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PropBase Scoping Study - Hydrogeological data

Urban Geosciences and Geological Hazards Programme
Internal Report IR/06/090

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PropBase Scoping Study - Hydrogeological data

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Foreword

This report is one of several supporting reports to the PropBase scoping study (BGS Internal Report IR/06/088). The study was undertaken between September 2005 and July 2006 to define the scope for and assess the priorities for the PropBase project. The PropBase project is intended to provide information on the physical, mechanical, chemical and mineralogical properties of UK rocks and soils and their interrelationships to enable attribution of the 3D geological model and modelling of the properties themselves, and to obtain a better understanding of how these properties change as a result of geological processes. While one of the key drivers for PropBase is to allow 3D geological models to be attributed with property information there are other geoscience activities for which the availability of systematic rock property information is important. These include BGS projects such as the engineering properties of formations and projects in the Groundwater Management Programme, especially groundwater modelling projects. Information in PropBase will be a key resource for a number of sectors including radioactive waste disposal studies and ongoing enhancement of GeoSure.

Acknowledgements

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Contents

FIGURES

TABLES

1 Hydrogeological Information

1.1 BACKGROUND TO EARLY PROJECT TASKS (2005-2008)

BGS in-house datasets for the UK include aquifer properties, water quality and borehole, well and spring information for c.107,000 sites, about 97% of which are in England and Wales. These data are widely used in-house for commercial enquiries, to provide background and raw data for CR and SB projects. Some data are organised so that they can be accessed from the WellMaster relational database via the GDI platform. Digitisation of this vital hydrogeologically-oriented system is now advanced, with >80% of 10 km x 10 km sheets in England and Wales now processed (see Figure 1). However, there are a number of valuable datasets mainly, but not exclusively, located at Wallingford that are not yet subsumed into this comprehensive and flexible system, being instead located in separate databases that have accumulated *ad hoc* over many years. These databases have attributes and features not currently available within WellMaster that are useful to (and employed by) users. They need to be brought into the GDI and in some cases integrated into the WellMaster system where they can be accessed by users.

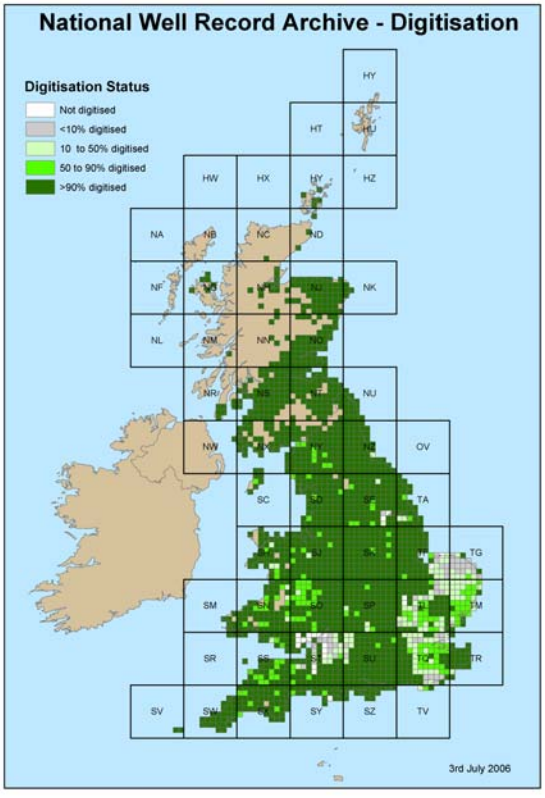

Figure 1 NWRA status, July 2006

The principal areas of information involved are aquifer properties, hydro-geophysical borehole logs and hydrogeochemical data.

1.2 AQUIFER PROPERTIES DATA

1.2.1 The aquifer properties database APD

Aquifer properties data include key parameters such as transmissivity (T), storage coefficient (S), diffusivity (D), specific capacity (Q/s), hydraulic conductivity (k) and interconnected porosity (*n*). Less widely available parameters include pore-neck size (PSD) and grain size distributions (Φ) and specific yield (S_y). Some parameters are field-derived from third parties (e.g. T and S calculated by pumping test analysis), laboratory derived from the BGS (e.g. k, n, Φ) and others could be derived as a database calculation option (e.g. D, Q/s). These parameters comprise the numerical foundation and everyday common currency for hydrogeology.

They complement other recognised WellMaster fields (such as yield (Q), drawdown (s), depth to water (RWL)) that are especially useful to the commercial enquiry service e.g. for borehole prognoses).

Major value-adding to aquifer properties datasets occurred in 1995-1996 as part of the Physical Properties of Major Aquifers co-funded project with the EA and then again in 1998 as part of the follow-up project on the Physical Properties of Minor Aquifers in England and Wales Together these projects brought together results from the six major aquifers and over 160 minor aquifers, comprising over 5,000 pumping tests at more than 4,250 sites and almost 15,000 core sample analyses from c. 960 sites. The strength of the resultant Aquifer Properties Database (APD) is that it incorporates, through a complex but well-validated querying process, a procedure for identifying the preferred value for a given test (multiple test results are not uncommon), and the preferred locality where there may be more than one site in a locality (a feature of databases compiled from more than one source). These procedures enable the better-quality tests to be chosen to represent the site values. A flowchart for selecting the preferred transmissivity is shown in Figure 22 as an example.

The APD is now more than seven years old (the major aquifers part is 10 years old) and a large number of additional test results have become available in the meantime, from the normal returns process to the National Well Record Archive (NWRA). Possibly another 2000 sets of data may be involved. These may be especially useful for the minor aquifers, many of which have scant coverage of aquifer properties values.

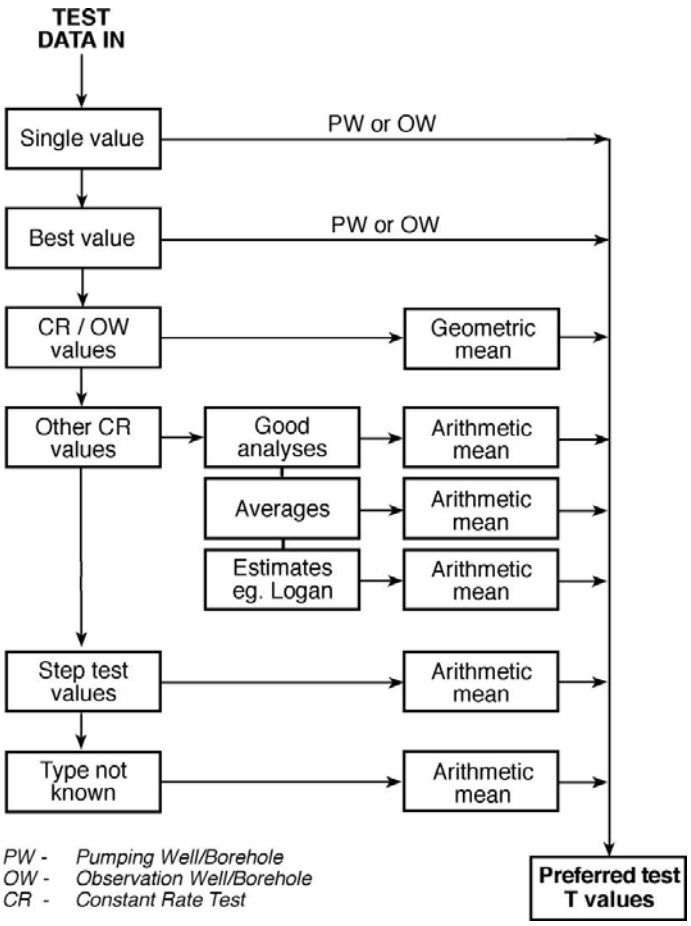

Figure 2. Flowchart that can be applied to APD to find preferred test transmissivity values for a site

Table 1, once completed, will provide an overview of the contents of the APD and of related fields in WellMaster. The derived parameter of diffusivity has not been included as the query structure to derive this parameter does not yet exist, but it could be added later.

Some data revision is reported to be necessary for the core properties part of the APD, stemming from inconsistencies noticed in use.

1.2.2 WellMaster

This comprehensive site-record oriented database is the obvious home for aquifer properties data. Figure 1 shows both the current (July 2006) progress on digitisation of records from the paper NWRA (white or grey squares versus green squares) and also the extent of the backlog for updating 10 km tiles with new records after they have been initially digitised. The updating procedure is conducted on an as-requested basis.

There is significant overlap of the raw data between the APD and WellMaster but both databases currently have drawbacks for aquifer properties data users. The APD data has been coded to permit the preferred value procedure to be applied, but the data array is quite out of date whereas the WellMaster data are generally more up to date but the preferred value procedures are not available.

1.2.3 Other datasets

Other aquifer properties data that would be of use are thought to be available but are not yet in either the APD or WellMaster. These include small datasets for a limited number of sites (PSD, S_y) at Wallingford and potentially larger but more dispersed datasets from other BGS disciplines (e.g. grain size distribution parameters such as d_{10}, d_{50}, d_{90}, derived uniformity coefficient and effective size values) like engineering geology (UGGH) and minerals assessment (EM). Value-adding uses for these data include their use for screen and gravel pack design in intergranular bedrock and Quaternary aquifers as an additional enquiries service and for CR/SB studies on recharge and associated contaminant movement.

1.2.4 Hydro-geophysical borehole logs

David Buckley has amassed a large amount of data from BGS hydro-logging activities over the last 50 years, as well as logging undertaken by, or on behalf of, the EA and water companies. The BGS logging vehicle was replaced in 2005 and has been commissioned although additional tools have yet to be purchased to increase the logging capability. The *hydro*-geophysical log data are partially integrated with the BGS RECALL (previously Wellog) database. Because of access difficulties and constraints on data fields in Wellog, a discreet database has been set up and now contains about 7000 logs from about 1060 boreholes. Data from between 30 and 50% of these have been transferred to Wellog and the remainder will be transferred to the corporate database in July 2006. All data gathered subsequently will be lodged in the RECALL database, subsequent to a protocol being established and staff trained in its use. Confidentiality is an issue with a considerable number of the logs.

Interpretation of logs for hydrogeology projects has used the VIEWLOG software package for the last 12 years. In 2004, this software was also purchased for use by staff in Keyworth. A considerable body of interpreted data now exists, comprising –

- Geological interpretations and cross-sections
- Horizons of active groundwater flow
- Hydrogeological cross-sections, including potentiometric levels and vertical flow direction.
- Detailed multi-borehole site interpretations

- Conductivity/temperature distribution and some water quality parameter logs
- Logging project reports and logging sections in other reports.

Derived data need to be extracted from the logs for inclusion in other databases – locations, stratigraphy, water levels (temporal), water quality, fracture distribution etc.

1.3 HYDROGEOCHEMICAL DATABASES

These databases are in an advanced state of development as are the plans for their integration into the corporate system and for access via the GDI and the Groundwater (or other BGS) Portal.

1.3.1 Groundwater Quality

BGS groundwater quality analyses carried out over the last 40 years, are held in three databases. The data are being validated and will be combined into one database prior to being linked to the "Groundwater Chemistry Data Warehouse", (GCDW) the repository for validated data. It is planned that the data will be ready by the end of March 2006 and the code for transfer will be developed and tested by May 2006.

A second stream of data comprises that collected over the years from EA, water companies etc. This includes profile and time-series data, some of which has already been transferred to the GCDW. Ownership and confidentially issues are addressed here. It is planned that all water quality data in WellMaster (some in arcane units) will also be stored in the GCDW.

The GCDW will be the source of data for queries relating to location, determinand, formation, time series etc., via the GDI and the Groundwater (or other BGS) Portal.

1.3.2 Geochemical properties

Phase 4 of this project to prepare a geochemical properties manual is nearing completion, the products being delivered in 2006-07. The project has been devised for digital and extranet delivery of products through the Geochemical Properties Interface (GPI) so is in line with, and could act as a model for, delivery of other PropBase data sets. The GPI not only allows access to the data base but also the ability to statistically manipulate and plot data. An initial extension of this interface is to incorporate the physical properties data

2 Ways forward

The delivery mechanism for PropBase, as with other datasets, is understood to be through the GDI. The GDI will continue to evolve towards a web-based system accessible through the internet/extranet as well as the intranet. Data will be stored on the IDA and databases will form a live basis for interrogation and presentation, including value-added interpretation to a range of levels. One route to access relevant information will be through the Groundwater Portal.

Tasks to achieve the objectives of PropBase therefore fall into three categories, the first two needing to be integrated into the BGS Information Structure to ensure compatibility and to avoid duplication, and the third requiring iteration with the other two:

- Entering current and backlog data into **databases**
- Continued development of **systems** to facilitate access to data, either in its raw form or as derived datasets, maps etc
- Develop the "**user end**" of the system to produce queries to service both internal and external enquirers, e.g. enquiries service, water companies, EA, consultants.

These categories are summarised in Table 2, and tasks have been identified that can be tackled in the short and medium-term, as well as ongoing.

Task G (for groundwater) 8 has been identified at the first priority to test the ability to draw together disparate data sets and to stimulate cross-BGS collaboration with a view to testing the use of the data and the scales to which they can be extrapolated.

Other high priority tasks are G1, G6, G9

Table 1 Overview of BGS aquifer properties digital datasets in England & Wales

Parent dataset	Data type	Statistic required	Count	Explanatory comments
Aquifer Properties Field values	Pumping tests	No. of tests assessed	*	Tests that have been selected under preferred test procedures to produce a T, S or Q/s
		No. of preferred test values	*	May or may not be same as total no. of tests assessed
	Transmissivity T	No. of T values	*	
		No. of preferred test T values	*	Covers tests that have undergone preferred test procedure and produced a T
		No. of localities	*	
		No. of preferred locality T values	*	Covers tests that have undergone preferred locality procedure and produced a T
		No. of aquifers named	*	This means no. of different formations/strat. names identified, not the number of times
		No. of T values unascribed	*	All recorded T values with no aquifer/formation name description
		No. of T localities unascribed	*	All recorded T localities with no aquifer/formation name description
	Storage coefficient/ Storativity S	No. of S values	*	
		No. of preferred test S values	*	Covers tests that have undergone preferred test procedure and produced an S
		No. of localities	*	
		No. of preferred locality S values	*	Covers tests that have undergone preferred locality procedure and produced an S
		No. of aquifers named	*	This means no. of different formations/strat. names identified, not the number of times
		No. of S values unascribed	*	All recorded S values with no aquifer/formation name description
		No. of S localities unascribed	*	All recorded S localities with no aquifer/formation name description
	Specific capacity Q/s	No. of Q/s values	*	
		No. of preferred test Q/s values	*	Covers tests that have undergone preferred test procedure and produced a Q/s
		No. of localities	*	
		No. of preferred locality Q/s values	*	Covers tests that have undergone preferred locality procedure and produced a Q/s
		No. of aquifers named	*	This means no. of different formations/strat. names identified, not the number of times
		No. of Q/s values unascribed	*	All recorded Q/s values with no aquifer/formation name description
		No. of Q/s localities unascribed	*	All recorded Q/s localities with no aquifer/formation name description
Aquifer Properties Lab. Values	Matrix permeability k	No. of k values	*	All k_h and k_v
		No. of k_h values	*	All k_h
		No. of k localities	*	All sampling sites
		No. of preferred locality k_h values	*	Covers tests that have undergone preferred locality value procedure and produced a k_h mean
		No. of aquifers named	*	This means no. of different formations/strat. Names identified, not the number of times
		No. of k values unascribed	*	All recorded k values with no aquifer/formation name description
		No. of k localities unascribed	*	All recorded k localities with no aquifer/formation name description
	Interconnected porosity *n*	No. of n values	*	All n
		No. of n localities	*	All sampling sites
		No. of preferred locality n values	*	Covers tests that have undergone preferred locality value procedure and produced a n mean

		No. of aquifers named	*	This means no. of different formations/strat. Names identified, not the number of times; NOTE; AAM advises this task requires more rigorous assignment of units
		No. of n values unascribed	*	All recorded n values with no aquifer/formation name description
		No. of n localities unascribed	*	All recorded n localities with no aquifer/formation name description
	Pore-neck size distribution PSD	No. of PSD values	*	All PSD
		No. of PSD localities	*	All sampling sites
		No. of aquifers named	*	This means no. of different formations/strat. names identified, not the number of times
		No. of k values unascribed	*	All recorded Φ values with no aquifer/formation name description
		No. of k localities unascribed	*	All recorded Φ localities with no aquifer/formation name description
	Specific yield S_y	No. of S_y values	*	All S_y
		No. of S_y localities	*	All sampling sites
		No. of aquifers named	*	This means no. of different formations/strat. names identified, not the number of times
Other lab. values	Grain size distribution Φ	No. of Φ values	Not yet	All Φ sets. This needs to be better defined to provide useable data e.g. the d_{50} or d_{90} or d_{40}/d_{90} uniformity coefficient rather than % retained/% passed raw numbers
		No. of Φ localities	Not yet	All sampling sites with one or more sets of Φ
		No. of aquifers named	Not yet	This means no. of different formations/strat. names identified, not the number of times
Well-master		No. of tests available	*	Tests BGS is aware/has been notified of e.g. by EA, drillers. Can be just yield tests or pumping tests
	Yield (Q)	No. of Q values	*	
		No. of localities	*	
		No. of aquifers named	*	This means no. of different formations/strat. names identified, not the number of times
		No. of Q values unascribed	*	All recorded Q values with no aquifer/formation name description
		No. of Q localities unascribed	*	All recorded Q localities with no aquifer/formation name description
	Yield & 1 drawdown value	No. of Q-with-s values	*	This group to capture Q/s independently of APD
		No. of Q-with-s localities	*	
		No. of Q-with-s aquifers named	*	
		No. of Q-with-s values unascribed	*	
		No. of Q-with-s localities unascribed	*	
	Yield and multiple drawdown values	No. of Q-with-time-series s values	*	This group to capture pumping tests not in APD, both analysed and raw data
		No. of Q-with--time-series s localities	*	
		No. of Q-with--time-series s aquifers named	*	
		No. of Q-with--time-series s values unascribed	*	
		No. of Q-with--time-series s localities unascribed	*	

* Please insert value

Table 2 Summary list of databases, systems and user needs

Item	Comment	Tasks
Databases		TASKS FOR PROPBASE IN RED
Aquifer properties, field	Field studies (FRACFLOW, LOCAR etc) have produced variety of data (packer, tracer, slug tests etc.) that need to be captured in the AP database. Also new pumping test data that may or may not have been analysed. Summary data from APM is to be made available via the groundwater portal.	Clean datasets to resolve known and unknown errors. (BLM, DJA). Get pump test data interpretations from EA or interpret. G1. Review litho-strat framework within APM and update (CSC, MAL)
Aquifer properties, laboratory	Out of date and also needs to draw on NIREX data	The laboratory database needs to be extended to accommodate Phys. Props data (AAM, JCT) and populated (MJB, ASB)
Derived data	Data from grids in models (T & S, for example) should be data based.	G2. Scope the availability of data and develop system into which it can be captured (???).
WellMaster	Population from groundwater archive continuing	In hand
Hydro-geophysical borehole logs	WL logs are on spreadsheet and some are integrated into WELL-RECALL	Train staff (ISW, AJGA) in the use of RECALL and how to enter data as they are collected. Transfer backlog of logs at WL. (ISW)
Groundwater quality analyses	GW quality data will be accessible by the end of June 2006.	In hand
Geochemical properties	Geochemical Properties database being developed as part of co-funded project due to finish in 2006.	In hand
Fracture distribution	Some data in Hydro and elsewhere in BGS. Needs to be drawn together.	G3. Scope scale of dataset, how and where it can be incorporated. This should be led from KW with JPB as the contributor in WL
Systems development		
Preferred results	Preferred T, k, S, Q/s, porosity results from a site are selected using a set of rules.	Review rules and make dynamic (AAM, JCT). Develop a query to generate Q/s (AAM)
National predictions	Depth to water table and fluctuations. Potentiometric heads and artesian flow	In hand
Groundwater quality/ Geochemical properties – Physical properties.	Groundwater quality data (NO_3, HCO_3, Cl) will be accessible by the end of June 2006. Geochemical Properties (cation exchange etc.) database being developed as part of co-funded project due to finish in 2006. This has been developed with a view to incorporating physical	Continue refinement of geochemical properties system. G4. Review Q/S methodology and relationships in light of new data and understanding. Develop on-line system for use by enquiries staff (BLM).

	properties data. This could be used as a model for accessing all PropBase data.	G5. Develop Q/S query layer for Physical properties data on WellMaster (AAM, CJM).
Meta-data	Multiple investigations at a site often provide most useful data (core logging, porewater analysis, geophysical logging etc). These need to be accessed easily for comparison.	Develop system that will identify all data sets that are available at a site and provide links.
Integration into corporate systems	Seamless with Geohazards, Lithoframe etc.	Consult with project leaders/programme managers
User needs/tools	Initial ideas are listed below. These needs to be consolidated and expanded	G6. Consult with users, both internal (enquiries staff, modellers) and external (water companies, EA and consultants). (ING).
WellMaster scans	Need to be available on GDI along with logs stored at KW	Make it so (AAM)
APMs data + derived information	PDF versions of these reports are available through the Groundwater Portal.	APMs data to be available through WellMaster once a browser is developed – summary data in June 2006 and full data access in Nov. 2006 (AAM, JCT).
Q/s data and derived information	Relationships for different formations developed by Dick Monkhouse in 19??. Needs to be revised and automated.	See Systems Development
Distribution of T in the Chalk aquifer	Variation, both laterally and vertically poorly understood. Also temporal variation (Changing water levels) poorly understood. This can be moved forward by using recently available datasets and statistical methods to produce an improved understanding and, possibly automated, estimation of T at selected locations.	G7. Re-examine T and Q/S datasets to produce "preferred values" at different water levels. Statistically determine the factors having the greatest influence on T. Assess the validity of the methodology on a test area, and compile a report (HKR + stat'n).
Porosity distribution	Porosity is measured at the sample, borehole and 'rock volume' scales using laboratory, geophysical and aquifer testing methods. Integration and comparison of these data will provide insight into scale dependency and confidence limits. Results are vital for volume attribution in lithoframe and hence models.	G8. Scope project and trial area in the Sherwood Sandstone where ideas can be developed and tested. Undertake study drawing together different disciplines to produce report assessing the possibilities and limitations for wider application to other areas and formations. (ING, CSC)
Hydro-geophysical logs – scans and digital logs.	All logs should be viewable through GDI and this should be simple once they are in RECALL	Add link to WellMaster browser (AAM).
Hydro-geophysical logs – derived information	Litho-strat. Interpretation. Water level (temporal). Porosity distribution. Temperature data. %ge clay etc., composite interpretations and cross-sections.	G9. Scope the scale of the task of making interpreted (e.g. cross-sections, photos etc.) data accessible (ING).
Groundwater Quality	Searchable by location, parameter (NO_3, HCO_3, Cl, etc.), time series (NO_3, etc.)	Will use the geochemical properties system when the data are available.
Geochemical properties	Searchable by location, parameter (Cation exch. etc.)	Done.
Water level reports	Searchable by location	Add to WellMaster browser (AAM).

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