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# Introduction

## 1.1 The need for a manual

In 2004 there were still at least 1 100 000 million people across the world who did not have access to safe, clean drinking water. Many of these people live in rural areas and are among the poorest and most vulnerable to be found anywhere in the world. Without clean water, people's health and livelihoods can be severely affected; the education of children (particularly girls) suffers as the daily tasks of survival take precedence over all other concerns. Faced with this depressing reality, the international community has set ambitious Millennium Development Goals to reduce by half the number of people without clean water by 2015 (United Nations 2000).

In this context, the need for sustainable development and management of groundwater cannot be overstated. Across large swathes of Africa, South America and Asia, groundwater provides the only realistic water supply option for meeting dispersed rural demand (Foster et al. 2000). Alternative water resources can be unreliable and expensive to develop: surface water (if available) is prone to contamination and often seasonal; rainwater harvesting can be expensive and requires good rainfall throughout the year. Groundwater, however, can be found in most environments if you look hard enough with the appropriate expertise. It generally requires no prior treatment since it is naturally protected from contamination; it does not vary significantly seasonally and is often drought resistant. Also it lends itself to the principles of community management – it can be found close to the point of demand and be developed incrementally (and often at low cost).

Yet many projects spend large amounts of money installing water sources without trying to understand the groundwater resources on which these sources depend. As a result, many supplies are unsuccessful or perform poorly. Successfully developing groundwater resources sustainably and cost-effectively on the scale required to help achieve the Millennium Development Goals is not trivial. The challenge is more than just providing extra drilling rigs to the worst-affected countries: technology, software and hardware must all be appropriate to the nature of the groundwater resources in the project area. For example, in sub-Saharan Africa alone, up to 300 million rural people live in areas where finding groundwater resources is difficult, and special techniques are required to help locate groundwater close to a community (MacDonald and Davies 2000). Because of their history of

failed water supply interventions, these areas are often highest priority for reducing poverty and improving health.

Information and expertise on groundwater resources is therefore fundamental to extending rural water supply to the poorest and most vulnerable. However, trained and experienced groundwater specialists are rare and expertise is not often available to projects. Hence the reason for this manual. The discipline of understanding the occurrence and behaviour of groundwater is called **hydrogeology**; and those with these skills are called **hydrogeologists**. This manual introduces the hydrogeological techniques and knowledge that are required for undertaking rural water supply projects. The aim is to take some of the magic and mystery out of hydrogeology so that those working on rural water supply projects will be able to apply some of the science of hydrogeology to improve the success of their projects.

The idea for this manual first came about in 1997 during a WaterAid project in rural Nigeria. This project was in an area where different techniques were required to site wells and boreholes across the project area. Training courses and workshops were run for the project engineers and hydrogeologists working in the area and a file of useful field techniques developed. This file was further developed to form a simple technical manual as part of a project funded by the UK Department for International Development (DFID), helping WaterAid projects in Ethiopia, Tanzania and Ghana (MacDonald et al. 2002). This first manual was produced in 2002 and distributed both on CD and via the Internet. The unexpectedly high level of interest in this technical manual, and in particular a demand to have it enlarged to include more techniques, led to a new project funded by DFID to produce the current manual. This project has involved widespread consultation on both the style and content of the manual – over 80 people from 29 countries have contributed ideas, either through workshops or by email. Their help is greatly appreciated and the acknowledgments page lists individuals who have contributed.

## 1.2 Who is the manual for?

The manual is aimed at the **implementers** of rural water supply projects in sub-Saharan Africa and Asia. In particular, those faced with the challenge of actually trying to site water points, design boreholes, judge whether the source will supply the required yield at the required quality, and estimate the likely sustainability of the supply, will find much in this book to guide them. This group comprises a wide range of skills and disciplines. It includes hydrogeologists, water engineers, geophysicists and general technicians working within, or for, rural water supply projects and their client communities; all of them are referred to as project engineers or hydrogeologists in this manual. In addition, those charged with the design, oversight and management of rural water supply projects will find the manual

useful, and a necessary reminder of the need to invest in resource assessment and waterpoint design, as well as source management and financing arrangements. The manual could also be useful to help benchmark the hydrogeological input required on projects. Such knowledge will facilitate local control of contractors or in judging the success and cost-effectiveness of projects.

### 1.3 The scope of the manual

The content of this manual was decided by a group of about 80 people from 29 countries. Two workshops and much email correspondence helped refine what subjects the manual would cover and what would be left out. One of the main decisions from this group was that the manual should be designed to help projects that are developing springs, wells or boreholes with low capacity: i.e. sources that will sustain the yield of a handpump (less than 10 m<sup>3</sup>/day).

This manual primarily deals with one part of rural water supply: the techniques used to help understand the groundwater resources and thereby help to increase the success and the sustainability of boreholes, wells and springs. These techniques are not presented in isolation, but have been put in the wider context of rural water supply, particularly ideas of community management and participation. The scope of the manual was further broadened during the consultation and review process to include information about the construction of water points and detailed information on water quality aspects of rural water supply.

The manual provides a resource of tried and tested techniques that together can help to increase the chance of obtaining successful water sources. All the techniques have been successfully applied to rural water supply projects across the world. To a trained hydrogeologist many of the techniques should be well known and familiar, although their specific application to rural water supply issues may be less well known. A computer is not needed to carry out any of the techniques described here – hydrogeology is a field science, and the use of a computer can sometimes reduce the quality of science rather than improve it.

The geographical emphasis of the manual is rural sub-Saharan Africa, where coverage of clean and safe water supplies is low and dispersed community water supplies through handpumps and shallow wells are a common solution. Many of the techniques will also be directly relevant to rural Asia and South America, where similar conditions apply. However, other groundwater issues prevalent in Asia, such as resource management due to overpumping, are not addressed in detail in this manual.

A word of caution: scientists may have devoted their working lives to studying just one small aspect of hydrogeology – this manual just scratches the

surface of that knowledge and expertise. In many cases, the techniques described here will prove sufficient for the small yields required for rural water supply. In some areas, however, where the hydrogeology is complex, more rigorous science may need to be applied and the experts will have to be called in.

## 1.4 The contents of the manual: a roadmap

This manual is not meant to be read cover to cover, nor is it meant as a blue print for guaranteed successful projects. Rather, it provides information and techniques that a project engineer should find useful to help understand the groundwater resources available to a community and design appropriate water points. Although many different techniques are described, the manual cannot be exhaustive, so further resources to be consulted are given at the end of each chapter.

**Chapter 2: Groundwater.** An introduction to groundwater, what it is and how it occurs. The main hydrogeological environments encountered in the world are described and illustrated with schematic diagrams. A summary is also given of the many different methods used to access groundwater around the world.

**Chapter 3: Projects and communities.** This chapter sets groundwater development in the wider context of rural water supply. The current approaches to rural water supply provision are described (e.g. community management and demand responsive approaches) and the impact that complex groundwater resources can have on these principles. The project cycle is introduced, and where groundwater expertise is required within this cycle. Information is also given on how to assess the cost-effectiveness of different technologies and the various skills required within a project.

**Chapter 4: Reconnaissance.** This short chapter describes the important steps needed for pre-project reconnaissance: where to find important data, who to talk to, how to carry out a reconnaissance visit and finally how to use all this information to create a rough groundwater development plan.

**Chapter 5: Finding groundwater.** Introduces all the different techniques used to help site wells and boreholes in communities – from geophysics to dowsing. A general framework is introduced to help decide which technique is appropriate in which situation and the general principles for using more complex techniques, such as geophysics. Techniques for helping to integrate communities into this process are also described. The chapter then describes three common siting techniques in detail: electrical conductivity, resistivity and magnetics. Information is given on how to carry out surveys and interpret the data in common hydrogeological environments.

**Chapter 6: Designing and constructing water points.** Describes the role of the project engineer/hydrogeologist in supervising the construction of

the water points. After introducing different drilling methods, detailed information is given on what data should be recorded from the construction process and then how this should be used to help design the water point. Different standard designs of borehole are given along with a standard well and spring design.

**Chapter 7: Assessing the yield of a source.** Several methods are given for assessing the yield of a borehole. Three pumping tests of different complexity are explained: a simple airlift, a bailer test and a constant rate test. Detailed descriptions of how to carry out each test and interpret the data are given. The chapter also suggests a simple method for assessing the performance of hand-dug well.

**Chapter 8: Water quality aspects of rural water supply.** This chapter describes the important aspects of water quality in rural water supply. After introducing international guidelines on drinking water quality, both microbiological contamination and inorganic (chemical) quality are discussed. Techniques are given for how to assess the risk of microbiological contamination both through the aquifer and through local routes. The occurrence and effect of arsenic, fluoride, nitrate and iron and manganese are described in detail, and some general guidance given on how to take water samples. The chapter also introduces a general framework for assessing the risk of pollution.

**Chapter 9: Learning lessons.** This chapter brings the manual to a close by emphasizing the need for holding on to all the hydrogeological data collected during rural water supply projects and putting it to good use.

## 1.5 Don't panic, you are not alone

Finally, in this introduction, two words of encouragement – don't panic. The hydrogeological community is small and generally friendly. If there are groundwater resource issues that this manual does not cover adequately, or the experience of your project does not match up to that described here, get in touch. Email has genuinely made the world smaller. There are a number of resource centres that can be called on, such as the British Geological Survey (BGS) in the UK, the IRC International Water and Sanitation Centre in the Netherlands or the family of hydrogeologists known as the International Association of Hydrogeologists (IAH). The science of hydrogeology is advancing all the time and new ways of finding usable groundwater resources in inhospitable environments are being routinely found.

## References, further reading and resources

British Geological Survey: <http://www.bgs.ac.uk>

## DEVELOPING GROUNDWATER

Foster, S.S.D., Chilton, J., Moench, M., Cardy, F. and Schiffler, M. (2000) Groundwater in Rural Development. World Bank Technical Paper No. 463. World Bank, Washington, DC. Available at: <http://www-wds.worldbank.org/>

International Association of Hydrogeologists: <http://www.iah.org>

IRC International Water and Sanitation Centre: <http://www.irc.nl>

MacDonald, A.M. and Davies, J. (2000) A brief review of groundwater for rural water supply in sub-Saharan Africa. BGS Technical Report WC/00/33. Available at: <http://www.bgs.ac.uk/hydrogeology/ruralwater/>

MacDonald, A.M., Davies, J. and Ó Dochartaigh, B.É. (2002) Simple methods for assessing groundwater resources in low permeability areas of Africa. British Geological Survey Technical Report CR/01/168. Available at: <http://www.bgs.ac.uk/hydrogeology/rural-water/>

United Nations (2000) Millennium Development Goals. Available at: <http://www.un.org.millenniumgoals>