Abstract

Evidence suggests that physical availability of groundwater may be only one of many factors in determining whether groundwater-based rural water supply schemes in South Africa are reliable or "sustainable". Other factors include budgetary constraints, community preferences, policy decisions, operation and maintenance (O&M) procedures, and the availability of skilled staff. These factors and others combine to create "complex problems" around the issue of rural water supplies that require a multidisciplinary approach if they are to be effectively resolved. This work is an ongoing part of Water Research Commission Project K5/2158 “Favourable Zone Identification for Groundwater Development: Options Analysis for Local Municipalities”, due to be completed in March 2014.

1. INTRODUCTION

The Reconstruction and Development Programme (RDP) and subsequent plans and strategies have enabled great progress in supplying our citizens with an improved water source since 1994. According to the 2010 Millennium Development Goal (MDG) Report (UNDP, 2010) in 1996 only 61.1% of the national population was using an improved drinking water source. In 2013 that figure stands at 95.2% (DWA, 2013), meaning that South African has easily achieved this MDG obligation. It is the relatively small percentage of people who are not yet served by an improved water source that is now of concern, along with the "sustainability" of some existing water supply schemes. Unserved citizens live mostly in rural areas of South Africa, and largely in the Eastern Cape and Kwa-Zulu Natal Provinces.
Many of the areas in which people still do not have access to an improved water supply are rural, and in these areas groundwater is often a good option for water supply. This is because groundwater is usually found close to where it is needed, the natural quality is usually good (i.e. it can be drunk with minimal treatment), it can be developed incrementally and as needed (i.e. borehole by borehole, rather than needing a large initial investment such as a dam or long pipeline), and the generally large volumes in storage insure against drought. Lack of access to a decent water supply is sometimes linked with a lack of a water resource, but in fact this is rare. Most of South Africa has enough water locally (including groundwater) to meet basic human needs, or for “RDP standard” supplies. However, there still seems to be a reluctance to invest in groundwater supplies and in the systems and organisational requirements needed to keep them operating. There are probably many reasons for this, including that groundwater is still seen as unsophisticated and rural, the past emphasis on surface water in South Africa, the lack of groundwater champions at national level, and a relatively poorly coordinated groundwater sector. However a major emerging reason for preferring other water sources over groundwater seems to be the perceived unreliability of groundwater – summarised by the sentence “the groundwater dried up” that one hears so often. Yet time and time again, the real reason for a groundwater supply failure is linked instead to the operational and maintenance (O&M) of the groundwater source. Rarely is groundwater failure (especially a small scheme designed for domestic use) genuinely due to exhaustion of the aquifer.

2. WATER SUPPLY BACKLOGS IN RSA

There are 231 Local Municipalities (aka “Category B Municipalities”) in South Africa. The national census of 2001 contains data on water source per household, in eleven categories as follows:

1. Piped water inside dwelling
2. Piped water inside yard
3. Piped water on community stand: distance less than 200m from dwelling
4. Piped water on community stand: distance greater than 200m from dwelling
5. Borehole
6. Spring
7. Rain-water tank
8. Dam/pool/stagnant water
9. River/stream
10. Water vendor
11. Other

If the percentage of households with water sources in categories 8, 9 and 10 are considered, then the local municipalities (LMs) with the largest backlogs can be found. A list of 42 of these “priority LMs” was compiled, all of which had more than 25% of households relying on category 8, 9 or 10 water sources. Of these 42 LMs, 25 were in Kwa-Zulu Natal, 14 in the Eastern Cape, 2 in Limpopo and 1 in Mpumalanga Provinces. Although the majority of the “backlog” LMs are in Kwa-Zulu Natal, more households in the Eastern Cape rely on category 8, 9 and 10 water supplies than any other province both as a percentage of all households in that province and as a total number of households (Figure 2).

The GRA1 data (Vegter 1995) classifies South African aquifers into yield classes, according to the scheme shown in Table 1 below. By overlaying these LM areas onto the GRA1 map of South Africa it was possible to obtain the proportion of the total area of all 42 priority LMs underlain by each aquifer class (Figure 3 and Figure 4).
TABLE 1 GRA1 CLASSIFICATION SYSTEM

<table>
<thead>
<tr>
<th>Aquifer Type</th>
<th>Borehole Yield Class (L/s)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Class “1”</td>
</tr>
<tr>
<td></td>
<td>0 - 0.1</td>
</tr>
<tr>
<td>Type “a”: Intergranular</td>
<td>a1</td>
</tr>
<tr>
<td>Type “b”: Fractured</td>
<td>b1</td>
</tr>
<tr>
<td>Type “c”: Karst</td>
<td>c1</td>
</tr>
<tr>
<td>Type “d”: Intergranular and fractured</td>
<td>d1</td>
</tr>
</tbody>
</table>

FIGURE 2 PERCENTAGE OF HOUSEHOLDS WITH WATER SUPPLY BACKLOGS PER PROVINCE

FIGURE 3 AQUIFER YIELD CLASS AND TYPE UNDERLYING PRIORITY LMS
It can be seen that the priority LMs fall predominantly on “d3” (59.9% of the total area of all of the priority LMs), with another 16.5% of the total area falling on “d2”. Only 5 of the 42 priority LMs have more than 10% of their surface area falling on aquifer yield class 1 (median borehole yield less than 0.1 L/s). The priority LMs also fall mainly within the relatively high rainfall region (eastern part) of South Africa, and recharge is expected to be reasonable. This is all evidence against an absolute lack of groundwater resources being a primary reason for non-availability of an improved water source. Households with poor access to an improved water source also tend to fall mainly in the former “homeland” areas of South Africa (Figure 5) supporting the argument that physical groundwater scarcity is not the main cause of lack of access to improved water sources.
directed at producing increasingly detailed and complex assessments, summaries and “tools” relating mainly to the physical nature of our groundwater resource. These include the following:

1. South Africa’s Groundwater Regions Maps and Booklets (Vegter, 2001)
2. The Groundwater Harvest Potential Map project (Baron et al, 1998)
3. The National Hydrogeological Map series (groundwater resource assessment phase 1, or GRA1) (Vegter, 1995)
4. The Department of Water Affairs’ GRA2 project (Sami and Witthüser, 2006)
5. The NORAD toolkit for water services (DWA, 2004)
6. The GRIP project (Botha, 2005)
8. DWA Guideline for Assessment, Planning and Management of Groundwater in RSA (DWA, 2008)
9. The National Groundwater Strategy and GRA3 (DWA, 2010a)
10. The Department of Water Affairs’ All-Towns Reconciliation Studies (e.g. DWA, 2010b)
11. The SADC hydrogeological map, and the UNESCO map legend (SADC, 2010)
13. WRC project K5/2048 Development of a Groundwater Resource Assessment Methodology (in progress)
14. WRC project K5/1763 The delineation of high-yielding wellfield areas in Karoo Aquifers as future water supply options to local authorities (Murray et al, 2011)
15. Specialist groundwater studies done for Tshwane Metro, Nelson Mandela Bay area, eThekwini, etc (e.g. Murray et al, 2008)
16. The update of the Water Resources of South Africa (WR2012) project (in progress)

These products are very useful to professional hydrogeologists, planners and other professionals, but are not sufficient on their own to address water supply backlogs or to tackle the problems of groundwater’s perceived “unreliability” and second-class status. They may even distract the groundwater community from other more nebulous reasons for groundwater’s “second class” status.

3. INTERVIEWS

Conscious and subconscious bias in evaluating the “real” reasons for groundwater scheme sustainability is hard to tackle without a poll of stakeholders. A series of interviews was therefore conducted in the Eastern Cape, Limpopo, Gauteng and North-West Provinces between March and July 2013 with the intention of learning as much as possible about the broad issue of groundwater scheme sustainability in rural areas (Table 2). This work is an on-going part of Water Research Commission Project K5/2158 “Favourable Zone Identification for Groundwater Development: Options Analysis for Local Municipalities”, due to be completed in March 2014.

<table>
<thead>
<tr>
<th>Province</th>
<th>Interviewee</th>
<th>Organisation</th>
<th>Main interest</th>
</tr>
</thead>
<tbody>
<tr>
<td>E Cape</td>
<td>Consultant engineer</td>
<td>Private consultancy</td>
<td>Water scheme operation</td>
</tr>
<tr>
<td>E Cape</td>
<td>Consultant engineer</td>
<td>Private consultancy</td>
<td>Small-scale irrigation</td>
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<tr>
<td>E Cape</td>
<td>Borehole maintenance technician</td>
<td>Private consultancy</td>
<td>O&amp;M of small schemes</td>
</tr>
<tr>
<td>E Cape</td>
<td>Municipal engineer</td>
<td>Municipality</td>
<td>Water scheme operations</td>
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<td>E Cape</td>
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<td>General groundwater, water scheme data</td>
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<td>E Cape</td>
<td>Scientist</td>
<td>Government Department</td>
<td>Rural asset management</td>
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<tr>
<td>E Cape</td>
<td>Engineer</td>
<td>Water Board</td>
<td>Water supply operations</td>
</tr>
</tbody>
</table>

TABLE 2 LIST OF INTERVIEWEES
A series of basic interview questions was compiled to guide each interview, although without constraining the interview – a general conversation was encouraged. In some cases, only the first few questions were asked after which the conversation moved to other water-related issues. Most interviews were recorded for later transcription but the names and identities of the interviewees are confidential. The basic interview questions were as follows, although these were adapted depending on the interviewee and the circumstances of the interview:

1. Do you think groundwater is preferred or liked by rural communities in South Africa?
2. In your opinion, is groundwater a reliable source for rural water supplies?
3. What are the main problems with rural groundwater supplies?
4. What are the strengths and weaknesses of groundwater supplies, as compared with other water sources?
5. Do you think we use too little groundwater, too much groundwater, or about the right amount?
6. Are we limited by the available technical information on groundwater availability and conditions?
7. If there was one thing we need to do to make groundwater supplies more reliable, what would it be?
8. Do you have any further comments or suggestions on groundwater, in the context of rural water supplies?
9. Do you have any suggestions for questions that I should be asking in these interviews?

4. INTERVIEW FINDINGS

The main findings from the interviews have been summarised under several headings, below:

Operation and maintenance

Most groundwater supplies appear to fail for reasons other than a lack of groundwater, or poor groundwater quality. These reasons are often grouped together under the “operation and maintenance” (O&M) heading, but range from pump failure due to normal wear and tear to theft or vandalism. As a result of groundwater scheme failure, some municipal planners have a preference for surface water supplies (often called “bulk schemes”), but this is not universal. There is still an acknowledgement of the importance of groundwater in areas which are difficult to supply with surface water. Some interviewees did report that groundwater is regarded as a poor alternative to a “proper” surface water supply, and one interviewee felt that groundwater supplies should be viewed as an interim solution only. There is a lack of skilled technicians and other O&M specialists, particularly in small towns and remote areas where many groundwater schemes are found. Such people must be able to repair a variety of problems and have skills in various areas (basic electrical work, welding, on-site...
fabrication, plumbing, etc) – in other words, a “jack of all trades” – and such people are rare. It may also be harder to do O&M for groundwater schemes compared with surface water schemes, for the same volume of water. Long distances / travel requirements are often the most expensive part of rural O&M of groundwater schemes, bringing in the added complexity of vehicles, fuel budgets, S&T allowances, overtime and other administrative issues. Simpler technology is generally more successful and longer-lasting (but may not be able to meet either demand or community expectations), whilst “repairability” may be far more important than “reliability” (Gibson, 2010 and 2011). The relative simplicity of groundwater schemes compared with surface water schemes may be more than outweighed by the numerous discrete installations and the long distances separating them – the problem becomes operational and not merely “technical”. Groundwater schemes are, by their nature, often chosen where topography makes surface water infeasible – but such areas (e.g. rural parts of the Eastern Cape) are also difficult and time-consuming for a technician to travel around.

The 2011 Municipal Capacity Assessment (Demarcation Board, 2012) reports a general shortage of municipal engineers, especially in rural Local Municipalities. This shortage is often despite the large infrastructure asset value in these municipalities. Those municipalities which might have the most cause to use groundwater (i.e. rural LMs with large rural populations and high improved water supply backlogs) have the fewest municipal engineers. The highest concentration of these professionals is in the metros and the secondary cities (Lawless, 2007).

Reliability of groundwater supplies

There was some frustration amongst planners with the available groundwater information, with more than one reporting that large and expensive efforts to find water in some areas had been fruitless. There is a feeling that surface water supplies are more assured and less “mysterious” than groundwater. Surface water supplies are easier to plan, and have fewer “unknowns”. At the same time, there was not wide awareness amongst planners of the various “technical” groundwater products available to assist in siting boreholes and planning wellfields (for example the GRA1 and GRA2 datasets, see list above). Most planners called on consultants when groundwater advice was needed, and hydrogeologists as permanent employees of municipalities or water boards appear to be very rare. Little centralised collection and interpretation of groundwater data from rural schemes is being done, although efforts are being made to address this - especially in Limpopo Province through the GRIP project (Botha, 2005). Consultants tend to be called in to carry out a specific, short-term job and then leave and there is some frustration amongst private consultants as a result. Difficulties with finding groundwater may also be linked to its status as a source of last resort, in difficult or marginal areas where other water supply options have not been viable. Groundwater is often only turned to during a drought or other emergency. Groundwater development in these circumstances is obviously not ideal, since detailed siting and planning is not always possible.

Groundwater funding

Schemes with a high ratio of initial capital cost to on-going operation and maintenance cost may be preferred by contractors and consultants, which will favour bulk (often surface) water schemes. This may be because bulk schemes are better understood, but may also be due to a simple profit motive. Operation and maintenance budgets at municipal level come under pressure from other budgetary demands throughout the financial year, and planning O&M under such circumstances is difficult. Thus a groundwater scheme, although cheaper overall, may not have the correct “profile” for funding, requiring a relatively small capital outlay but a larger on-going O&M budget. The timely transfer of funds from water services authorities (municipalities) to water boards and private contractors was also raised as a serious issue. It is also easier to recover costs from users of a centralised surface water system (e.g. the bulk buyers of water from a dam) than from scattered homesteads relying on
groundwater. This could make surface water schemes more attractive to private capital investment, a mechanism under consideration for water infrastructure funding (Ruiters, 2013).

**Community role**

Most interviewees agreed that community members should assist in operating and maintaining groundwater supplies, but that they also needed support and cannot do all of the necessary O&M on their own. Community members need to be able to call on specialist assistance when needed, and where they are trained or hired to do monitoring or basic maintenance then some level of supervision is needed. Community members quickly lose interest in reporting supply failures if no response is forthcoming (reasonably enough) implying that a good O&M strategy should be highly responsive and should treat community members as valuable “eyes and ears”. Although no ordinary water consumers were interviewed as part of this work, there is anecdotal evidence that many rural villagers expect their groundwater supplies to be operated and repaired by someone else, and are reluctant to fully “own” the problem (just as town-dwellers rarely need to get involved with the routine operation and maintenance of their supplies). More community ownership or involvement is seen by some as a partial solution to the problem of theft and vandalism, which is crippling in some areas (e.g. parts of Limpopo Province).

**Groundwater quality**

Natural groundwater quality is a problem in some areas (e.g. high salinity in the coastal parts of Amathole District Municipality in Eastern Cape Province), and anthropogenic quality such as high nitrate concentrations in others (e.g. Limpopo Province). Groundwater often has a higher salinity than surface water (whilst still well within potable water guidelines) and people may reject it as a source of drinking water particularly if they are used to a surface water supply. Treating salinity or high ion contents can be complex and expensive. Chronic microbiological contamination of some groundwater supplies is probably an area than needs further attention in future, too.

5. **CONCLUSIONS**

The reliability or sustainability of municipal groundwater supplies can be regarded as a “complex problem” – in other words it has many interconnected issues that can combine with unexpected results. The availability and sustainability of the physical groundwater resource is only one of these issues, and may even be a relatively minor issue when compared with long term strategies for asset management, effective champions within the public sector, overcoming the legacy of apartheid, or reliability of funding, for example. Of all of the issues, it appears that operation and maintenance (O&M) is the key to groundwater scheme sustainability. Whilst hydrogeological issues such as recharge, transmissivity and groundwater quality are important (and influence O&M), it is O&M that “makes or breaks” a groundwater supply. It has been shown that the forty-two “priority” Local Municipalities (LMs) with the most serious water supply backlogs are situated on aquifers of mostly reasonable groundwater prospects (often “d3” – i.e. intergranular and fractured aquifers with median borehole yields of 0.5 – 1.0 L/s), and most are also in higher rainfall / good runoff areas of South Africa. This supports the contention that rolling out better and more reliable groundwater supplies is not primarily a “technical” or hydrogeological issue at all, but that many other factors intervene.
6. REFERENCES


DWA (2012) Budget Vote Speech for the Departments of Water and Environmental Affairs by the Minister of Water and Environmental Affairs, Minister BEE Molewa on 6 June 2012, in the National Council of Provinces. Department of Water Affairs, Pretoria.

DWA (2013) Speech by the Minister of Water and Environmental Affairs, Mrs BEE Molewa on the occasion of the presentation of Budget Vote Number 37 on behalf of the Department of Water Affairs on 21 May 2013, in the Old Assembly Chamber, Parliament, Cape Town. Department of Water Affairs, Pretoria.


