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The SADC Groundwater Data and Information Archive, Knowledge Sharing and Co-operation Project: Final Report

Groundwater Science Programme

Open Report OR/11/010

BRITISH GEOLOGICAL SURVEY

GROUNDWATER SCIENCE PROGRAMME

OPEN REPORT OR/11/010

The SADC Groundwater Data and Information Archive, Knowledge Sharing and Co-operation Project: Final Report

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Keywords

Report; keywords.

Front cover

Windlass on well in the Molopo Valley near Werda, southern Botswana, January 1973

Bibliographical reference

DAVIES J, COBBING J, ROBINS N S AND TALBOT J C. 2010. The SADC Groundwater Data and Information Archive, Knowledge Sharing and Co-operation Project: Final Report. *British Geological Survey Open Report*, OR/11/010. 31pp.

Keyworth, Nottingham British Geological Survey 2011

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The "SADC Groundwater Data and Information Archive" was funded by the German Federal Ministry for Economic Cooperation and Development (BMZ) in delegated cooperation with the UK Department for International Development (DFID) and the Australian Agency for International Development (AusAID), and implemented by the Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) under their Transboundary Water Management in SADC programme.

Commissioned by: **In Delegated Cooperation with:**

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Acronyms

AEGOS	European Union African-European Georesources Observation System
ASP	Active Server Pages
BGR	German Geological Survey
BGS	British Geological Survey
BRGM	French Geological Survey
CEH	Centre for Ecology and Hydrology
CFML	ColdFusion Markup Language
DFID	Department for International Development (UK)
D.R.C.	The Democratic Republic of Congo
EU	European Union
GB	Gigabyte
GIZ	German Development Cooperation
GSSA	Geological Society of South Africa
GW	Groundwater
HTML	HyperText Markup Language
IAH	International Association of Hydrogeologists
IPR	Intellectual Property Rights
IPs	Internet Protocol
ISO	International Standards Organisation
JSP	JavaServer Pages
KAR	Knowledge and Research
MB	Megabyte
MDGs	Millennium Development Goals
MySQL	My Structured Query Language
NERC	National Environment Research Council
OCR	Optical Character Recognition
ODA	Overseas Development Administration (UK)
PDF	Portable Document Format
PHP	PHP: Hypertext Preprocessor
RAD	rapid application development (platform)
SADC	Southern African Development Community
SAN	Storage Area Network
UKAID	formerly the Department for International Development (UK)
UNEP	United Nations Environment Programme

URL	Uniform Resource Locator
WAI	Web Accessibility Initiative
WRC	Water Research Commission (of SouthAfrica)
W3C	World Wide Web Consortium

Summary

The Southern African Development Community (SADC) Groundwater Data and Information Archive, Knowledge Sharing and Co-operation Project, funded by the German Development Cooperation (GIZ) and Department for International Development, UK (DFID), was initiated in September 2009 to identify, catalogue and subsequently promote access to the large collection of reports held in the UK by the British Geological Survey (BGS). The work has focused on a wealth of unpublished so-called “grey” data and information which describes groundwater occurrence and development in Southern Africa and was gathered by the BGS over its many decades of involvement in the region.

The project has four main aims:

- To catalogue and describe the "grey data" documents on SADC groundwater held by the BGS within a digital metadatabase.
- To identify a sub-set of scanned documents to be made freely available to groundwater practitioners and managers in the SADC region by electronic distribution.
- To link the metadatabase and digital sub-set of documents via a web portal hosted by the BGS, to enable download of documents by SADC groundwater workers.
- To strengthen links between BGS hydrogeologists with counterparts in SADC, and provide an example of groundwater data sharing which could be emulated by other European Geological Surveys with substantial data holdings on SADC groundwater.

The project has successfully met these aims. The assessment of BGS archived material produced an electronic meta-database describing 1735 items held in hard copy. Of these, 1041 have been scanned digitally to searchable Portable Document Format (PDF) format. A subset of 655 PDFs including partial documents related to groundwater development from the colonial and post independence period as well as BGS internal project reports and reports approved for web dissemination by host countries are now available to download (free of charge) at http://www.SADCgroundwaterarchive.com . Initial results indicate a good deal of interest both from within SADC and elsewhere, accessed by directly addressing the website and via a search engine such as Google. The information presented has already been used by in-region projects such as the SADC Hydrogeological Mapping project and the Malawi Water Assessment Project.

This is essentially a pilot project providing an example of how Web delivery of the archive is an important step forward for the well-being of the SADC region. It permits access to documents few even new existed and will, it is hoped, provide a valuable dataset that should inhibit the temptation to waste scarce resources by ‘re-inventing the wheel’.

1 Introduction

The Southern African Development Community (SADC) Groundwater Data and Information Archive, Knowledge Sharing and Co-operation Project, funded by the German Development Cooperation (GIZ) and the Department for International Development, UK (DFID), was initiated in September 2009 to identify, catalogue and subsequently promote access to the large collection of reports held in the UK by the British Geological Survey (BGS). The work has focused on a wealth of unpublished so-called "grey" data and information which describes groundwater occurrence and development in Southern Africa and was gathered by the BGS over its many decades of involvement in the region.

Although much effort had been expended on the development of groundwater supplies during the International Decade for Clean Drinking Water, 1981-1990, little scientific and technical information had been systematically collected to advance knowledge of the occurrence, development or sustainability of such resources. Many thousands of boreholes have been drilled, and wells and spring systems installed. However emphasis appears to have been placed upon delivery at the expense of understanding the geometry of the resource, something that engineers would always strive to understand when building dam projects but fail to do when developing groundwater systems as they are out of sight and, therefore, difficult to describe accurately in mathematical and engineering terms.

The advent of the Millenium Development Goals (MDGs) especially in Southern Africa highlighted the importance of groundwater to the wellbeing and economy of rural areas in sub-Saharan Africa and elsewhere in the developing world. With the advent of general computer use since 1995, reports have been produced mainly in digital as well as paper copy formats. Many of these reports are now available via the world-wide-web especially where subject to freedom of information legislation. Recently qualified hydrogeologists are familiar with this vast post-1995 resource but are often unfamiliar with the pre-1995 literature and experiences generated by researchers and development professionals who undertook studies and the development of groundwater resources during the 1960-1995 era. Various publishers are currently looking at making their pre 1995 issues of journal papers and books available via web sites through the process of Optical Character Recognition (OCR) scanning and delivery in Portable Document Format (PDF) format. However, much material from the pre-1995 era remains to be digitised, especially so called grey data locked away in government, institute and consultant archives.

1.1 SADC SITUATION

As part of its water development strategy the SADC established a Groundwater Section, initially based in Maseru in Lesotho but now located in the SADC secretariat in Gaborone, Botswana. The SADC groundwater section has addressed aspects of groundwater including the availability of data in each country, the status of mapping, water level and water quality monitoring.

Safe and reliable water supplies are needed for growth and development in the SADC region. Most people in the SADC region rely on groundwater resources (wells, boreholes or springs) for their drinking water, and many small towns and irrigation schemes depend on groundwater. Groundwater resource development and appraisal in SADC needs improved data and technical information to reduce the costs of development and management the resource in a sustainable manner, especially as demand increases and climate change adds uncertainty to resource planning.

A lot of useful and relevant information on groundwater in the SADC region is held in the form of reports, maps and datasets by institutions outside Africa, such as the BGS. Unfortunately, much of this material was not published and is now difficult to obtain. It is sometimes difficult to know exactly what is available as some early groundwater studies are now all but forgotten. These materials, collectively known as “Grey Data” or “Grey Literature”, include unpublished books, reports, maps, notes and datasets which, whilst theoretically available, are in practice difficult to obtain. Much of this material may not be in an accessible format as grey data are commonly found only as fragile paper copies, since much of the work reported was done before the common use of computers. The BGS has collected 1735 “grey data” items relating to groundwater in the SADC countries. Much of this material is not confidential since it was gathered in partnership with an African government or organisation rather than for commercial gain. However, it is not easy to access. SADC cannot afford to duplicate work which has already been done.

1.2 BRIEF PROJECT DESCRIPTION

The German Development Cooperation (GIZ) supported the 18 month project entitled “Groundwater Knowledge Sharing and Cooperation in SADC” through funding provided by the UK DFID (UKAID). The project, begun in July 2009, was completed at the end of December 2010. The project had the following tasks, as specified in the contract terms of reference:

1. To catalogue and describe the "grey data" holdings on SADC groundwater held by the British Geological Survey (BGS). A database ("the metadatabase") of the items will be compiled describing the subject area of each, the geographical area and aquifer type covered, the country or countries referred to, and other information.

2. To identify a sub-set of the grey data holdings (at least 500 items) which can be made freely available to groundwater practitioners and managers in the SADC region, and to scan, digitize or otherwise digitally reproduce the items so that they can be distributed electronically.

3. To link the metadatabase and the digital sub-set of grey data holdings with a suitable web portal hosted by the British Geological Survey, so that the metadatabase can be viewed and the sub-set of digital items freely downloaded by SADC groundwater workers.

4. To link BGS hydrogeologists with counterparts in SADC, and provide an example of groundwater data sharing which could be emulated by other European Geological Surveys with substantial data holdings on SADC groundwater.

The Groundwater Knowledge Sharing project was led by the British Geological Survey (Mr Jeff Davies and Dr Nick Robins) and supported by Water Geosciences Consulting in South Africa (Mr Jude Cobbing and Dr Kevin Pietersen). Dr Shafick Adams of the South African Water Research Commission (WRC) assisted the study by linking the project with current SADC research priorities. The WRC supported a pilot phase of the project, which led to initial agreements with BGS, and the approach to GIZ for support.

A SADC Groundwater Institute is currently being set up, with EU assistance. This Institute will be based in Bloemfontein in South Africa, adjacent to the existing Institute for Groundwater Studies (IGS) at the University of the Free State. It is envisaged that the SADC Groundwater Institute (when operational) will assist with dissemination of the Groundwater Knowledge Sharing project results, and with coordination of research.

1.3 DELIVERABLES

The project started in June 2009 and was completed eighteen months later in December 2010. The following deliverables were planned to be produced by the project (Table 1).

Table 1 Planned Project Deliverables

Deliverable	Due date
Interim project report describing progress to date.	April 2010 (month ten)
Comprehensive metadatabase of BGS grey data holdings on groundwater in the SADC region.	June 2010 (month twelve)
Linking of the metadatabase to a suitable web portal.	December 2010 (month eighteen)
Linking of an electronically available sub set of the grey data holdings to the web portal, where they can be freely downloaded. This sub set will comprise no less than 500 items. The BGS will endeavour to maintain the web portal for a maximum of ten years from date of project completion.	December 2010 (month eighteen)
Dissemination of the project outputs, and exploration of further phases of the project involving other European geological surveys, most likely under the AEGOS initiative.	December 2010 (month eighteen).
Final project report describing the project in full, and making recommendations for future partnerships with other geological surveys.	December 2010 (month eighteen)

1.4 PROJECT STATUS

Work undertaken during the project period is listed in Table 2.

Table 2 Project Activities

#	Task	Progress
1	Catalogue and describe "grey data" holdings on SADC at BGS	Catalogue (metadatabase) of "grey data" items produced containing 1735 documents.
2	Identify sub-set of data to be made available for distribution	A sub-set of 655 documents were selected from the 1041 items scanned in searchable PDF format for presentation on the web site.
3	Linking of metadatabase and scanned items to web portal	Following discussions with BGS data and web portal manager in October 2010, the website structure was based upon that used by the existing BGS portal.
4	Links with SADC hydrogeologists, and work towards follow-on project	The project has been described to consultants on the EU funded SADC hydrogeological map project and SADC hydrogeologists at a seminar on 8 October 2009 in Gaborone. Progress was described to a meeting of SADC/GIZ on 24th November 2009. Dr Nick Robins (BGS) presented a paper describing the project at the November 2009 groundwater conference of the Groundwater Division of the Geological Society of South Africa, in Somerset West, Western Cape, South Africa. There, the project was discussed with a wide range of professionals from the subcontinent; the paper forms part of the conference proceedings. The content of the project was discussed with German Geological Survey (BGR) in Hanover with possible collaboration on an expanded metadatabase. Project progress during the data collection phase was presented to GIZ/SADC at a meeting in Gaborone on 27th April 2010. The project website structure and content were described to GIZ/SADC at a meeting in Gaborone in December 2010. An updated version of the website will be presented to a wider African and International audience at the joint International Association of Hydrogeologists (IAH)/ Geological Society of South Africa (GSSA) meeting planned to be held in Pretoria during September 2011. Articles and papers describing the project are listed in the reference section.

Most of the actual work was undertaken by the BGS, as the lead organization in this project. The project comprised four main tasks, as shown in the activity schedule (Figure 1).

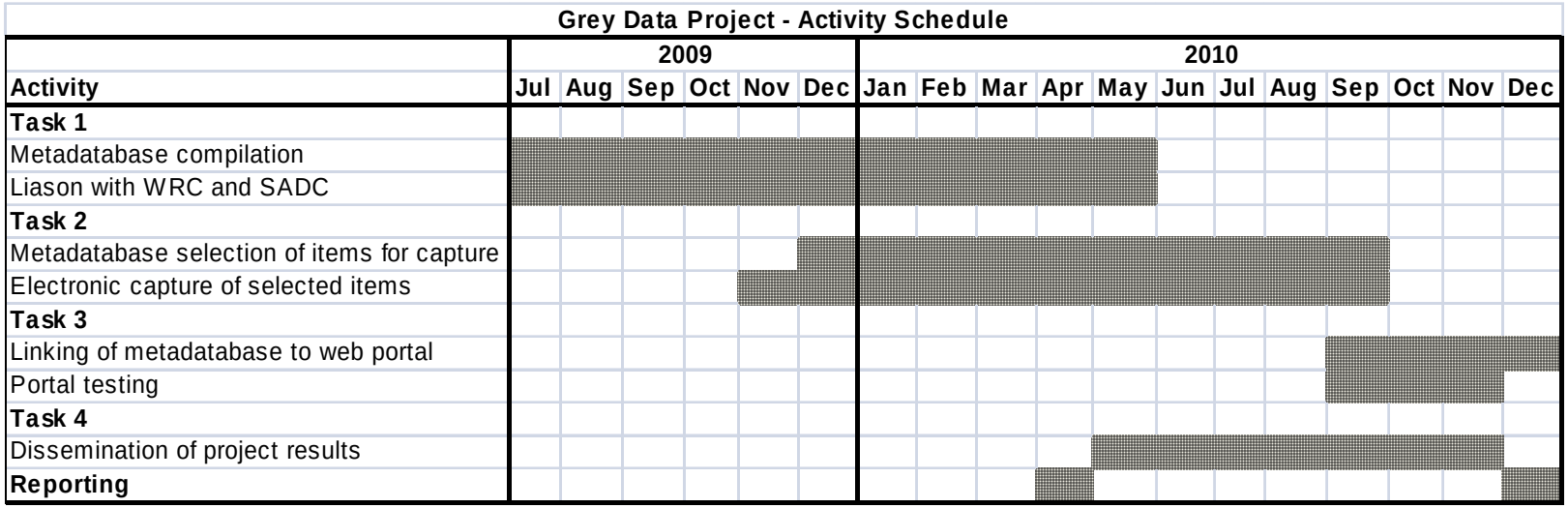

Figure 1 Project Activity Schedule Gantt Chart

2 SADC Groundwater Archive Compilation

2.1 THE BGS SOUTHERN AFRICA GROUNDWATER ARCHIVE

The original documents are held in two BGS repositories. Historical documents mainly dating from the 1890-1970 colonial and post-colonial eras are held at the main BGS library at Keyworth. Project reports and related data analyses produced by BGS hydrogeologists working in SADC countries subsequent to 1970 are held in the groundwater archive at Wallingford. The information in these collections documents the history of groundwater use and the development of hydrogeology as a science within the SADC community of nations. Of particular note are methods used to assess groundwater resource potential and specifically the development and exploitation of the Precambrian Basement Complex aquifers within eastern and southern Africa.

2.2 KEYWORTH DOCUMENTS

Holdings at the BGS library in Keyworth mainly relate to records derived from the geological survey departments of former British colonial territories (Table 3).

Table 3 Number of documents per country obtained from the Keyworth library colonial archive.

Country	Documents	From	To
Angola	13	1961	1972
Botswana	59	1951	1997
D.R. Congo	12	1939	1966
Lesotho	17	1946	1963
Malawi	78	1923	1983
Mozambique	8	1912	1977
Namibia	5	1934	1965
Swaziland	48	1943	1989
Tanzania	28	1930	1960
South Africa	139	1896	2001
Zambia	40	1939	1966
Zimbabwe	14	1924	1998
Totals	461		

The large mass of information from South Africa reflects interest both in the mineral extraction sector and provision of groundwater for township and agricultural supply within that country. Elsewhere, holdings from Botswana, Lesotho, Malawi, Swaziland, Tanzania, Zambia and Zimbabwe reflect the presence of British geologists on the staff of the geological surveys of these countries during colonial and post colonial periods. Whilst these geologists were primarily employed on field geological mapping, they were also required to locate sites for water borehole drilling. These records enable the development of groundwater resources within southern and eastern Africa during the 1920-1970 period to be charted, especially the use of geophysical survey methods for borehole site location.

The Keyworth documents provide insight into the importance of groundwater to the economic development of the former British colonial territories. At that time, the exploration and development of groundwater held within weathered and fractured basement complex rocks that underlie much of these countries was undertaken primarily by geological survey departments for departments of water, irrigation and public works. Early electrical resistivity apparatus was used to locate borehole sites subsequently drilled using steam driven drilling rigs. Boreholes and wells were located mainly as sources of water for townships, railways and cattle trek routes.

2.3 WALLINGFORD DOCUMENTS

Holdings at the BGS archive in Wallingford mainly relate to records derived from the secondment of UK hydrogeologists to various geological surveys during the post-independence period and to BGS research activities within the region (Table 4).

Table 4 Number of documents per country obtained from the Wallingford archive.

Country	Documents Collected	Documents Scanned as PDF	From	To
Angola	15	8	1989	2005
Botswana	293	103	1956	2008
D.R. Congo	5	2	1957	2005
Lesotho	59	9	1970	2004
Madagascar	90	68	1921	2008
Mauritius	7	3	1989	2003
Malawi	143	65	1965	2004
Mozambique	13	10	1987	2002
Namibia	49	15	1967	2004
SADC	93	25	1948	2007
Seychelles	6	2	1974	2002
Swaziland	10	5	1977	1989
Tanzania	73	39	1927	2005
South Africa	127	61	1976	2008
Zambia	50	25	1970	2005
Zimbabwe	241	149	1961	2002
Totals	1274	589		

The total number of references per country reflects BGS secondment and research activities. During the 1970-1984 period numbers of BGS hydrogeologists were seconded to posts in Botswana, Malawi, Swaziland and Zimbabwe. Research activities predominated during the 1980-2000 period in Botswana, Lesotho, Malawi, Tanzania, Zambia and Zimbabwe, mainly investigating the weathered Basement aquifer systems and rural water supply options. During this period, several international organisations funded the compilation of Water Master Plans at national and district levels notably in Zambia, Botswana, Zimbabwe and Tanzania. Activities within the 2000 to present period have concentrated upon participation in various SADC projects with in-region partners.

It is envisaged that the Groundwater Knowledge Sharing project will provide a detailed picture of how groundwater resources development methodologies evolved within the British colonial territories of Southern African region. Parallels can be drawn between these developments and those evolving within the Francophone countries of west and central Africa at the same time. Therefore, this project will hopefully pave the way for a follow-on project with a wider geographical remit, possibly involving other European geological surveys (particularly the French Geological Survey (BRGM) and the German Geological Survey (BGR)). It is hoped that further funding via the European Union African-European Georesources Observation System (EU AEGOS) project may be realized for this follow-on project. The Groundwater Knowledge Sharing project will demonstrate workable approaches to issues including portal architecture, intellectual property and collaboration with regional partners, and will serve as a template for the follow-on project.

The Wallingford documents provide information on groundwater exploration, research and development in the SADC region countries especially where BGS hydrogeologists were seconded to support activities within geological surveys. Major projects were undertaken in Malawi, Zimbabwe and Botswana where studies were made of groundwater occurrence in weathering profiles and fractures in Basement Complex aquifers. Assessment of reports from other SADC countries indicate that similar studies were undertaken at that time by Scandinavian consultants in Tanzania, by Portuguese hydrogeologists in Mozambique and French workers in Madagascar and elsewhere.

A metadatabase of hydrogeological materials from SADC constituent countries held at the BGS library in Keyworth and the groundwater archive in Wallingford was compiled. The metadatabase lists 1735 hard copy grey data items of which 1041 are held in PDF format. The complex issues regarding the copyright of such a large number of diverse provenance is discussed in section 4.4. These items are listed within a Microsoft Excel metadatabase that mainly includes:

- BGS research and country visit reports
- Materials collected by BGS hydrogeologists for projects undertaken
- Materials donated to the BGS library by SADC government institutions during the colonial and post colonial era
- Books and journal papers from the pre-1940 era that are now out of copyright
- Listed references to post 1940 published material of limited availability derived from country visits

The archive does not include numerical databases, and international published materials such as journal papers, maps and books produced during the last 50 years.

The overall objective of the Groundwater Knowledge Sharing project is to allow wider access to data and information on SADC groundwater, currently held by the BGS. The chief indicator of this will be a web portal allowing access to the metadatabase and the sub-set of scanned items. A further indicator of project success was the constructive discussion held with BGR representatives, with agreement in principle to continue working towards the project objective. The indicators of progress are:

- Catalogue of “grey data” items compiled within EndNote and Excel software
- A sub-set of items identified for wider distribution, and preliminary document scans as PDFs completed
- Liaison with SADC hydrogeologists

3 Metadatabase and Document Scanning

3.1 METADATABASE FORMULATION

The quantity and nature of "grey data" holdings for the various SADC countries on groundwater are highly variable. There is comparatively little data for some countries (e.g. D.R.C.), and a considerable amount for other countries (e.g. Botswana and South Africa). The data held at the BGS is naturally drawn from those (mainly Anglophone) countries where BGS staff have worked. It is likely that "grey data" holdings at other European geological surveys will have a slightly different profile, and that engagement with these surveys in future will help to address the lack of data for some of the SADC countries.

The archive was initially listed within EndNote, a commercial reference management software package, which contained links to the PDF files. To facilitate the transfer of the references from EndNote to an Oracle database, used to store the references for the website, the data was exported to Microsoft Excel. From the metadatabase of 1735 items a subset of 655 was selected for presentation on the website. These items had to be single PDFs and less than 100 MB in size.

3.2 DOCUMENT COLLECTION AND SCANNING

During July discussions held with the IT and reproduction sections of BGS indicated that the format of the proposed web site would be based upon a web site developed by BGS for the for the presentation of international reports for DFID-KAR. A similar web site has also been prepared by BGS for the Geological Survey of Afghanistan. The diverse nature of archive holdings at Keyworth and Wallingford, the necessity for partial document photocopying and scanning in numerous cases precluded the scanning of documents en-mass by a commercial organisation. Document selection, copying and scanning proceeded on an ad hoc basis until, by the end of August 2010, the project grey data holding had reached 1735 items of which 1041 had been scanned in PDF format. These scanned items were then subjected to quality control procedures designed to assess the quality of scanned text, to straighten the text pages and make the scanned text readable and searchable for key words. Items that need to be rescanned were identified. This process also included the combination of partial document PDFs to form single items and undertake size reduction to conform with the limit for single items imposed by the web site.

Problems experienced during the scanning process included:

- Poor quality typed text– the character recognition software employed had difficulty in recognising text characters.
- Book bindings especially on rebound books with tight bindings – proved difficult to scan books without damaging bindings, partial opening of volumes leads to fade out of text on inner margins.
- Thin "flimsy" paper especially on single copy reports – can be difficult to scan especially double sided pages.
- Ideally need to scan originals after removing any binding, but mainly had to resort to scanning photocopies to preserve the originals.

3.3 PORTABLE DOCUMENT FORMAT (PDF) FILES

The 1735 collated documents listed in the metadatabase are available in up to three formats (Table 5).

- The 1735 grey data documents are available in hard copy format with the number of documents held for each SADC country are listed in column 2.
- The total number of scanned PDF documents held for each country, including oversize and multi-part PDFs still to be made available on the website, are listed in column 3.
- The numbers of scanned PDF format documents per country currently available on the website for download are listed in column 4.

As some documents in the metadatabase refer to more than one SADC country the actual number of unique documents for each category above is is lower than the totals.

Table 5 Number of documents per country within the metadatabase, in scanned format and presented on the web-site.

Country	Documents in Metadatabase	Documents Scanned as PDF	PDF Documents on Website
Angola	31	22	14
Botswana	356	166	88
D. R. Congo	19	16	12
Lesotho	76	26	21
Madagascar	90	68	18
Malawi	233	149	98
Mauritius	7	3	2
Mozambique	24	20	11
Namibia	57	21	9
SADC	91	26	3
Seychelles	6	2	2
South Africa	273	205	145
Swaziland	59	54	53
Tanzania	102	68	42
Zambia	93	68	44
Zimbabwe	272	174	105
Totals	1789	1088	667
Unique	1735	1041	655

4 Construction and Delivery of Website

4.1 WEBSITE SUMMARY

The website is hosted by BGS at Keyworth. It is based upon pre-existing code written for the DFID-KAR International Reports Database. The stylesheet used is an in-house style for BGS hosted websites. The domain www.sadcgwarchive.net was purchased so that this domain could be used for promotion purposes and printed materials.

The website is primarily written in ColdFusion which is a commercial rapid application development (RAD) platform. ColdFusion uses its own scripting language, ColdFusion Markup Language (CFML), which compares to the scripting components of ASP, JSP and PHP in purpose and features, but more closely resembles HTML in syntax. ColdFusion is often used for data-driven websites and is the chosen and supported platform within BGS.

The website also uses some Javascript, primarily for form input validation and the browse by country feature. It is compliant with W3C coding standards and WAI accessibility guidelines.

4.2 DATABASE

An Oracle database is used to store the metadata for the references using the structure shown in Figure 2. The structure is straightforward. A reference has details held in Catalogue Detail, this includes title, file size, year of release etc. Each reference can have multiple countries associated using ISO codes held in the Country dictionary. Similarly each reference can have multiple categories which is constrained by the Category dictionary. Multiple authors can be associated with each reference and these have an author order.

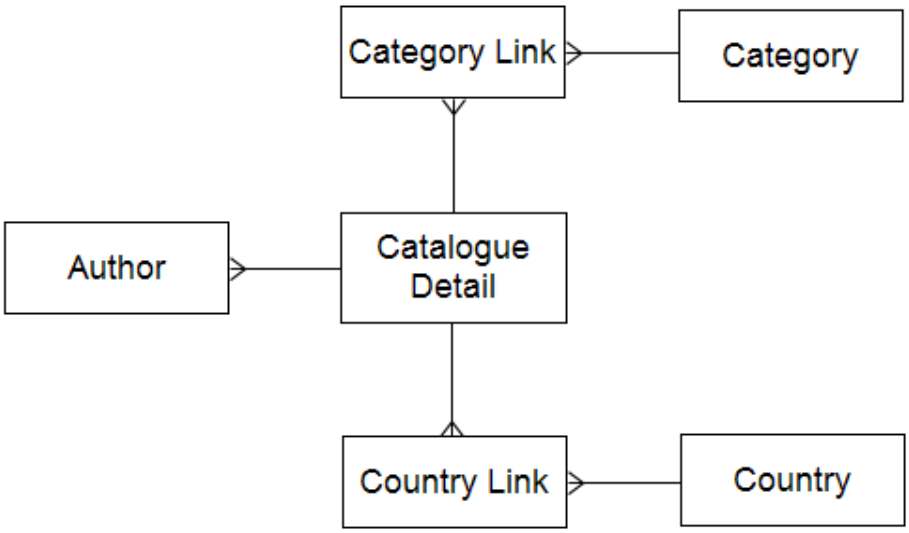

Figure 2 Entity relationship diagram

The PDF documents for the references are held on the BGS Storage Area Network (SAN).

There are 1735 references in the database of which 655 are available to download. Adding new references is straightforward, by adding entries into the database and uploading the PDF if required they will immediately appear on the website.

4.3 WEBSITE INTERFACE

The user may navigate to individual country pages (Figure 3) using the left-hand menu or the Google Map interface in the centre of the home page (Figure 3).

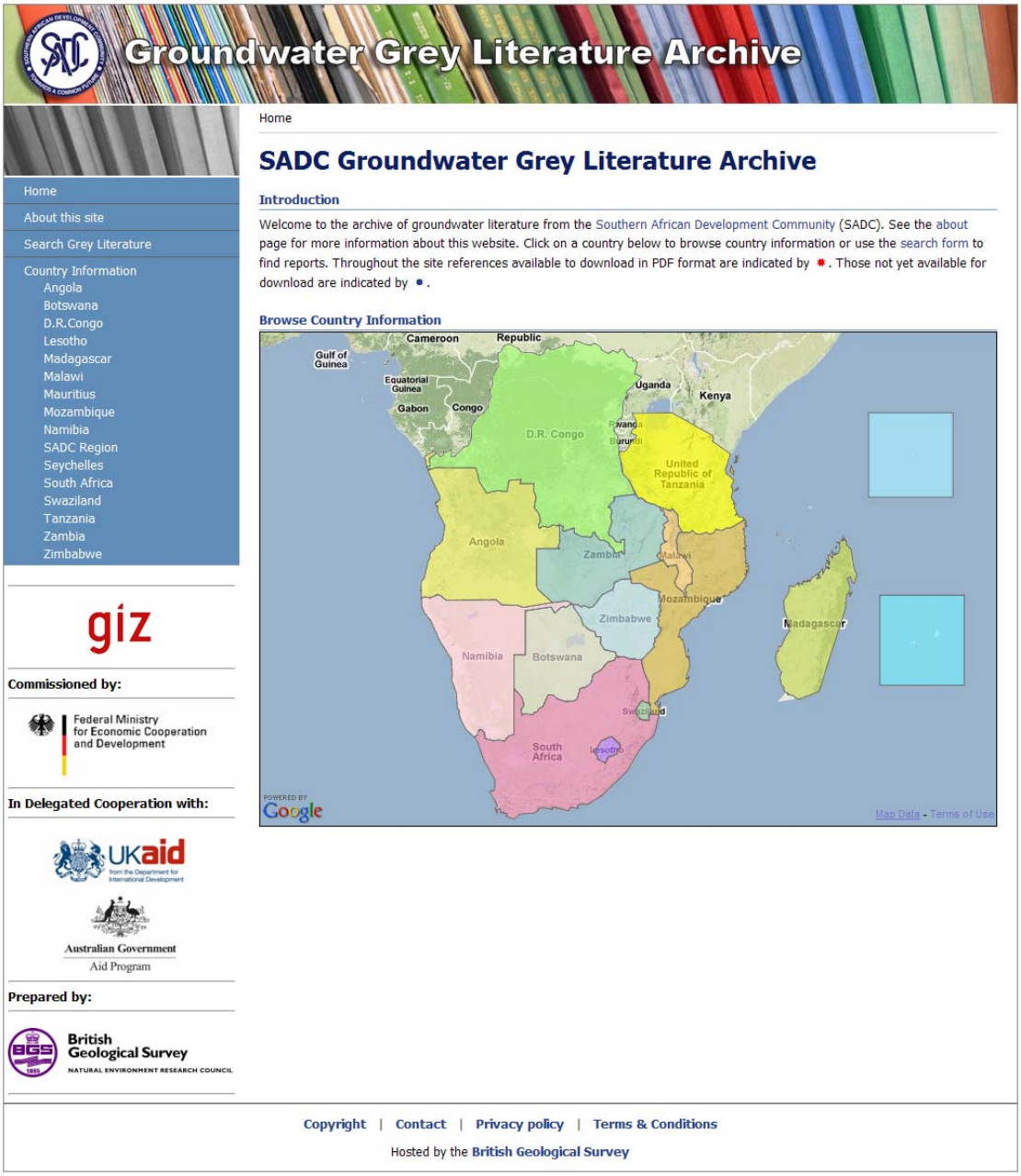

Figure 3 Home page.

Botswana

Summary

There are numerous references available on hydrogeology . These reflect the large number of BGS staff employed on secondment to the Geological Survey during the 1970-1990 period who subsequently deposited copies of annual reports, project reports and geological map memoirs with the BGS archive. Long term hydrogeological research projects undertaken by BGS of Karoo-age and other aquifers generated a substantial number of reports.

References

There are 356 references available. Currently 88 of these are available to download in PDF format.

Key References

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  Categories: Botswana , Sand River
- **GS10 Project - evaluation of underground water resources: final report** (**1981**).
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  Categories: Karoo , Botswana , Hydrogeology
- **Groundwater in Eastern, Central and Southern Africa: Botswana** (**1989**).
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  Categories: Botswana , African Hydrogeology
- **Compilation of the hydrogeological map atlas for the SADC region: Situation Analysis Report Annex B - Botswana.** (**2002**).
  Groundwater Consultants Bee Pee (Pty) Ltd , SRK Consulting (Pty) Ltd
  Categories: Botswana , Groundwater Mapping , SADC

Discussion

During the pre-1960 period, the development of groundwater resources of Botswana, then the Bechuanaland Protectorate, was the responsibility of the Geological survey. The annual reports record the formal establishment of a groundwater section at the Bechuanaland Geological Survey in 1951 and its subsequent development. These records include the application of geophysical prospecting methods for the location of borehole drilling sites in the Kalahari. Water boreholes drilled are reported in these documents.

Figure 4 Country page

Each country page consists of the same elements (Figure 4). A summary paragraph followed by a link to the references. A live count of the total number of references and the number available to download is shown. Several key references are selected with direct links to the metadata and download (if available). A discussion section describes the history of groundwater information for that country.

A search form (Figure 5) is available for the user to find references by one or more keywords found in the title, author, category and country. Each search can be limited only to those that are currently available for download. A browse all references alphabetically by country option is also available on the search form.

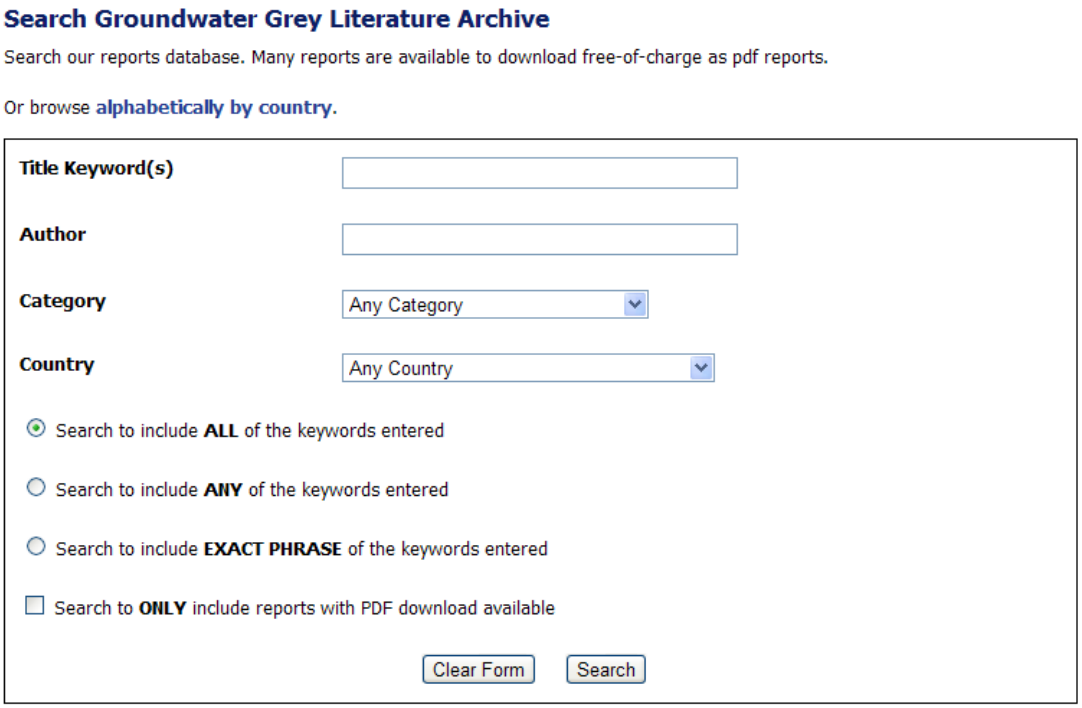

Figure 5 Search form

A successful search will return a list of references meeting the criteria specified. Those with an available download are distinguished (Figure 6).

Figure 6 Search results example

Each item in the search results list links to the metadata for that reference held in the database, if the reference is available to download a link with the file size is shown (Figure 7).

Report Details

Title:	A background to the GS10 Gaborone - Lobatse groundwater study
Authors:	JL Farr , JH Baron
Year released:	1978
Categories:	Botswana , Data , Groundwater
Country covered:	Botswana
Publishing organisation:	Department of Geological Survey, Lobatse, Botswana

Download this report (PDF 272 kB)

Figure 7 Reference metadata display

4.4 COPYRIGHT ISSUES

Whilst being wholly supportive of the project aims and intentions, the BGS is naturally concerned as to the possible copyright and other legal implications of making "grey data" freely available. The project team has worked closely with BGS IPR management and archive representatives to reach agreement on the sub-set of items required for open-access distribution. It is believed that this experience will stand the project team in good stead in terms of further negotiations with other geological surveys in the future.

The issue of copyright is one of major concern when presenting printed material for distribution via electronic distribution such as via a web site. Both BGS and GIZ share this concern. The content of the metadatabase was initially divided into sections and advice was sought from the IPR section of BGS:

1. Documents more than 100 years old – nominally free of copyright issues
2. Documents produced by BGS/CEH as a result of research projects funded by DFID/ODA – permission for distribution was acquired from DFID.
3. Documents more than 60 years old – nominally beyond the time limit for copyright – IPR section advised that although these may be safe issues could arise.
4. Other material that may require copyright issues to be addressed

If the project adhered to sections 1 and 2 above only about 100 documents would have been available for presentation on the website. Given the diverse and often ambiguous nature of possible document ownership, tracing potential owners of these documents, most of which contain non-controversial content, would require monumental efforts requiring time and resources beyond the scope of the present project. These issues were discussed at length with the IPR section of BGS. Considering the large number of items involved IPR section at BGS pragmatically advised that if all commercially sensitive scanned material was removed then the following "takedown policy" clause could be inserted within the website terms and conditions to provide a mechanism by which offending material could be removed:

NOTICE AND TAKEDOWN POLICY

If you are a copyright holder and are concerned that you have found material on our website belonging to you, for which you have not granted permission, or where permission is automatically granted by way of national/international law, please contact us in writing stating the following:

(1) Your contact details.

(2) The full bibliographic details of the material.

(3) The exact and full URL where you found the material.

(4) Proof that you are the rights holder and a statement confirming that you are the rights holder or are an authorised representative.

Given proof of valid objection BGS will takedown the relevant material from the website.

To date BGS has not received any requests for the removal of documents.

4.5 FUTURE

BGS has agreed to host the website for 5 years. If the site is required to be moved it should be noted that ColdFusion and Oracle are rarely found on external hosts and could be expensive. It would not be too onerous a task to rewrite the website using commonly found alternatives, e.g. PHP and MySQL. Also to be noted is the bandwidth this website requires, BGS can offer fast high-bandwidth, not always so readily available from external hosts. In the first five weeks of hosting the site has generated over 5.5GB of bandwidth.

4.6 LINKS AND APPLICATION

Links are being developed between this new web site and the BGS Internet site as well as the SADC / GIZ knowledge hub website. The wider applications of the archive are presented in Appendix 1.

5 Project Results Dissemination

5.1 PUBLICATIONS

In addition to publication of material on the website, the project team have disseminated information about the project to the wider community. The project team submitted a paper entitled Grey data: groundwater knowledge sharing in SADC at the Groundwater-Pushing the Limits Conference held in Cape Town (16-18 November 2009) (Robins N S, Cobbing J & Davies J, 2009) and an article entitled Groundwater – Returning to the Sources in “Planet Earth” the internal magazine of the UK Natural Environment Research Council (NERC). NERC is the “parent” council of the BGS. (Cobbing, J. and Davies, J., 2010). An essay has been submitted for publication in the Hydrogeology Journal and an abstract has been submitted for an oral paper at the 2011 GSSA/IAH Conference to be held in Pretoria, South Africa in September 2011.

5.2 IMPACT STATISTICS

BGS generates full statistics for all of its hosted websites every three months. The website went live on 23 November 2010 so at the time of writing we only have about 5 weeks of statistics available (to end December 2010) (Table 6).

Table 6 Web site hit statistics

Page Views	
Total Page Views	5,215
Average Page Views per Day	133
Average Page Views per Visitor	3.92
Visitors	
Total Visitors	1,329
Average Visitors per Day	34
Total Unique IPs	376

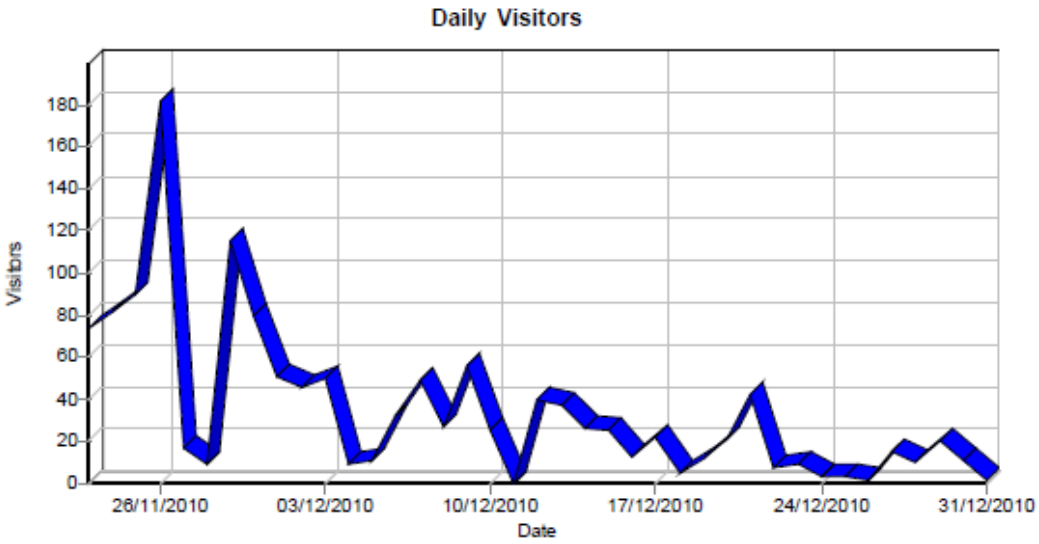

Figure 8 Daily visitors

The daily visitor trend holds fairly steady after the initial launch period despite the Christmas and New Year break, Figure 8. We will know how visitor numbers are holding up after the next three month reporting period at the end of March 2011.

There have been 475 visitors who have downloaded at least one reference as a PDF document from 427 unique IPs. In total 1,352 references have been successfully downloaded. IPs from 77 different countries have downloaded references. On average 12 PDF references have been downloaded per day.

225 visitors have found PDFs directly from a search engine using a diverse range of search terms, e.g. Notwani Dam Bechuanaland, pit latrines in mbuga soil, limestone in Singida. This shows that the website is reaching out and servicing the needs of researchers and developers in the SADC region. It emphasises the importance applying character recognition (OCR) to the documents so that they can be found directly using internet search engines.

5.3 POTENTIAL COLLABORATION

During August-September 2010 Mr Kevin Peitersen and Mr Jude Cobbing visited the BGS at Wallingford to review project progress and during that period undertook a visit to the offices of German Geological Survey (BGR) in Hanover to inform Dr Willi Stuckmeir, Deputy Director BGR, of project content and to discuss possible future links with the BGR archive, Whymap, the SADC hydrogeology mapping project and the EU-AEGOS project.

Discussions were also made with Dr Alan MacDonald of IAH Burden Commission as to the future use of project material for the preparation of thematic assessments of the hydrogeology of Africa.

6 Conclusions

This is essentially a pilot project providing an example of how Web delivery of the archive is an important step forward for the well-being of the SADC region. It permits access to documents few even knew existed and will, it is hoped, provide a valuable dataset that should inhibit the temptation to waste scarce resources by 're-inventing the wheel'.

This project shows potential for expansion within the SADC region where much grey information remains to be gathered from the groundwater archives of the member states and for replication elsewhere in Africa and Asia in regions where BGS holds extensive groundwater related archives.

7 References

Robins N S, Cobbing J & Davies J 2009. 'Grey data': groundwater knowledge sharing in SADC. Transactions of Groundwater-Pushing the Limits Conference, Cape Town (16-18 November 2009).

Cobbing, J. and Davies, J., 2010. Groundwater – Returning to the Sources, Planet Earth, Spring 2010, pp 16-17. http://www.nerc.ac.uk/publications/planetearth/2010/spring/spr10-groundwater.PDF

Appendix 1

POINTS ON THE WIDER CONTEXT AND APPLICATION OF THE GREY DATA PROJECT ARCHIVE

1. Groundwater and food security

Small garden irrigation and stock watering using groundwater is key to improved food security of poor rural communities in SADC lacking surface water resources.
The archive provides information on groundwater resources for small scale irrigation in areas lacking recent data.

2. Groundwater and drought / climate change

In southern Africa, a region prone to drought, a typical response to serious drought is the drilling of boreholes for groundwater. Climate change forecasts for southern Africa anticipate hotter, drier weather with more intense but less frequent rainfall events. The advantages of groundwater i.e. low evapotranspiration and slow water level decline with higher volumes stored underground compared with surface water, mean that it should form a key strategy in response to climate change. The issue is urgent; "…climate change may bring about a new set of weather patterns and extremes that are well beyond what the local communities in southern Africa are capable of dealing with" (UNEP) .
The Grey Data Project makes available a considerable body of data and reports, in some cases dating back over many decades. Collectively, this resource will inform on past responses of (ground) water resources to climate variations in the SADC area, and also on the wider context of institutional and social reaction.

3. Groundwater and rural poverty

Rural areas can be difficult to supply with surface water, since the economies of scale found with centralised (surface) water sources in urban areas do not apply. Groundwater on the other hand is often ideal for rural water supply purposes, for the following reasons:

- Groundwater is a "proximal resource" – it is usually found close to where it is needed, making it ideal for small-scale water supplies in rural areas and for smaller municipalities. Long pipelines from distant surface water sources are not required.
- Groundwater is resistant to the effects of drought, because large amounts of water are stored underground, and rates of evapotranspiration are low.
- The natural quality of groundwater is usually good, with little or no treatment needed. Treatment plants, with associated operation and maintenance implications, are usually not necessary for small-scale supplies. Some treatment of groundwater is carried out e.g. chlorination; not all groundwater is safe to drink without treatment.
- Groundwater can also be developed "incrementally". Surface water supplies usually require large initial investment e.g. dam and treatment plant, whereas additional boreholes can be drilled as demand increases and budgets allow.

Even relatively simple, reliable groundwater supply schemes may not be installed and operated without technical assistance, and appropriate data and information.

The Grey Data Project aims to fill some of the knowledge gaps of the resource, especially in marginalised and remote areas where rural poverty is severe. Groundwater provides the small but reliable quantities of water necessary to sustain rural economies, enabling businesses such as brick making, vegetable gardening, stock raising and many others. Information provided by the Grey Data Project greatly assists in estimating both the reliability of existing resources, and the potential of the resource for further development (e.g. towards larger-scale irrigation).

4. Management of Groundwater Resources

Although groundwater is a "proximal resource" – i.e. it is found in relatively small quantities in most areas – the management of groundwater benefits from both local and national institutional inputs. Data collected at local level allows national and regional pictures of availability, quality and reliability to be resolved.

The Grey Data Project, collecting together information on many decades of groundwater data collection and management interventions, helps to show how this balance has been attempted in the past, and assists in our efforts to refine management in the present. The Project also helps to facilitate greater transboundary and transnational cooperation in groundwater resource management, by making data and information across the region much more easily accessible.

5. Cost savings

The Grey Data Project is aimed at making data, research and knowledge products on SADC groundwater much more easily available. At present, much of this information is very difficult to access for practical purposes, and there is a consequent danger of re-doing work that has already been done. The improved information on regional groundwater resources that the Grey Data Project will make available also helps to enable more efficient and effective (and cheaper) groundwater management.

The Grey Data Project has contributed directly and indirectly to the recently launched Hydrogeology map of SADC, through provision of information and maps of Madagascar and the Democratic Republic of Congo. During project visits, Mr Jeff Davies has met with members of the SADC mapping team and provided advice and data that have contributed to the map. This has been particularly important in areas where data is very scarce, or for countries where data submissions were limited. Mr Davies has been acknowledged by the mapping team in the map brochure, and elsewhere. This input demonstrates the potential of the Project to contribute to contemporary regional initiatives aimed at understanding and managing groundwater, and at closer regional cooperation.

Additional potential benefits through provision of Archive material to water sector issues in SADC are outlined in the attached table.

The SADC Grey Data Archive The SADC Grey Data Archive, based on grey data held by the British Geological Survey in the UK, provides an initial compilation of non-published materials derived from Southern African government and other institutions describing groundwater development activities during 1877-2009	
Water Sector Issues	**Benefits – Archive provides information on the development of:**
MDGs – increased demand for groundwater due to population increase Health – provision of groundwater to rural and peri-urban hospitals and clinics Water Supply – provision of groundwater sources close to rural settlements Education - provision of groundwater to rural and peri-urban schools Food security –limited groundwater used for watering community gardens	**MDGs –archive shows GW development during 20C for:** Health – provision of GW to town and rural hospitals and clinics Water Supply – use of GW for town and rural settlement by use of springs, boreholes and wells Education – GW for establishment of schools Food security – supply of GW along cattle trek routes and for irrigation
Climate Change – only understood by analysis of long term data Historical time series data show impact of climate change on GW resources Impact of climate and anthropogenic change on groundwater fed rivers	**Climate Change – recognition of drought/flood cyclicity** Impacts climate change on GW systems during 20C Shows how spring fed water courses change with time
Integrated Water Resource Management GW a major part of water cycle feeding springs and rivers GW a vital buffer against effects of drought on surface water GW the main rural water supply source through construction of sand dams, hand pumped boreholes and hand dug wells	**Integrated Water Resource Management** GW recognised as part of water cycle feeds springs and rivers GW used to mitigate effects of drought on surface water Design of GW abstraction systems based on construction of sand dams, hand pumped boreholes and hand dug wells has not changed in 20C
Transboundary Groundwater Cooperation Ephemeral alluvial aquifers along major boundary rivers Aquifer types common to both sides of national borders	**Transboundary Groundwater Cooperation:** Development of ephemeral alluvial aquifers along major boundary rivers Development of understanding of aquifer common to both sides of national borders
Transport Hubs/Routes Historically groundwater vital for the development of rail routes Modern transport routes and hubs need groundwater to be sustainable	**Transport Hubs/Routes:** groundwater resources along rail routes to supply steam locomotives base network of roads to supply oxen and steam powered carts and junctions
Irrigation Use of limited groundwater resources to address rural food security issues Use of systems such as collector wells and drip irrigation systems Construction of sand dams, hand pumped boreholes	**Irrigation;** Commercial irrigation of sugar etc. based on groundwater Use of systems such as collector wells and drip irrigation systems Construction of sand dams, hand pumped boreholes
Consultant and Institutional Research Activities Compilation of the SADC Hydro-geological Map Groundwater sensitive and reliant ecological systems	**Consultant and Institutional Research Activities:** Study of the resources and characteristics of specific aquifers Assessment of GW resources for national and district water master plans Compilation of national hydrogeological maps with description of resources