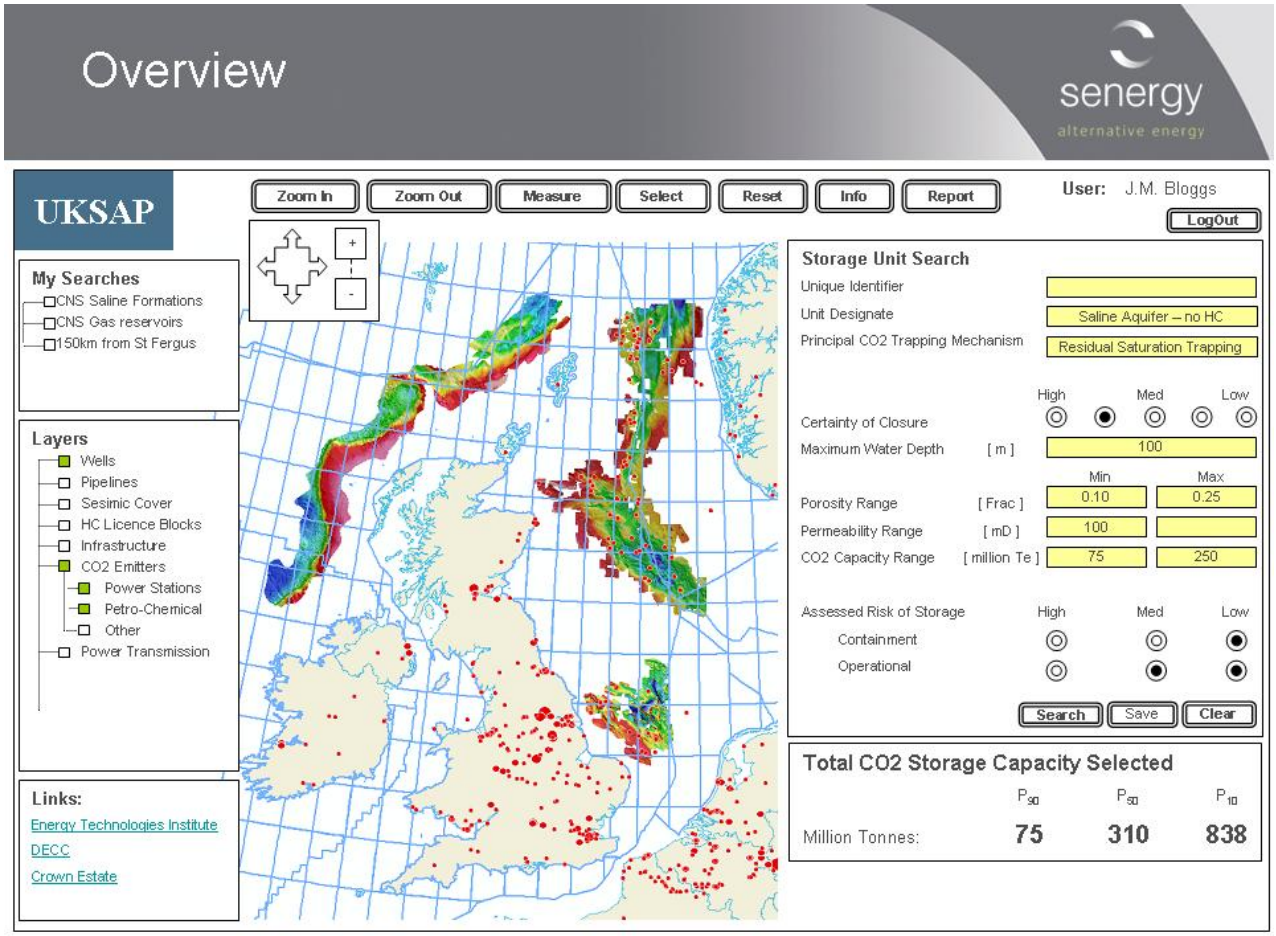


Fig 5-1 Overview

NB: the map used above is taken from the UKSAP Technology Contract, where it was intended to show the PGS Megamerge seismic coverage rather than anything to do with Storage Unit locations; it is thus for illustrative purposes only.

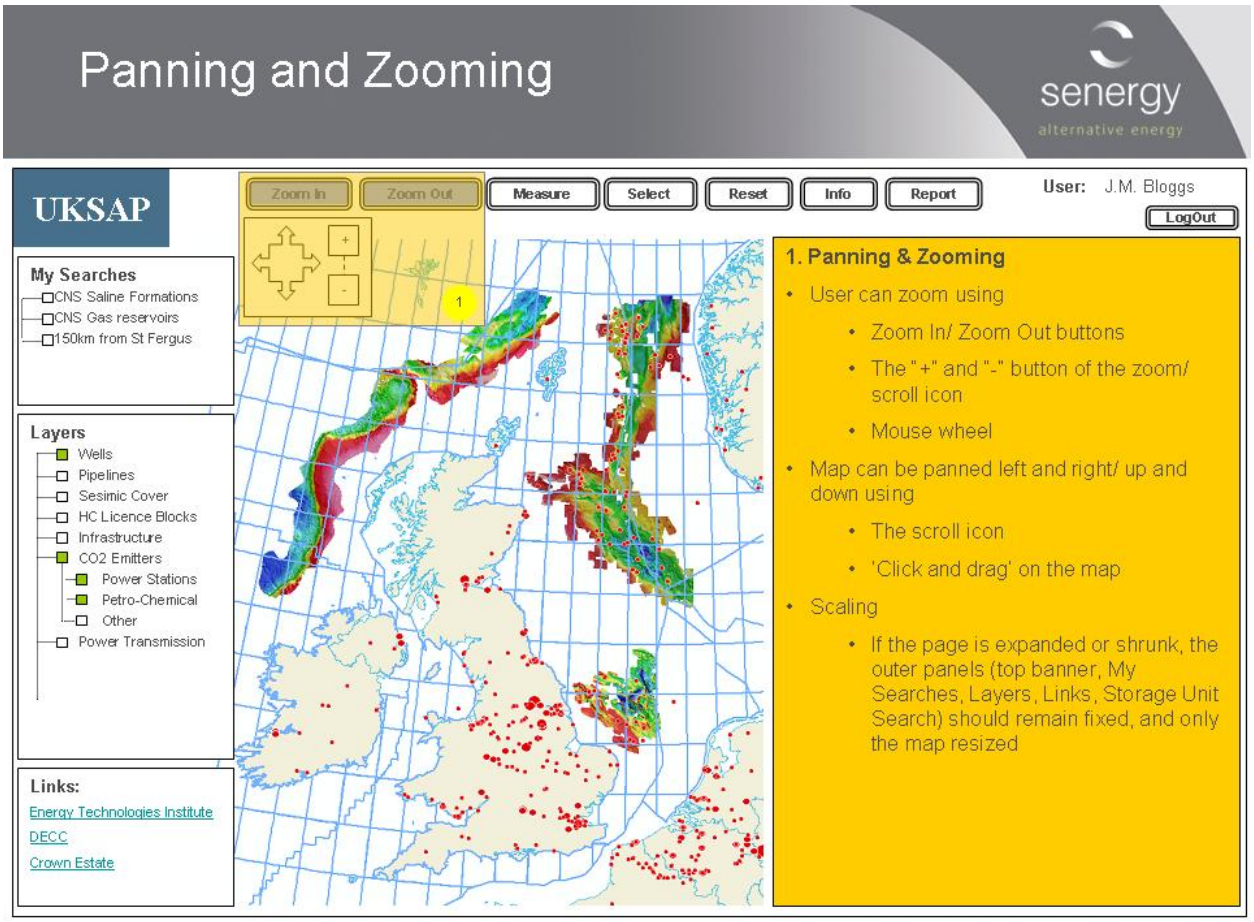


Fig 5-2 Panning and Zooming

Standard ArcGIS Server functionality

Level: Standard

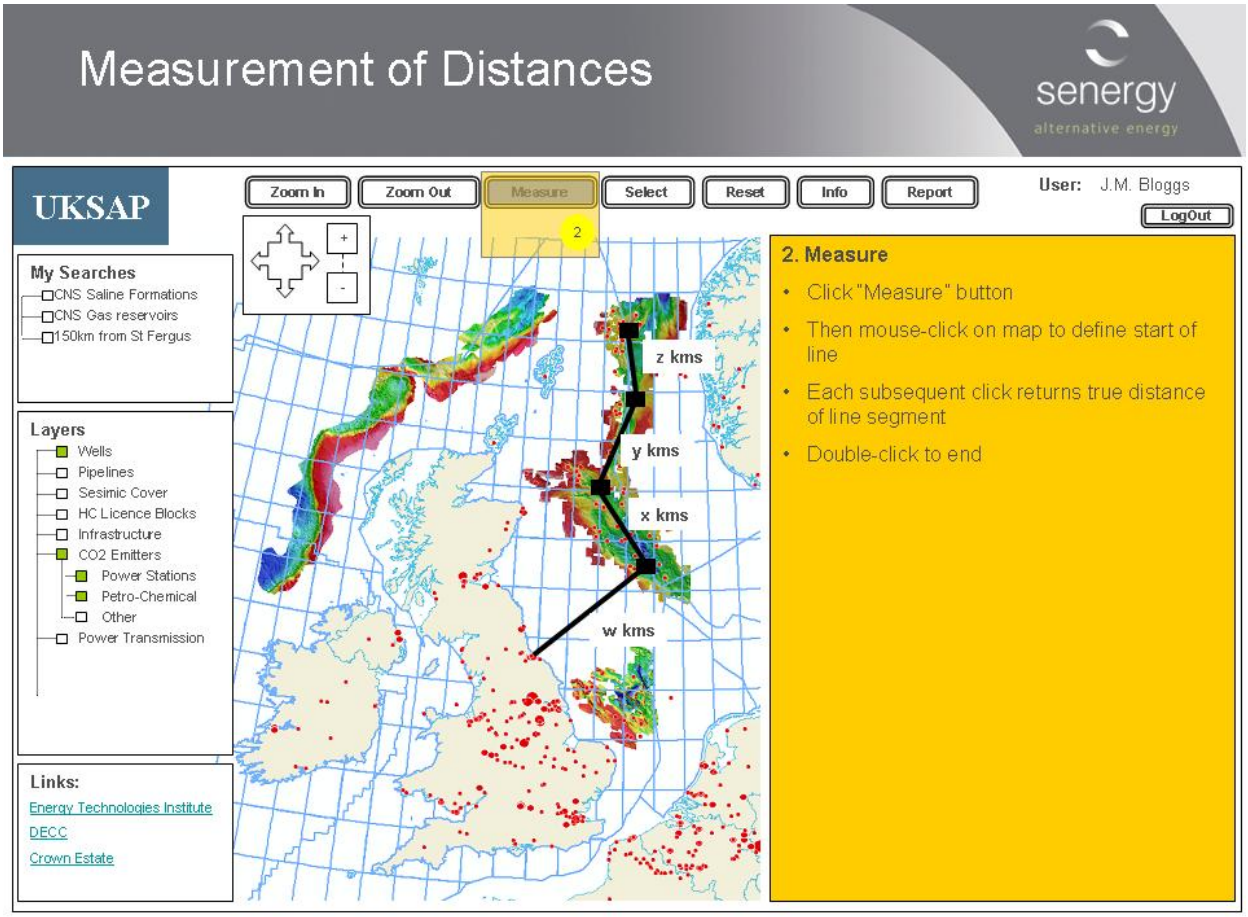


Fig 5-3 Measurement of Distances.

Measurements will be in metres – as WDG uses projected data

Level: Standard

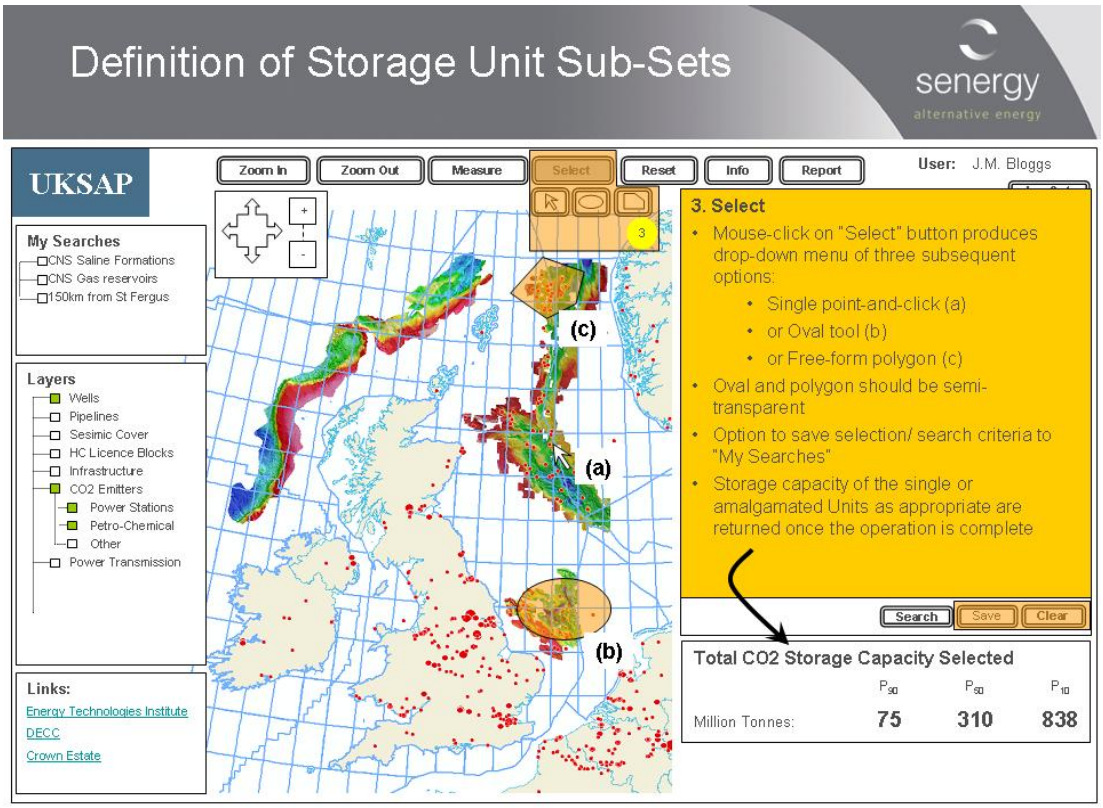


Fig 5-4 Definition of Storage Unit Sub-Sets

Select point or square search – Standard

Select oval or polygon search – Advanced

Save “Searches” - Advanced

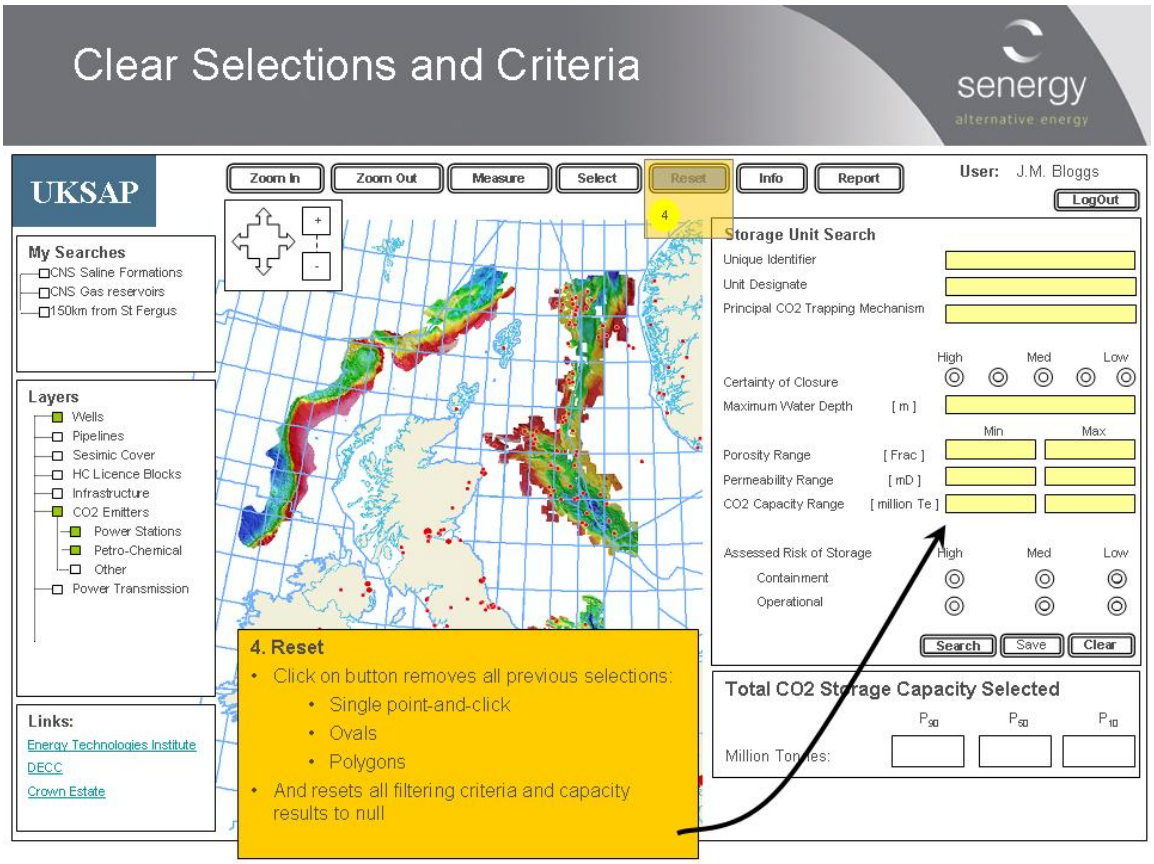


Fig 5-5 Clear Selections and Criteria

Level: Standard

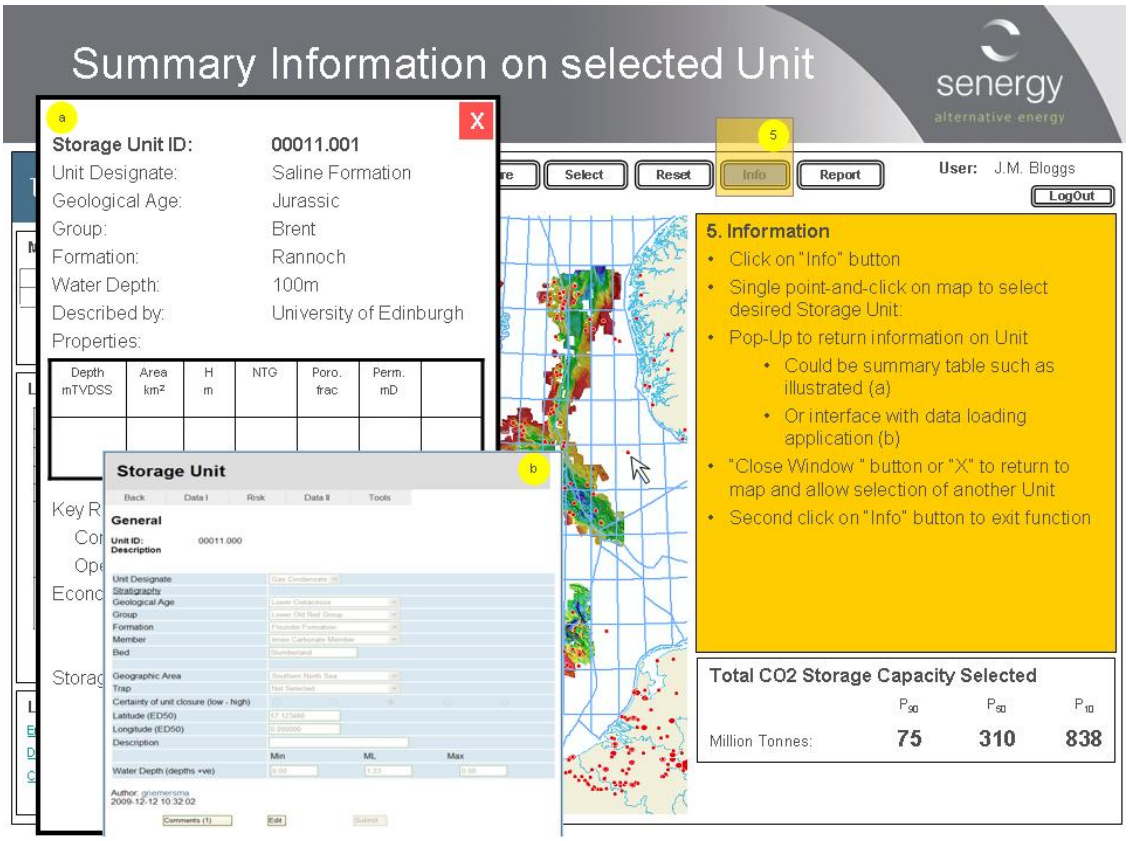


Fig 5-6 Summary Information on selected Unit

Select Info button will enable summary results of storage unit to be displayed. How this will be shown is to be advised.

Summary results page will have links to Data Storage pages to show the pertinent page. All data Storage pages will be accessible via the Summary results page.

Press [back] or [Map] to return to the map – to be advised.

Level: Standard

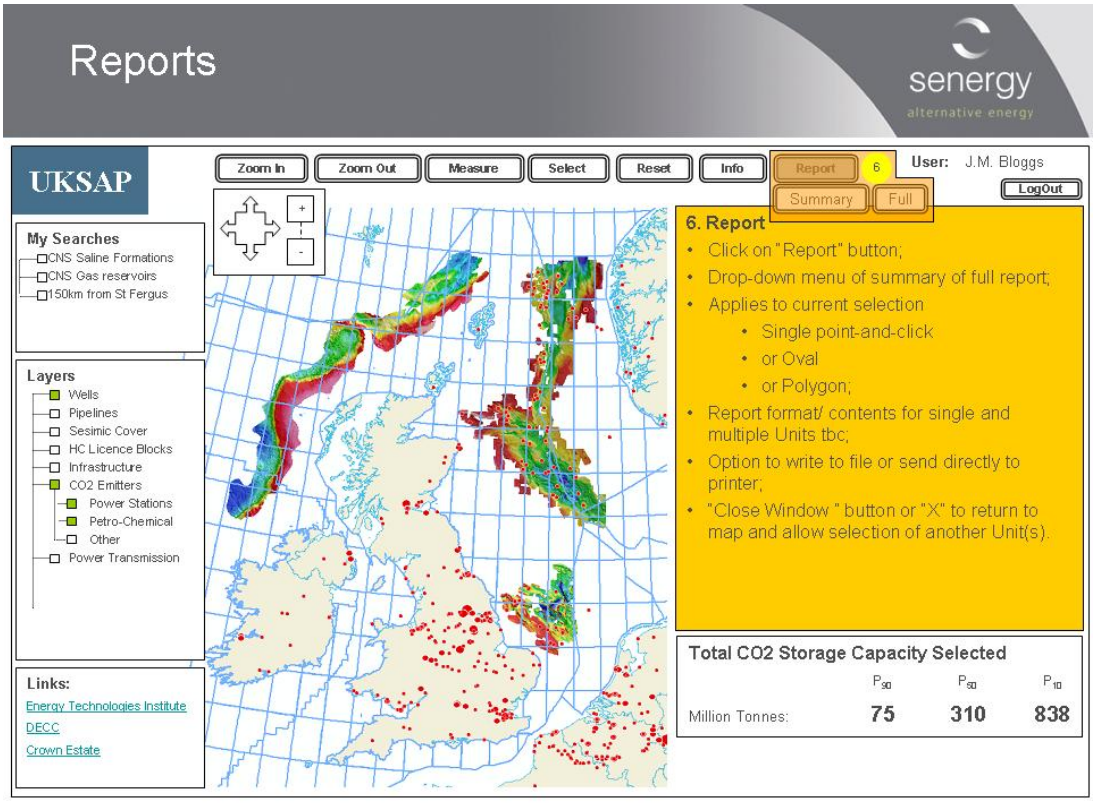


Fig 5-7 Reports

Summary or full report buttons will be active when search (by attribute or geographical or info) is complete. The user can then open one or other of the report types.

Level: Standard

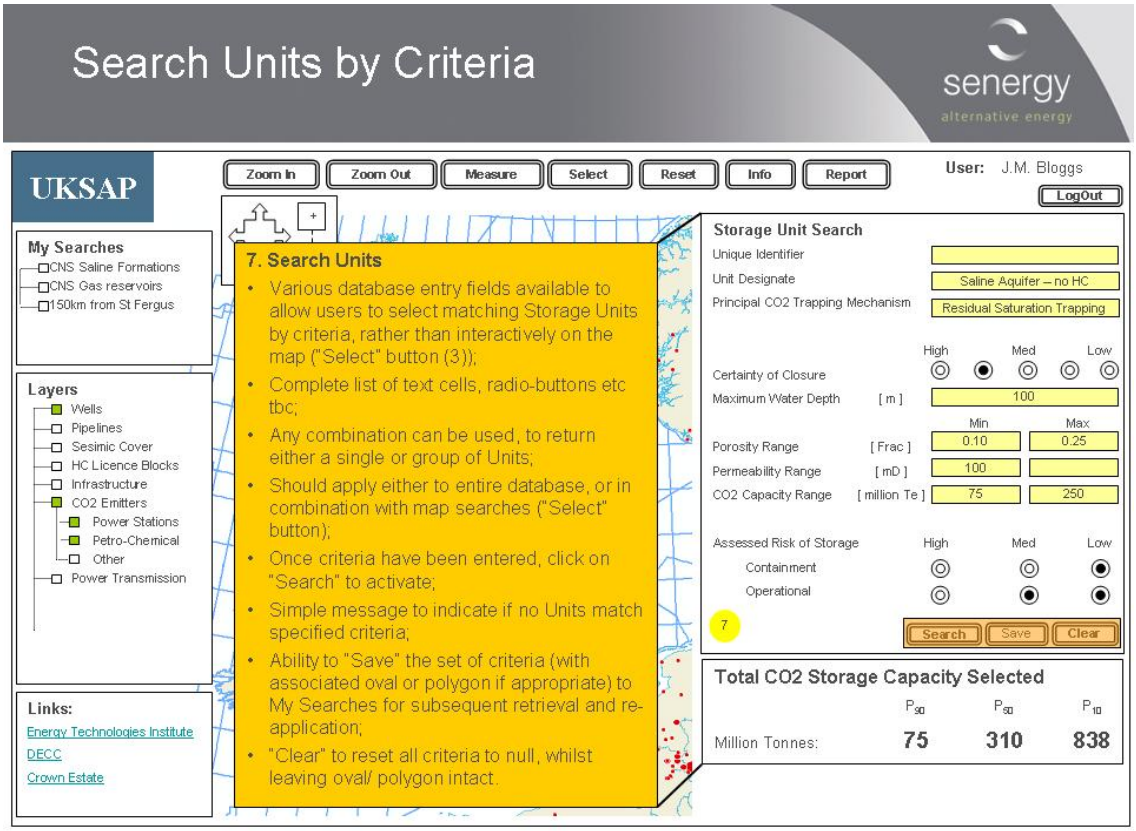


Fig 5-8 Search Units by Criteria

See Section 5.4 for details on Search functionality.

The Search illustrated potentially relates to a multi-attribute query covering multiple database tables

Level: Standard (if 2 attributes) or Advanced (if e.g. 10 attributes) or Advanced (in combination with map searches)

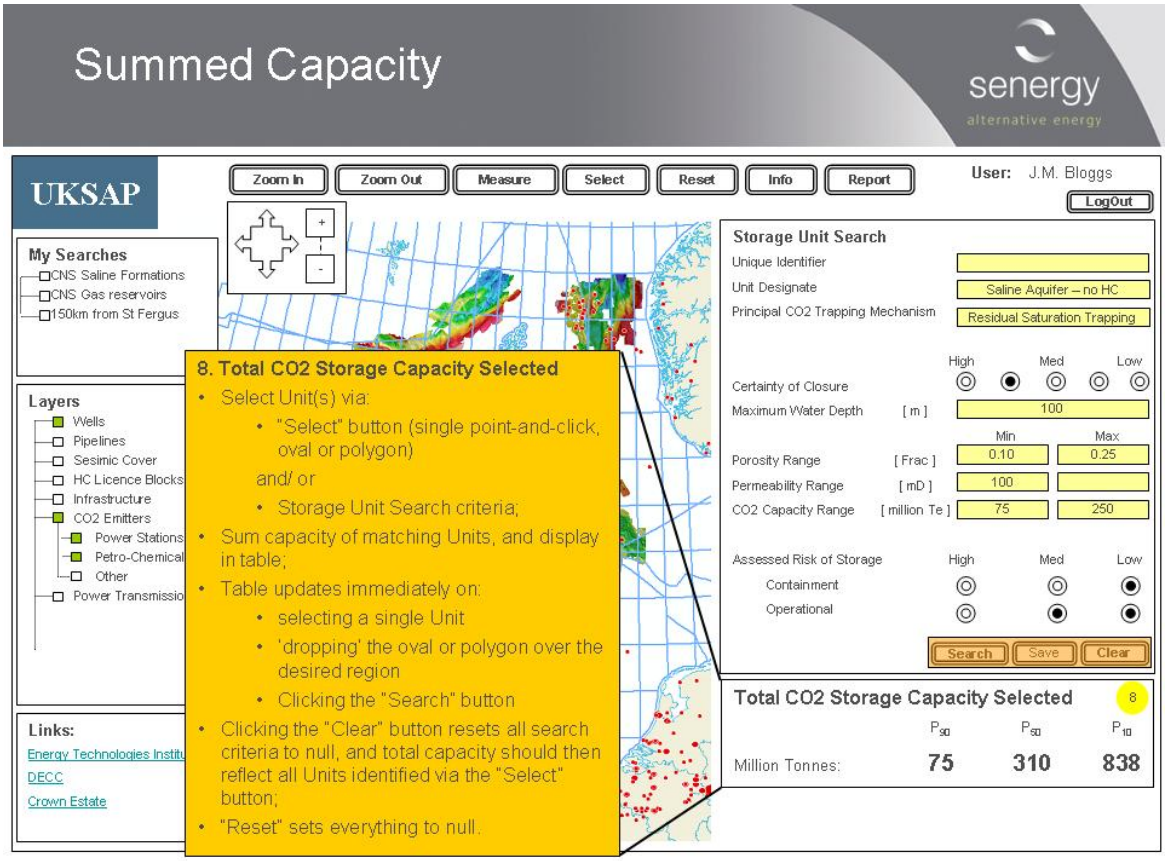


Fig 5-9 Summed Capacity

Assuming Summed Capacity algorithm is summation of individual capacities- Standard

More complex summation- Advanced

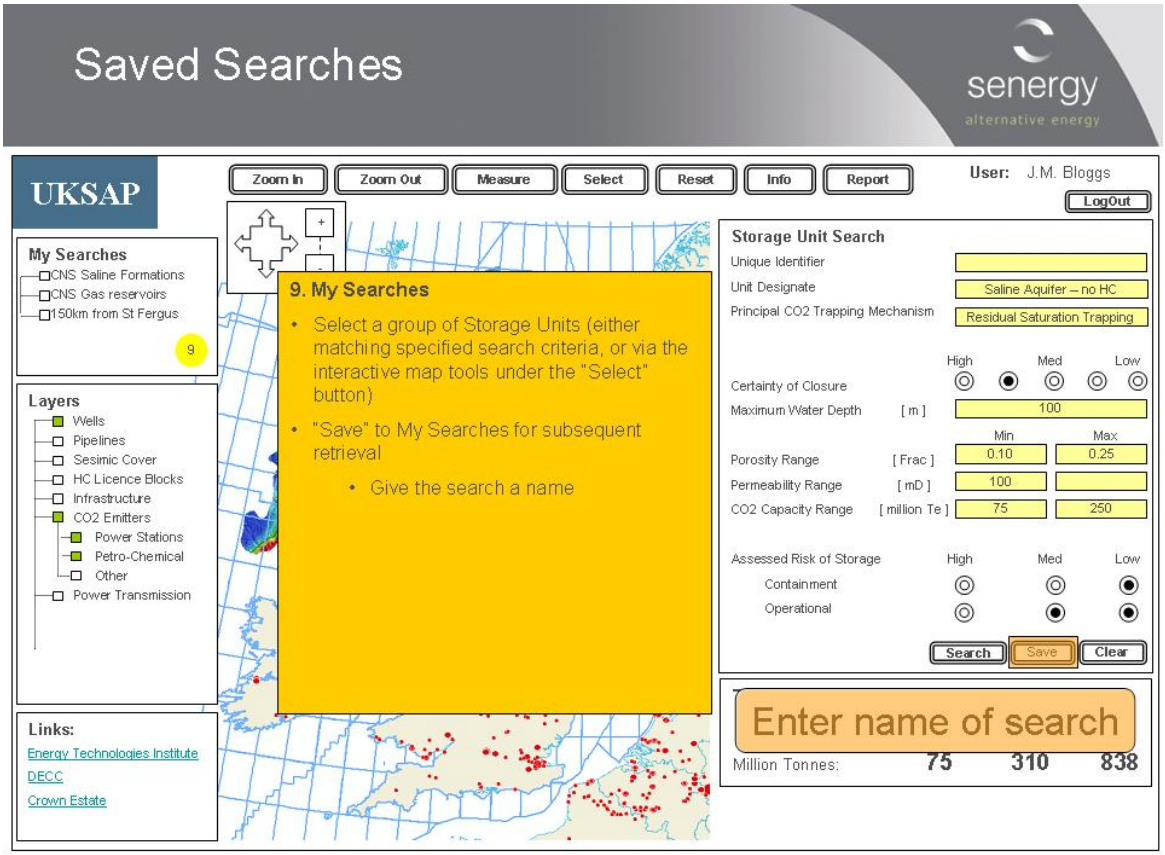


Fig 5-10 Saved Searches

My Searches – not Standard functionality and would need to be specifically developed.

Level: Advanced

5.6 Summary Levels of Functionality Options

Function	Package		
	BASIC	**STANDARD**	**ADVANCED**
Data Presentation and Information	As per 5.2	As per 5.2	As per 5.2
Viewable Data Layers	• UK Coastline • Individual Storage Unit outlines	• UK Coastline • Individual Storage Unit outlines	• UK Coastline • Individual Storage Unit outlines • UK DEAL Data • KISCA Submarine Cables • UK Power Stations • UKCS Bathymetry
Identify	As per 5.2	As per 5.2	As per 5.2
Querying	• No query functionality	• 'One step' single attribute query. (Sec 5.4.1) *and* 'One step' Geographic queries (Sec 5.4.1)	• Multiple attribute querying (Sec 5.4.2) • Multiple Geographic queries (Sec 5.4.2)
Reporting	• No reporting functionality	• Graph generator (Sec 5.7) • Summary and Comprehensive report output. • SQL query output to text file.	As per 'Standard' package, plus extra functions TBA

5.7 Reporting Functions

5.7.1 Graph Production

The WDG will need to be capable of generating various types of graphical output, the capacity to generate the following will be regarded as a Standard output:

- Storage capacity against probability
- Storage availability as a function of time
- Cost of storage as a function of capacity

5.7.2 Data export

The following reports are required as Standard:

- Text reports for each storage unit, input parameters, data sources, results, key risks etc.
- Choice of ‘Full’ or ‘Summary’ report.
- Contents of Full and Summary report to be confirmed.
- Export of Full or Summary reports as comma separated files.

APPENDICES

Appendix 1 Database Specification

This Datasheet Version 4 was the 'Final' version submitted for construction of the Data Loader on 4-11-09. Some subsequent amendments have been implemented after requests from the Lead Co-ordinator.

A1-1 Storage Unit Index sheet:

Description	Units	Input Style	Input Type	Required	Min	Max	Default	Range	Comments
Filter by User		dropdown	select	n				as per login Table	
Storage Unit ID		textbox	alphanumeric	n					
Filter by Geological Age		dropdown	select	n				as per Geological Age list	
Filter by Group		dropdown	select	n				as per Group list	
Filter by Formation		dropdown	select	n				as per Formation list	
Filter by Geological Area		dropdown	select	n				as per Geographic Area list	

A1-2 Storage Unit QC sheet

Description	Units	Input Style	Input Type	Required	Min	Max	Default	Range	Comments
Filter by Author		dropdown	select					as per login Table	
Filter by Organisation		dropdown	select					as per login Table	
Filter by Status		dropdown	select					Black,Red,Amber,Green	
Sort by Static Capacity		radio button			ascending	descending			

A1-3 General

Description	Units	Input Style	Input Type	Required	Min	Max	Default	Range	Populated by	Used by	Comments
Unique Identifier		automatic		y				Geographic Area + Unique ID + Child ID			
Unit Designate		dropdown	alpha	y				Saline Aquifer, Oil & Gas, Gas, Gas condensate			
Geological Age		dropdown		y				as per Geological Age list			
Group		dropdown	alpha	y				as per Group list			
Formation		dropdown		y				as per Formation list			
Member		dropdown	alpha	n				as per Member list			
Bed		textbox	alpha	n							
Geographic Area		dropdown	select	y				as per Geographic Area List			
Trap		dropdown	alpha	y				Dip, Fault, Stratigraphic, Residual Saturation			Agree appropriate list of descriptors
Certainty of unit closure			Integer	y		1	5	1=Confident, unit is hydraulically isolated; 3=intermediate; 5=Unsure, unit could connect with another			
Nominal Injection Point											
Coordinate (latitude)		geographical coord	numeric	y		90	90	N,S			
Coordinate (longitude)		geographical coord	numeric	y		180	180	E,W			
Water Depth (Min)	m	textbox	numeric	n		0	10000				Min water depth over unit extent
Water Depth (ML)	m	textbox	numeric	y		0	10000				Consistent with preceding coordinates
Water Depth (Max)	m	textbox	numeric	n		0	10000				Max water depth over unit extent
Author(s)		automatic	alpha	y				as per login Table			delimited list of author initials, with last author always the last person to edit
Last Edited on		date	automatic	y							Updated during record submit

A1-4 Pore Volume

Description	Units	Input Style	Input Type	Required	Min	Max	Default	Range	Populated by	Used by	Comments
Static Volumes											
Area (Min)	kmsq	textbox	numeric	y							
Area (ML)	kmsq	textbox	numeric	y							
Area (Max)	kmsq	textbox	numeric	y							
Area (Source)		selectpage	alphanumeric	y							delimited list of integer
Area (Confidence)		dropdown	integer	y				high, medium, low			
Average Gross Thickness (Min)	m	textbox	numeric	y							
Average Gross Thickness (ML)	m	textbox	numeric	y							
Average Gross Thickness (Max)	m	textbox	numeric	y							
Average Gross Thickness (Source)		selectpage	alphanumeric	y							delimited list of integer
Average Gross Thickness (Confidence)		dropdown	numeric	y				high, medium, low			
Estimated relief	m	textbox	numeric	y							moved from risk analysis tab
Average Areal % Sand (Min)	%	textbox	numeric	y							
Average Areal % Sand (ML)	%	textbox	numeric	y							In essence, a horizontal NTG
Average Areal % Sand (Max)	%	textbox	numeric	y							
Average Areal % Sand (Source)		selectpage	alphanumeric	y							
Average Areal % Sand (Confidence)		dropdown	integer	y							
Average Vertical NTG (Min)	frac	textbox	numeric	y							
Average Vertical NTG (ML)	frac	textbox	numeric	y							
Average Vertical NTG (Max)	frac	textbox	numeric	y							
Average Vertical NTG (Source)		selectpage	alphanumeric	y							delimited list of integer
Average Vertical NTG (Confidence)		dropdown	integer	y				high, medium, low			
Average Porosity (Min)	%	textbox	numeric	y		0	100				
Average Porosity (ML)	%	textbox	numeric	y		0	100				
Average Porosity (Max)	%	textbox	numeric	y		0	100				
Average Porosity (Source)		selectpage	alphanumeric	y							delimited list of integer
Average Porosity (Confidence)		dropdown	integer	y				high, medium, low			
BRV(Min)	10e6m3	result		n							computed using "canned" equation
BRV(ML)	10e6m3	result		n							computed using "canned" equation
BRV(Max)	10e6m3	result		n							computed using "canned" equation
Pore Volume (Min)	10e6m3	result		n							computed using "canned" equation
Pore Volume (ML)	10e6m3	result		n							computed using "canned" equation
Pore Volume (Max)	10e6m3	result		n							computed using "canned" equation
Aspect Ratios											
Dip Length : width (Min)	ratio	textbox	numeric	y							
Dip Length : width (ML)	ratio	textbox	numeric	y							
Dip Length : width (Max)	ratio	textbox	numeric	y							
Thickness : Area (Min)		result		n					computed		
Thickness : Area (ML)		result		n					computed		
Thickness : Area (Max)		result		n					computed		
Comment		memo	alphanumeric	n							
Author(s)		automatic	alpha	y				as per login Table			delimited list of author initials, with last author always the last person to edit
Last Edited on		date	automatic	y							Updated during record submit

A1-5 Static Capacity

Description	Units	Input Style	Input Type	Required	Min	Max	Default	Range	Populated by	Used by	Comments
Shallowest Depth (Min)	m TVDSS	textbox	numeric	n					uncertainty due to poor seismic coverage, time to depth conversion etc		
Shallowest Depth (ML)	m TVDSS	textbox	numeric	y							
Shallowest Depth (Max)	m TVDSS	textbox	numeric	n							
Mean Depth (Min)	m TVDSS	textbox	numeric	n					uncertainty due to poor seismic coverage, time to depth conversion etc		
Mean Depth (ML)	m TVDSS	textbox	numeric	y							
Mean Depth (Max)	m TVDSS	textbox	numeric	n							
Storage Unit Depth (Source)		selectpage	alphanumeric	y							
Storage Unit Depth (Confidence)		dropdown	integer	y				high, medium, low			
~~Datum Depth of Storage Unit~~	~~m TVDSS~~	~~textbox~~	~~numeric~~	~~y~~					Remove this data entry field		
Formation Temperature at Top Reservoir (Min)	deg C	textbox	numeric	y							
Formation Temperature at Top Reservoir (ML)	deg C	textbox	numeric	y							
Formation Temperature at Top Reservoir (Max)	deg C	textbox	numeric	y							
Formation Temperature (Source)		selectpage	alphanumeric	y							
Formation Temperature (Confidence)		dropdown	integer	y				high, medium, low			
Pore Pressure at Top Reservoir (Min)	MPa	textbox	numeric	y							
Pore Pressure at Top Reservoir (ML)	MPa	textbox	numeric	y							
Pore Pressure at Top Reservoir (Max)	MPa	textbox	numeric	y							
Pressure at Datum at Start of CO2 Injection	MPa	textbox	numeric	y							
Lithostatic Pressure at Top Reservoir (Min)	MPa	textbox	numeric	y							
Lithostatic Pressure at Top Reservoir (ML)	MPa	textbox	numeric	y							
Lithostatic Pressure at Top Reservoir (Max)	MPa	textbox	numeric	y							
Fracture Pressure (of Primary Seal) at Top rese	MPa	textbox	numeric	y							
Fracture Pressure (of Primary Seal) at Top rese	MPa	textbox	numeric	y							
Fracture Pressure (of Primary Seal) at Top rese	MPa	textbox	numeric	y							
Stress field data available		radio	yes/ no flag	n							Flag that stress field is available (not that it's been loaded)
Aquifer Seal Capacity (Min)	MPa	textbox	numeric	y							
Aquifer Seal Capacity (ML)	MPa	textbox	numeric	y							
Aquifer Seal Capacity (Max)	MPa	textbox	numeric	y							
Pressure Data (Source)		selectpage	alphanumeric	y							
Pressure Data (Confidence)		dropdown	integer	y				high, medium, low			
CO2 Density at mean depth	te/m3	result		n					computed using "canned" equation		
CO2 viscosity at mean depth	cP	result		n					computed using "canned" equation		
Hydrostatic Pressure (Min)	MPa	result		n					computed		
Hydrostatic Pressure (ML)	MPa	result		n					computed		
Hydrostatic Pressure (Max)	MPa	result		n					computed		
CO2 Column Height (Min)	m	result		n					computed		
CO2 Column Height (ML)	m	result		n					computed		
CO2 Column Height (Max)	m	result		n					computed		
Rock Compressibility	MPa^{-1}	textbox	numeric	y							
Rock Compressibility (Source)		selectpage	alphanumeric	y							
Rock Compressibility (Confidence)		dropdown	integer	y				high, medium, low			
Formation Water Compressibility	MPa^{-1}	textbox	numeric	y							
Water Compressibility (Source)		selectpage	alphanumeric	y							
Water Compressibility (Confidence)		dropdown	integer	y				high, medium, low			
Formation Water Salinity (TDS)	ppm	textbox	numeric	y							
Water Salinity (Source)		selectpage	alphanumeric	y							
Water Salinity (Confidence)		dropdown	integer	y				high, medium, low			

A1-6 Injectivity

Description	Units	Input Style	Input Type	Required	Min	Max	Default	Range	Populated by	Used by	Comments
Storage Formation Permeability (Min)	mD	textbox	numeric	y							
Storage Formation Permeability (ML)	mD	textbox	numeric	y							
Storage Formation Permeability (Max)	mD	textbox	numeric	y							
Formation Permeability (Source)		selectpage	alphanumeric	y							
Formation Permeability (Confidence)		dropdown	integer	y							
Formation Fluid Viscosity	cP	textbox	numeric	y			tbc				
Formation Fluid Viscosity (Source)		selectpage	alphanumeric	y							
Formation Fluid Viscosity (Confidence)		dropdown	integer	y							
Comment		memo	alphanumeric	n							
Author(s)		automatic	alpha	y				as per login Table			delimited list of author initials, with last author always the last person to edit
Last Edited on		date	automatic	y							Updated during record submit

A1-7 Risk Analysis

Description	Units	Input Style	Input Type	Required	Min	Max	Default	Range	Populated by	Used by	Comments	Comment II	Low	Medium	High
Seal (leakage/containment)															
Fracture pressure capacity (likelihood of failure)		radio	integer			0	3	unknown, low, medium, high	GPT		likelihood definitions in columns O-Q		maximum column	max column height 1.5-	max column height <
Fracture pressure capacity (severity/impact)		radio	integer			0	4	unknown, low, medium, high, very high	GPT		low = no impact on other subsurface user; medium				
Fracture pressure capacity (confidence)		radio	integer			1	3	low,medium, high	GPT		low=analogue; medium=offset/vintage; high=direct				
Fracture pressure capacity (Source)		selectpage	alphanumeric						GPT						
Seal chemical reactivity (likelihood of failure)		radio	integer			1	3	low, medium, high	GPT		likelihood definitions in columns O-Q		evaporites (halite,	dominated by fine - very seal includes	
Seal chemical reactivity (severity/impact)		radio	integer			0	4	unknown, low, medium, high, very high	GPT		low = no impact on other subsurface user; medium				
Seal chemical reactivity (confidence)		radio	integer			1	3	low,medium, high	GPT		low=analogue; medium=offset/vintage; high=direct				
Seal chemical reactivity (Source)		selectpage	alphanumeric						GPT						
Seal degradation (likelihood of failure)		radio	integer			1	3	low, medium, high	GPT		likelihood definitions in columns O-Q		no evidence of seal	one of the following:	one of the following:
Seal degradation (severity/impact)		radio	integer			0	4	unknown, low, medium, high, very high	GPT		low = no impact on other subsurface user; medium				
Seal degradation (confidence)		radio	integer			1	3	low,medium, high	GPT		low=analogue; medium=offset/vintage; high=direct				
Seal degradation (Source)		selectpage	alphanumeric						GPT						
Comment		memo	alphanumeric	n											
Author(s)		automatic	alpha	y				as per login Table			delimited list of author initials, with last author				
Last Edited on		date	automatic	y							Updated during record submit				
Faults (leakage/containment)															
Density (likelihood of failure)		radio	integer			0	3	unknown, low, medium, high	BGS and Uof Ed		likelihood definitions in columns O-Q	(relative to defined unit size)	none recorded	less than 10 resolved	more than 10 resolved
Density (severity/impact)		radio	integer			0	4	unknown, low, medium, high, very high	BGS and Uof Ed		low = no impact on other subsurface user; medium				
Density (confidence)		radio	integer			1	3	low,medium, high	BGS and Uof Ed		low=analogue; medium=offset/vintage; high=direct				
Density (Source)		selectpage	alphanumeric						BGS and Uof Ed						
Throw and fault seal (likelihood of failure)		radio	integer			0	3	unknown, low, medium, high	BGS and Uof Ed		likelihood definitions in columns O-Q	(is estimated offset greater	none (comment on	recorded offset less	greater than estimated
Throw and fault seal (severity/impact)		radio	integer			0	4	unknown, low, medium, high, very high	BGS and Uof Ed		low = no impact on other subsurface user; medium				
Throw and fault seal (confidence)		radio	integer			1	3	low,medium, high	BGS and Uof Ed		low=analogue; medium=offset/vintage; high=direct				
Throw and fault seal (Source)		selectpage	alphanumeric						BGS and Uof Ed						
Vertical extent (likelihood of failure)		radio	integer			0	3	unknown, low, medium, high	BGS and Uof Ed		likelihood definitions in columns O-Q	(does fault termintate >800m	fault displacement	fault terminates in	displacement to
Vertical extent (severity/impact)		radio	integer			0	4	unknown, low, medium, high, very high	BGS and Uof Ed		low = no impact on other subsurface user; medium				
Vertical extent (confidence)		radio	integer			1	3	low,medium, high	BGS and Uof Ed		low=analogue; medium=offset/vintage; high=direct				
Vertical extent (Source)		selectpage	alphanumeric						BGS and Uof Ed						
~~Active faulting (likelihood of failure)~~		~~radio~~	~~integer~~			~~0~~	~~3~~	~~unknown, low, medium, high~~	~~BGS and Uof Ed~~		Remove lines with strikethrough text; not required		~~no evidence for active~~	~~evidence for activity in~~	~~evidence for activity~~
~~Active faulting (severity/impact)~~		~~radio~~	~~integer~~			~~0~~	~~4~~	~~unknown, low, medium, high, very high~~	~~BGS and Uof Ed~~		~~low = no impact on other subsurface user; medium~~				
~~Active faulting (confidence)~~		~~radio~~	~~integer~~			~~1~~	~~3~~	~~low,medium, high~~	~~BGS and Uof Ed~~		~~low=analogue; medium=offset/vintage; high=direct~~				
~~Active faulting (Source)~~		~~selectpage~~	~~alphanumeric~~						~~BGS and Uof Ed~~						
													geological evidence	geological evidence	evidence of pressure

A1-7 Risk Analysis part 2

Comment	memo	alphanumeric	n								
Author(s)	automatic	alpha	y			as per login Table		delimited list of author initials, with last author			
Last Edited on	date	automatic	y					Updated during record submit			
Lateral Migration (leakage/containment)											
Structural trend (likelihood of failure)	degrees	integer		0	180	unknown, low, medium, high	BGS and Uof Ed	likelihood definitions in columns O-Q	no dominant	mild tectonic fabric	intense tectonic fabric
Structural trend (severity/impact)	radio	integer				unknown, low, medium, high, very high		low = no impact on other subsurface user; medium			
Structural trend (confidence)	radio	integer		1	3	low,medium, high	BGS and Uof Ed	low=analogue; medium=offset/vintage; high=direct			
Structural trend (source)	selectpage	alphanumeric					BGS and Uof Ed				
Depositional/diagenetic fabric (likelihood of failure)	degrees	integer		0	180	unknown, low, medium, high	BGS and Uof Ed	likelihood definitions in columns O-Q	isotropic	multiple fabric/migration	dominant migraiton
Depositional/diagenetic fabrid (severity/imppact)	radio	integer				unknown, low, medium, high, very high		low = no impact on other subsurface user; medium			
Depositional/diagenetic fabric (confidence)	radio	integer		1	3	low,medium, high	BGS and Uof Ed	low=analogue; medium=offset/vintage; high=direct			
Depositional/diagenetic fabric (Source)	selectpage	alphanumeric					BGS and Uof Ed				
Dip Direction (likelihood of failure)	degrees	integer		0	360	unknown, low, medium, high	BGS and Uof Ed	likelihood definitions in columns O-Q	dominant dip direction	dominant dip direction	dominant dip direction towards surface/shallower then 800m
Dip Direction (severity/impact)	radio	integer				unknown, low, medium, high, very high		low = no impact on other subsurface user; medium			
Dip Direction (confidence)	radio	integer		1	3	low,medium, high	BGS and Uof Ed	low=analogue; medium=offset/vintage; high=direct			
Dip Direction (Source)	selectpage	alphanumeric					BGS and Uof Ed				
Dip (likelihood of failure)	degrees	integer		0	90	unknown, low, medium, high	BGS and Uof Ed	likelihood definitions in columns O-Q	<1 degree	1-5 degrees	>5 degrees
Dip (severity/impact)	radio	integer				unknown, low, medium, high, very high		low = no impact on other subsurface user; medium			
Dip (confidence)	radio	integer		1	3	low,medium, high	BGS and Uof Ed	low=analogue; medium=offset/vintage; high=direct			
Dip (Source)	selectpage	alphanumeric					BGS and Uof Ed				
Rugosity (likelihood of failure)	slider	integer		1	3	unknown, low, medium, high	BGS and Uof Ed	likelihood definitions in columns O-Q	estimated max	estimated max	estimated max
Rugosity (severity/impact)	radio	integer				unknown, low, medium, high, very high		low = no impact on other subsurface user; medium			
Rugosity (confidence)	radio	integer		1	3	low,medium, high	BGS and Uof Ed	low=analogue; medium=offset/vintage; high=direct			
Rugosity (Source)	selectpage	alphanumeric					BGS and Uof Ed				
~~Relief~~				~~1~~	~~500~~	~~should be in general tab along with measure~~		moved to pore volume tab			
Hydrodynamics (likelihood of failure)	slider	integer		1	3	unknown, low, medium, high	BGS and Uof Ed	likelihood definitions in columns O-Q	no aquifer influx during	significant pressure	active discharge at
Hydrodynamics (severity/impact)	radio	integer				unknown, low, medium, high, very high		low = no impact on other subsurface user; medium			
Hydrodynamics (confidence)	radio	integer		1	3	low,medium, high	BGS and Uof Ed	low=analogue; medium=offset/vintage; high=direct			
Hydrodynamics (Source)	selectpage	alphanumeric					BGS and Uof Ed				
Pressure sinks in storage unit (likelihood of failure)	radio	integer		1	3	unknown, low, medium, high	BGS and Uof Ed	likelihood definitions in columns O-Q	none recorded (but	single small-medium	multiple reservoirs or
Pressure sinks in storage unit (severity/impact)	radio	integer				unknown, low, medium, high, very high		low = no impact on other subsurface user; medium			
Pressure sinks in storage unit (confidence)	radio	integer		1	3	low,medium, high	BGS and Uof Ed	low=analogue; medium=offset/vintage; high=direct			
Pressure sinks in storage unit (source)	selectpage	alphanumeric					BGS and Uof Ed				

A1-7 Risk Analysis part 3

Comment	memo	alphanumeric	n									
Author(s)	automatic	alpha	y			as per login Table		delimited list of author initials, with last author				
Last Edited on	date	automatic	y					Updated during record submit				
Wells												
Well Density	textbox	integer					GRL	**expected to be automated later and most data generated externally**		This will be automated		
Well Density (confidence)	radio	integer		1	3	low,medium, high	GRL			Histogram of active well		
Well Density (Source)	selectpage	alphanumeric					GRL			Density of abandoned		
Vintage	result	integer					GRL					
Vintage (confidence)	radio	integer		1	3	low,medium, high	GRL					
Vintage (Source)	selectpage	alphanumeric					GRL					
Formation Damage (injectivity/operational risk)												
mineralogy of grains and cements (likelihood of failure)	radio	integer		0	3	unknown, low, medium, high	GRL	likelihood definitions in columns O-Q		quartz dominant pore	minor carbonate (if as	abundant carbonates
mineralogy of grains and cements (severity/impact)	radio	integer		0	4	unknown, low, medium, high, very high	GRL	low = formation damage localised and temporary				
Mineralogical description available	radio	yes/ no flag	n				GPT	Flag that a compositional analysis is available (not that it's been loaded)				
mineralogy of grains and cements (confidence)	radio	integer		1	3	low,medium, high	GRL	low=analogue; medium=offset/vintage; high=direct				
mineralogy of grains and cements (Source)	selectpage	alphanumeric					GRL					
mechanical integrity (likelihood of failure)	radio	integer		0	3	unknown, low, medium, high	GRL	likelihood definitions in columns O-Q		consolidated formation	poorly consolidated	unconsolidated
mechanical integrity (severity/impact)	radio	integer		0	4	unknown, low, medium, high, very high	GRL	low = formation damage localised and temporary				
mechanical integrity (confidence)	radio	integer		1	3	low,medium, high	GRL	low=analogue; medium=offset/vintage; high=direct				
mechanical integrity (Source)	selectpage	alphanumeric					GRL					
salinity (likelihood of failure)	radio	integer		0	3	unknown, low, medium, high	GPT	likelihood definitions in columns O-Q	If high salnity note major	<50g/L	50-150g/L	>150g/L
salinity (severity/impact)	radio	integer		0	4	unknown, low, medium, high, very high	GPT	low = formation damage localised and temporary				
brine compositional analysis available	radio	yes/ no flag	n				GPT	Flag that a compositional analysis is available (not that it's been loaded)				
salinity (confidence)	radio	integer		1	3	low,medium, high	GPT	low=analogue; medium=offset/vintage; high=direct				
salinity (Source)	selectpage	alphanumeric					GPT					
Comment	memo	alphanumeric	n									
Author(s)	automatic	alpha	y			as per login Table		delimited list of author initials, with last author				
Last Edited on	date	automatic	y					Updated during record submit				
Dynamic Capacity (compartmentalization)									see also fault			
stratigraphic compartmentalization vertical (likelihood of	radio	integer		0	3	unknown, low, medium, high	BGS and Uof Ed	likelihood definitions in columns O-Q		stacked channels,	limited vertical	lack of erosive stacking,
stratigraphic compartmentalization vertical	radio	integer		0	4	unknown, low, medium, high, very high	BGS and Uof Ed	low = evidence suggest compartments are large				
stratigraphic compartmentalization vertical (confidence)	radio	integer		1	3	low,medium, high	BGS and Uof Ed	low=analogue; medium=offset/vintage; high=direct				
stratigraphic compartmentalization vertical (Source)	selectpage	alphanumeric					BGS and Uof Ed					

A1-7 Risk Analysis part 4

stratigraphic compartmentalization horizontal (likelihood of	radio	integer		0	3	unknown, low, medium, high	BGS and Uof Ed	likelihood definitions in columns O-Q		laterally continuous	laterally discontinuous	isolated
stratigraphic compartmentalization horizontal	radio	integer		0	4	unknown, low, medium, high, very high	BGS and Uof Ed	low = evidence suggest compartments are large				
stratigraphic compartmentalization horizontal (confidence)	radio	integer		1	3	low,medium, high	BGS and Uof Ed	low=analogue; medium=offset/vintage; high=direct				
stratigraphic compartmentalization horizontal (Source)	selectpage	alphanumeric					BGS and Uof Ed					
structural/fault compartmentalization (likelihood of failure)	radio	integer		0	3	unknown, low, medium, high	BGS and Uof Ed	likelihood definitions in columns O-Q		none recorded (but	faults allow wetting fluid	Evidence of risk of fault
structural/fault compartmentalization (severity/impact)	radio	integer		0	4	unknown, low, medium, high, very high	BGS and Uof Ed	low = evidence suggest compartments are large				
structural/fault compartmentalization (confidence)	radio	integer		1	3	low,medium, high	BGS and Uof Ed	low=analogue; medium=offset/vintage; high=direct				
structural/fault compartmentalization (Source)	selectpage	alphanumeric					BGS and Uof Ed					
diagenesis (likelihood of failure)	radio	integer		0	3	unknown, low, medium, high	BGS and Uof Ed	likelihood definitions in columns O-Q		geological evidence	geological evidence	evidence of pressure
diagenesis (severity/impact)	radio	integer		0	4	unknown, low, medium, high, very high	BGS and Uof Ed	low = evidence suggest compartments are large				
diagenesis (confidence)	radio	integer		1	3	low,medium, high	BGS and Uof Ed	low=analogue; medium=offset/vintage; high=direct				
diagenesis (Source)	selectpage	alphanumeric					BGS and Uof Ed					
transnational migration (likelihood of failure)	radio	integer		0	3	unknown, low, medium, high	BGS and Uof Ed	likelihood definitions in columns O-Q		hydraulically connected	defined storage unit 1-	defined storage unit
transnational migration (severity/impact)	radio	integer		0	4	unknown, low, medium, high, very high	BGS and Uof Ed	low = evidence suggest compartments are large				
transnational migration (confidence)	radio	integer		1	3	low,medium, high	BGS and Uof Ed	low=analogue; medium=offset/vintage; high=direct				
transnational migration (Source)	selectpage	alphanumeric					BGS and Uof Ed					
Faults (compartmentalization)												
Pressure isolation (likelihood of failure)	radio	integer		0	3	unknown, low, medium, high	GPT	likelihood definitions in columns O-Q		geological evidence	geological evidence	evidence of pressure
Pressure isolation (severity/impact)	radio	integer		0	4	unknown, low, medium, high, very high	GPT	low = evidence suggest compartments are large				
Pressure isolation (confidence)	radio	integer		1	3	low,medium, high	GPT	low=analogue; medium=offset/vintage; high=direct				
Pressure isolation (Source)	selectpage	alphanumeric					GPT					
Granulation/seal (likelihood of failure)	radio	integer		0	3	unknown, low, medium, high	BGS and Uof Ed	likelihood definitions in columns O-Q	(this is a smaller scale version	geological evidence	geological evidence	evidence of pressure
Granulation/seal (severity/impact)	radio	integer		0	4	unknown, low, medium, high, very high	BGS and Uof Ed	low = evidence suggest compartments are large				
Granulation/seal (confidence)	radio	integer		1	3	low,medium, high	BGS and Uof Ed	low=analogue; medium=offset/vintage; high=direct				
Granulation/seal (Source)	selectpage	alphanumeric					BGS and Uof Ed					
Comment	memo	alphanumeric	n									
Author(s)	automatic	alpha	y			as per login Table		delimited list of author initials, with last author				
Last Edited on	date	automatic	y					Updated during record submit				

A1-8 Economics

Description	Units	Input Style	Input Type	Required	Min	Max	Default	Range	Populated by	Used by	Comments
Scenario I											
CAPEX (Min)	GBP	textbox	numeric								
CAPEX (ML)	GBP	textbox	numeric								
CAPEX (Max)	GBP	textbox	numeric								
OPEX (Min)	GBP	textbox	numeric								
OPEX (ML)	GBP	textbox	numeric								
OPEX (Max)	GBP	textbox	numeric								
MMV (Min)	GBP	textbox	numeric								
MMV (ML)	GBP	textbox	numeric								
MMV (Max)	GBP	textbox	numeric								
NPV £/t CO2 (Min)	GBP	textbox	numeric								
NPV £/t CO2 (ML)	GBP	textbox	numeric								
NPV £/t CO2 (Max)	GBP	textbox	numeric								
Scenario Definition		memo	alphanumeric								
Scenario II											
CAPEX (Min)	GBP	textbox	numeric								
CAPEX (ML)	GBP	textbox	numeric								
CAPEX (Max)	GBP	textbox	numeric								
OPEX (Min)	GBP	textbox	numeric								
OPEX (ML)	GBP	textbox	numeric								
OPEX (Max)	GBP	textbox	numeric								
MMV (Min)	GBP	textbox	numeric								
MMV (ML)	GBP	textbox	numeric								
MMV (Max)	GBP	textbox	numeric								
NPV £/t CO2 (Min)	GBP	textbox	numeric								
NPV £/t CO2 (ML)	GBP	textbox	numeric								
NPV £/t CO2 (Max)	GBP	textbox	numeric								
Scenario Definition		memo	alphanumeric								
Scenario III											
CAPEX (Min)	GBP	textbox	numeric								
CAPEX (ML)	GBP	textbox	numeric								
CAPEX (Max)	GBP	textbox	numeric								
OPEX (Min)	GBP	textbox	numeric								
OPEX (ML)	GBP	textbox	numeric								
OPEX (Max)	GBP	textbox	numeric								
MMV (Min)	GBP	textbox	numeric								
MMV (ML)	GBP	textbox	numeric								
MMV (Max)	GBP	textbox	numeric								
NPV £/t CO2 (Min)	GBP	textbox	numeric								
NPV £/t CO2 (ML)	GBP	textbox	numeric								
NPV £/t CO2 (Max)	GBP	textbox	numeric								
Scenario Definition		memo	alphanumeric								
Comment		memo	alphanumeric	n							
Author(s)		automatic	alpha	y				as per login Table			delimited list of author initials, with last author always the last person to edit
Last Edited on		date	automatic	y							Updated during record submit

A1-9 Dynamic Modelling

Description	Units	Input Style	Input Type	Required	Min	Max	Default	Range	Populated by	Used by	Comments
Comment		memo	alphanumeric	n							
Author(s)		automatic	alpha	y				as per login Table			delimited list of author initials, with last author always the last person to edit
Last Edited on		date	automatic	y							Updated during record submit

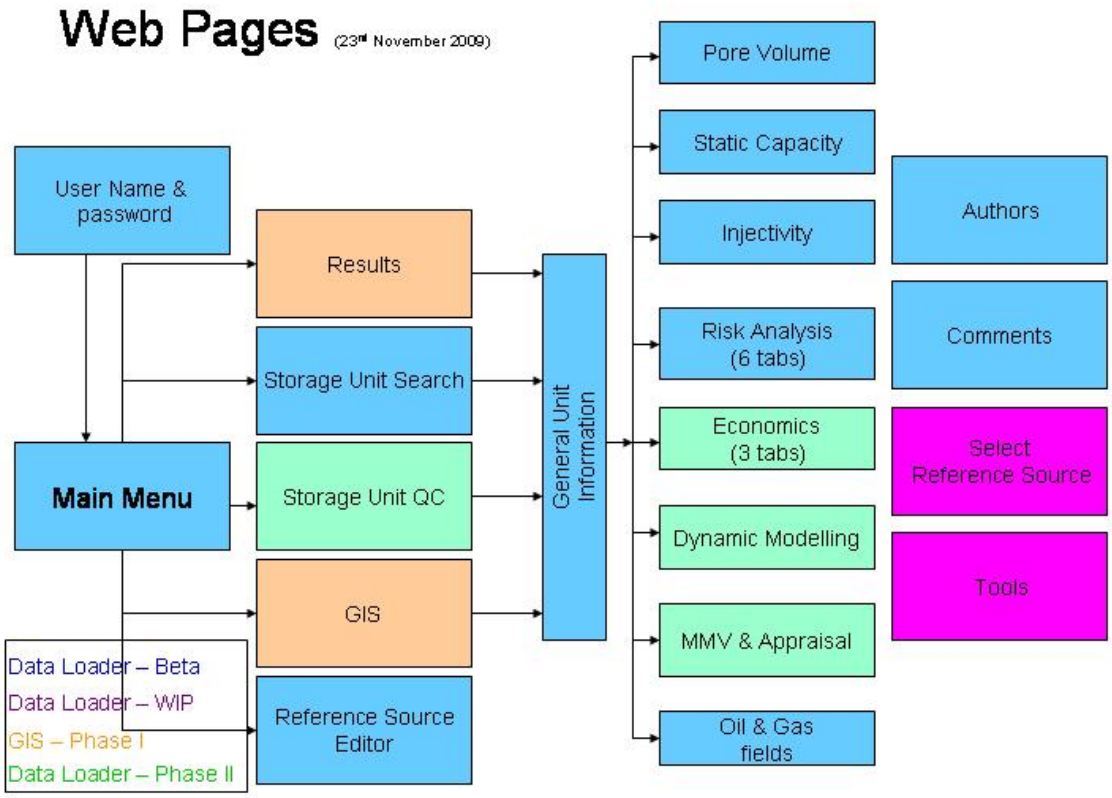
A1-10 MMV and Appraisal

Description	Units	Input Style	Input Type	Required	Min	Max	Default	Range	Populated by	Used by	Comments
Comment		memo	alphanume	n							
Author(s)		automatic	alpha	y				as per login Table			delimited list of author initials, with last author always the last person to edit
Last Edited on		date	automatic	y							Updated during record submit

A1-11 Oil and Gas Fields

Description	Units	Input Style	Input Type	Required	Min	Max	Default	Range	Populated by	Used by	Comments
Development Type		dropdown	Integer					as per development list			
Oil Export		dropdown	Integer					as per Oilexport list			
Gas Export		dropdown	Integer					as per Gasexport list			
Number of Active Oil Production Wells	none	textbox	Integer	n							
Number of Active Gas Production Wells	none	textbox	Integer	n							
Number of Active Water Injection Wells	none	textbox	Integer	n							
Number of Active Gas Injection Wells	none	textbox	Integer	n							
Number of Suspended Wells	none	textbox	Integer	n							
Number of Abandoned Wells	none	textbox	Integer	n							
Total Number of Wells	none	textbox	Integer	n							If breakdown by well type not available, allow input of simple total
Well Type (Source)		selectpage	alphanumeric	y							
GOC or GWC	m TVDSS	textbox	numeric	n							
OWC	m TVDSS	textbox	numeric	n							
depth to crest	m	textbox	numeric	y							
Oil Saturation	frac	textbox	numeric	n							
Oil Compressibility	psi-1	textbox	numeric	n							
Oil Gravity	?	textbox	numeric	n							
Oil Specific Gravity	sg	textbox	numeric	n							
Solution Gas-Oil Ratio	scf/stb	textbox	numeric	n							
HC Gas Saturation	frac	textbox	numeric	n							
Gas Gravity wrt Air	sg	textbox	numeric	n							
Fluid PVT (Source)		selectpage	alphanumeric	y							
Fluid PVT (Confidence)		dropdown	integer	y							
STOIIP	mmstb	textbox	numeric	n							
GIIP (Gas Cap)	bcf	textbox	numeric	n							
Cumulative Oil Production	mmstb	textbox	numeric	n							
Cumulative Gas Production	bcf	textbox	numeric	n							
Cumulative Water Production	mmstb	textbox	numeric	n							
Cumulative Gas Injection	bcf	textbox	numeric	n							
Cumulative Water Injection	mmstb	textbox	numeric	n							
Hydrocarbon Volumes (Source)		selectpage	alphanumeric	y							
Hydrocarbon Volumes (Confidence)		dropdown	integer	y							
Expected Cessation of Production	year	textbox	numeric	y							
CoP (Source)		selectpage	alphanumeric	y							
CoP (Confidence)		dropdown	integer	y							
Comment		memo	alphanumeric	n							
Author(s)		automatic	alpha	y				as per login Table			delimited list of author initials, with last author always the last person to edit
Last Edited on		date	automatic	y							Updated during record submit

Appendix 2 Website/Data Loader Specification



Appendix 3 Unit Shapefile Attribute Definition

The table below details the specific attributes of the shapefile

Attribute	Data Type	Length (Characters)	Description	Comment
Shape	Polygon	N/A	Shape	See Section 5.2
[storageid]	Int	N/A	unitID	See note* below
[user]	Text	50	Author	Username as per carbonstore website user id.
[organisation]	Text	100	Organisation	
[description]	Text	200	Description	Description as per 'unit' entry on UKSAP data entry website

*multiply the storage id by 1000 to remove decimal point. So the first Storage ID=1000, the first child thereof is 1001.

Appendix 4 WDG Website Access Technical Requirement

This describes the specific minimum technical information required for a user to enable then to successfully access the WDG website and databases.

A user will require Internet Explorer 8 or Mozilla Firefox as their web-browser. Some security settings must be slightly lowered (eg ability to download Flash components)

The user must be permitted to download contents (eg csv files) from the website.

Internet connection of 2Mbps is sufficient.

Standard screen resolution 1024 x 768 is required as a minimum.

User must have the right to access the following websites:

www.carbonstore.org.uk

www.carbonstore.co.uk

Or any sub-domains thereof.

Any update to these settings will be advised on the UKSAP SharePoint site

Appendix 5 Survey Control

Horizontal control

All geo-referenced data will be delivered using geographic coordinates quoted in the European Datum 1950. If a datum shift is required from WGS84 the following parameters will be used.

Datum Parameters – WGS84	
EPSG	4326
Spheroid	WGS84
Semi-major axis	6 378 137.000m
Semi-minor axis	6 356 752.314
Flattening	1/298.257223563

Datum Parameters – European Datum 1950 (ED50)	
EPSG	4230
Spheroid	International 1924
Semi-major axis	6 378 388.000m
Semi-minor axis	6 356 911.946
Flattening	1/297
Unit	International metre

WGS84 – ED50 Transformation Parameters		
Translation	**Rotation**	**Scale (ppm)**
dX: + 89.500m	Rx: 0.000”	SF: -1.2
dY: + 93.800m	Ry: 0.000”	
dZ: + 123.100m	Rz: +0.156”	

Vertical Datum

The vertical datum used for all depths within this report is Lowest Astronomical Tide (LAT) unless otherwise stated.

NB. Depths will be positive values.

Appendix 6 Analysis Engine Formulae

A6.1 Basic Static Capacity

The following parameters will be derived using the formulae below:

GRV

Area x Av. Gross Thickness

The input parameters are both present on the Pore Volume data entry page.

Pore Volume

Area x Av. Gross Thickness x Av. Areal Net Sand x Av. Vertical NTG x Av. Porosity

The input parameters are both present on the Pore Volume data entry page.

Thickness:Area ratio

The ratio is a simple division of the Av. Gross Thickness by the Area parameter. Both parameters are present on the Pore Volume data entry page.

CO2 Density at mean depth [te/m3]

This will be computed via lookup table of Pressure vs Temperature using a 2-dimensional interpolation.

The look up table is as shown in Table A6-1

CO2 Viscosity at mean depth [cP]

This will be computed via lookup table of Pressure vs Temperature using a 2-dimensional interpolation.

The look up table is as shown in Table A6-1 below

Hydrostatic Pressure [MPa]

The following formula is used. The input parameters are present on the Static capacity data entry page.

Mean True Vertical Depth Subsea x Water Density (corrected for salinity) x g

CO2 Column Height

The following formula will be used. The input parameters are present on the Static Capacity data entry page

$$\frac{(0.9 \times \text{Frac Pressure @ top res} - \text{Expected Pore Pressure @ top res at start of injection})}{(\text{Water Density} - \text{CO2 Density}) \times g}$$

This formula is approximate, and may be refined for example to account for variable CO_2 density with depth.

Pressure Capacity ('closed' storage units)

This formula is detailed in section 5.1.2.2 of the Technology Contract, reproduced below.

$$S_i = A \cdot H \cdot NTG \cdot \Phi \cdot \rho_{CO2} \cdot C_t \cdot \Delta P$$

where	S_i	=	Storage Capacity of unit i	[mm tonnes]
	A	=	Area of storage unit	[km^2]
	H	=	Average gross thickness	[m]
	NTG	=	Average Net-to-Gross	[frac]
	Φ	=	Average porosity	[frac]
	ρ_{CO2}	=	CO2 density at storage conditions (P_{max}, T)	[g/cc]
	C_t	=	Total compressibility ($C_f + C_w$)	[psi^{-1}]
	ΔP	=	Max. allowable pressure increase ($P_{max} - P_{int}$)	[psi]

A similar approach will be used for hydrocarbon-bearing structures by substituting the appropriate compressibility terms.

The above will be modified to include "Average Areal Net Sand" (see Pore Volume calculation).

Static Capacity (of 'open' storage unit):

S= PV x E-factor

Maximum Injection Rate

The computation of $\mathbf{M_i}$ will require an inversion of the DeltaP formula as detailed in the Technology Contract, reproduced below. This will be expanded by Mathias/ GPT and will be supplied by the Consortium.

$$\Delta P = P_0\left\{-\frac{1}{2}\ln\left(\frac{t_0}{2\gamma t_{dur}}\right)-1+\frac{1}{\gamma}-\frac{1}{2\gamma}\left[\ln\left(\frac{\alpha}{2\gamma^2}\right)+0.5772\right]+\beta\right\}$$

where

$$\alpha=\frac{M_i\mu_{CO2}C_t}{2\pi H\rho_{CO2}k},\quad \beta=\frac{M_i kb}{2\pi H r_w\mu_{CO2}},\quad \gamma=\frac{\mu_{CO2}}{\mu_{FF}},\quad P_0=\frac{M_i\mu_{CO2}}{2\pi H\rho_{CO2}k},\quad t_0=\frac{2\pi\Phi H r_w^2\rho_{CO2}}{M_i}$$

and	μ_{CO2}	=	CO_2 viscosity at storage conditions (P_{max}, T)	[Pa s]
	μ_{FF}	=	Formation fluid viscosity at storage conditions (P_{max}, T)	[Pa s]
	k	=	Intrinsic permeability	[m^2]
	b	=	Forchheimer parameter ($b \approx 0.005\Phi^{-5.5}k^{-0.5}$)	[m^{-1}]
	r_w	=	Well radius	[m]
	t_{dur}	=	Duration of injection period (say 50 years)	[s]

A6.2 Probabilistic Static Capacity

The Probabilistic computation will use a Monte-Carlo simulation. The formula will use similar to Oracle's Crystal Ball. This software will be used to quality control and benchmark any results of the project developed Monte-Carlo simulation.

The algorithm will be programmed in Java.

The input parameters to the Monte-Carlo simulation will be as follows, and include the Min, Most Likely and Max values (or alternatively, mean and standard deviation):

Mean Depth
Area
Av. Gross Thickness
Av. Areal Net Sand
Av. Vertical NTG
Av. Porosity
Expected Pore Pressure @ top reservoir at start of CO_2 injection
Fracture Pressure @ top reservoir
Formation Temperature @ top reservoir

The output of the Monte-Carlo simulation will the Storage Capacity probability values:
P_{10}, P_{20}, P_{30}, P_{40}, P_{50}, P_{60}, P_{70}, P_{80}, P_{90}

A series of statistical parameters will be calculated as follows:

No of iterations (trials)
Mean
Median
Mode
Standard Deviation
Variance

CO2 Density Look-Up Table
(grammes / cubic centimetre, or tonnes / cubic metre)

Pressure (MPa) \ Temperature (deg C)	5	20	25	30	35	40	45	50	55	60	65	70	75	80	85	90	95	100	105	110	115	120
5																						
10	0.8569	0.8180	0.7719	0.7135	0.6300	0.5001	0.3849	0.3249	0.2898	0.2657	0.2477	0.2333	0.2216	0.2116	0.2029	0.1953	0.1886	0.1825	0.1770	0.1720	0.1674
15	0.9048	0.8773	0.8477	0.8157	0.7809	0.7426	0.7003	0.6539	0.6045	0.5546	0.5069	0.4641	0.4275	0.3971	0.3718	0.3505	0.3324	0.3169	0.3033	0.2913	0.2806
20	0.9379	0.9151	0.8914	0.8666	0.8407	0.8135	0.7850	0.7552	0.7241	0.6920	0.6593	0.6265	0.5943	0.5632	0.5337	0.5062	0.4809	0.4579	0.4371	0.4184	0.4015
25	0.9637	0.9438	0.9233	0.9022	0.8804	0.8581	0.8351	0.8114	0.7872	0.7625	0.7374	0.7120	0.6865	0.6613	0.6364	0.6122	0.5888	0.5664	0.5450	0.5249	0.5059
30	0.9852	0.9672	0.9487	0.9300	0.9108	0.8913	0.8714	0.8511	0.8305	0.8097	0.7886	0.7674	0.7461	0.7248	0.7036	0.6827	0.6622	0.6421	0.6226	0.6037	0.5855
35	1.0038	0.9871	0.9702	0.9530	0.9356	0.9180	0.9002	0.8821	0.8638	0.8454	0.8269	0.8083	0.7896	0.7709	0.7523	0.7339	0.7156	0.6976	0.6800	0.6627	0.6459
40	1.0202	1.0046	0.9888	0.9729	0.9568	0.9406	0.9242	0.9077	0.8911	0.8743	0.8576	0.8407	0.8239	0.8071	0.7903	0.7736	0.7571	0.7408	0.7246	0.7088	0.6932
45	1.0350	1.0203	1.0054	0.9904	0.9753	0.9602	0.9449	0.9296	0.9142	0.8987	0.8833	0.8678	0.8523	0.8368	0.8214	0.8061	0.7909	0.7759	0.7610	0.7463	0.7318
50	1.0486	1.0345	1.0204	1.0062	0.9919	0.9776	0.9632	0.9488	0.9344	0.9199	0.9054	0.8910	0.8765	0.8622	0.8478	0.8336	0.8194	0.8054	0.7915	0.7777	0.7641
55	1.0610	1.0475	1.0340	1.0205	1.0069	0.9933	0.9796	0.9660	0.9523	0.9387	0.9250	0.9114	0.8978	0.8842	0.8708	0.8574	0.8440	0.8308	0.8177	0.8048	0.7920
60	1.0726	1.0596	1.0467	1.0337	1.0206	1.0076	0.9946	0.9816	0.9685	0.9555	0.9426	0.9296	0.9167	0.9039	0.8911	0.8784	0.8658	0.8532	0.8408	0.8285	0.8164
65	1.0834	1.0709	1.0584	1.0459	1.0333	1.0208	1.0083	0.9958	0.9834	0.9709	0.9585	0.9461	0.9338	0.9216	0.9094	0.8972	0.8852	0.8733	0.8614	0.8497	0.8381
70	1.0936	1.0815	1.0694	1.0573	1.0452	1.0331	1.0210	1.0090	0.9970	0.9850	0.9731	0.9612	0.9494	0.9377	0.9260	0.9143	0.9028	0.8914	0.8800	0.8688	0.8576
75	1.1033	1.0915	1.0797	1.0680	1.0563	1.0446	1.0329	1.0213	1.0097	0.9981	0.9866	0.9752	0.9638	0.9525	0.9412	0.9300	0.9189	0.9079	0.8970	0.8861	0.8754
80	1.1124	1.1009	1.0895	1.0781	1.0667	1.0553	1.0440	1.0328	1.0215	1.0104	0.9992	0.9882	0.9771	0.9662	0.9553	0.9445	0.9338	0.9231	0.9126	0.9021	0.8918
85	1.1211	1.1099	1.0988	1.0877	1.0766	1.0655	1.0545	1.0436	1.0327	1.0218	1.0110	1.0003	0.9896	0.9790	0.9684	0.9580	0.9476	0.9373	0.9271	0.9169	0.9069
90	1.1294	1.1185	1.1076	1.0967	1.0859	1.0752	1.0645	1.0538	1.0432	1.0326	1.0221	1.0117	1.0013	0.9910	0.9807	0.9706	0.9605	0.9505	0.9405	0.9307	0.9210
95	1.1374	1.1267	1.1160	1.1054	1.0949	1.0843	1.0739	1.0635	1.0531	1.0428	1.0326	1.0224	1.0123	1.0023	0.9923	0.9824	0.9726	0.9628	0.9532	0.9436	0.9341
100	1.1450	1.1346	1.1241	1.1137	1.1034	1.0931	1.0829	1.0727	1.0626	1.0525	1.0425	1.0326	1.0227	1.0129	1.0032	0.9935	0.9840	0.9745	0.9651	0.9557	0.9465

CO2 Viscosity Look-Up Table
(centipoise, cP)

Pressure (MPa) \ Temperature (deg C)	5	20	25	30	35	40	45	50	55	60	65	70	75	80	85	90	95	100	105	110	115	120
5																						
10	0.0958	0.0863	0.0766	0.0662	0.0543	0.0404	0.0315	0.0280	0.0262	0.0251	0.0244	0.0239	0.0235	0.0233	0.0231	0.0229	0.0228	0.0227	0.0227	0.0226	0.0226
15	0.1096	0.1014	0.0935	0.0859	0.0785	0.0713	0.0644	0.0577	0.0515	0.0460	0.0415	0.0379	0.0352	0.0332	0.0316	0.0304	0.0295	0.0287	0.0281	0.0277	0.0273
20	0.1208	0.1130	0.1056	0.0986	0.0919	0.0855	0.0795	0.0738	0.0684	0.0633	0.0586	0.0544	0.0506	0.0473	0.0444	0.0419	0.0398	0.0380	0.0365	0.0353	0.0342
25	0.1307	0.1230	0.1158	0.1089	0.1025	0.0964	0.0906	0.0852	0.0801	0.0753	0.0708	0.0666	0.0627	0.0591	0.0559	0.0530	0.0503	0.0480	0.0459	0.0440	0.0423
30	0.1398	0.1321	0.1249	0.1181	0.1117	0.1057	0.1001	0.0947	0.0897	0.0850	0.0805	0.0763	0.0725	0.0688	0.0655	0.0624	0.0595	0.0569	0.0545	0.0523	0.0503
35	0.1485	0.1407	0.1334	0.1266	0.1202	0.1142	0.1085	0.1031	0.0981	0.0934	0.0889	0.0848	0.0808	0.0772	0.0737	0.0705	0.0675	0.0647	0.0622	0.0598	0.0576
40	0.1568	0.1489	0.1415	0.1346	0.1281	0.1220	0.1163	0.1109	0.1058	0.1011	0.0966	0.0923	0.0884	0.0846	0.0811	0.0778	0.0747	0.0718	0.0691	0.0666	0.0643
45	0.1650	0.1569	0.1494	0.1423	0.1357	0.1295	0.1237	0.1182	0.1131	0.1082	0.1037	0.0994	0.0953	0.0915	0.0879	0.0845	0.0814	0.0784	0.0756	0.0730	0.0705
50	0.1730	0.1647	0.1570	0.1498	0.1431	0.1367	0.1308	0.1252	0.1200	0.1150	0.1104	0.1060	0.1019	0.0980	0.0943	0.0908	0.0876	0.0845	0.0816	0.0789	0.0763
55	0.1810	0.1725	0.1645	0.1571	0.1502	0.1437	0.1377	0.1320	0.1266	0.1216	0.1168	0.1123	0.1081	0.1041	0.1004	0.0968	0.0935	0.0903	0.0873	0.0845	0.0818
60	0.1888	0.1801	0.1720	0.1644	0.1573	0.1506	0.1444	0.1386	0.1331	0.1279	0.1230	0.1184	0.1141	0.1100	0.1062	0.1025	0.0991	0.0958	0.0928	0.0899	0.0871
65	0.1967	0.1877	0.1793	0.1715	0.1642	0.1574	0.1510	0.1450	0.1394	0.1341	0.1291	0.1244	0.1200	0.1158	0.1118	0.1081	0.1046	0.1012	0.0980	0.0950	0.0922
70	0.2046	0.1953	0.1867	0.1787	0.1712	0.1641	0.1576	0.1514	0.1456	0.1402	0.1351	0.1302	0.1257	0.1214	0.1173	0.1135	0.1099	0.1064	0.1032	0.1001	0.0972
75	0.2126	0.2030	0.1941	0.1858	0.1781	0.1708	0.1641	0.1578	0.1518	0.1462	0.1410	0.1360	0.1313	0.1269	0.1227	0.1188	0.1151	0.1115	0.1082	0.1050	0.1020
80	0.2206	0.2107	0.2015	0.1929	0.1850	0.1775	0.1706	0.1641	0.1579	0.1522	0.1468	0.1417	0.1369	0.1323	0.1281	0.1240	0.1202	0.1165	0.1131	0.1098	0.1067
85	0.2287	0.2184	0.2089	0.2001	0.1919	0.1842	0.1770	0.1703	0.1640	0.1581	0.1526	0.1473	0.1424	0.1377	0.1333	0.1292	0.1252	0.1215	0.1179	0.1146	0.1114
90	0.2368	0.2262	0.2164	0.2073	0.1988	0.1909	0.1835	0.1766	0.1701	0.1641	0.1583	0.1529	0.1479	0.1431	0.1385	0.1342	0.1302	0.1263	0.1227	0.1192	0.1159
95	0.2451	0.2341	0.2240	0.2145	0.2058	0.1976	0.1900	0.1829	0.1762	0.1700	0.1641	0.1585	0.1533	0.1484	0.1437	0.1393	0.1351	0.1312	0.1274	0.1239	0.1205
100	0.2535	0.2421	0.2316	0.2219	0.2128	0.2044	0.1966	0.1892	0.1824	0.1759	0.1698	0.1641	0.1588	0.1537	0.1489	0.1444	0.1401	0.1360	0.1321	0.1285	0.1250

Table A6-1 CO_2 Lookup Table