

# Groundwater Availability

## newsletter #5

### Groundwater Strategy 2010

#### Newsletter #5: Groundwater In The National Water Balance

##### How Much Groundwater Does South Africa Have?

This fundamental question was the title of a paper reporting on the national Groundwater Resource Assessment 2 (GRA 2). In this paper Woodford et al. (2005) noted the frustration expressed by planners of not having clear information, and set out to show that, through GRA 2, we do know enough to better utilise the resource.

##### Terminology

From both a planning and utilisation perspective, groundwater and surface water need to be understood in similar terms.

The National Water Resource Strategy provides an estimate for the volume of all surface water (mean annual runoff) generated across South Africa, and how much of that water is at present available for use on an assured basis.

The term for this is **Available Yield**; the actual volume of groundwater known to be in use is added to this to give Total Available Yield. South Africa can still capture a little more of its mean annual runoff, making this “available”, although practical, economic and ecological constraints are such that the additional potential for surface water is now very limited.

*Terms used for groundwater and surface water need to be matched as closely as possible:*

##### Assurance of Supply

Estimates of surface water availability are made on the basis of a 1:50 year assurance of supply. There is an expectation that the given volume can, on average, be delivered for 49 years out of every 50, but that the delivery can be expected to “fail” once every 50 years, when less than the planned volume will be available. In order to compare groundwater availability to that of surface water, groundwater volumes should be estimated from levels of sustainable use where a failure would only occur in one out of 50 years.

**Harvest Potential** is the total volume of groundwater that could theoretically be abstracted if there were no constraints at all.

**Yield Potential** (or Potential Yield) is the potential capacity of an aquifer, if it could be fully utilised, to sustainably deliver a volume of water at an assurance of supply similar to that for surface water (e.g. 1:50 year assurance).

**Actual Yield** of an aquifer is the amount of water that the aquifer is currently supplying, and will depend on the number and size and siting of boreholes installed to exploit that aquifer<sup>[1]</sup>.

**Utilisable Yield** is the Actual Yield, plus the additional Potential Yield that could reasonably be expected to be put to sustainable use within the foreseeable future. The possibility of use has thus been identified, but additional boreholes would still be needed to abstract more water. The timeframe for this prospective development should be clearly defined. From a practical perspective **Utilisable Yield** best expresses the availability of groundwater in a way that is most closely equivalent to the way ‘Available Yield’ is used for surface water. In the case of surface water ‘available yield’ is part of the existing system supply, while for groundwater part of the ‘utilisable yield’ may still need to be accessed.

**Utilisable Groundwater Exploitation Potential (UGEP)**. This provides for a management restriction on the volumes that may be abstracted based on a defined “maximum” allowable water level drawdown. If production boreholes were optimally distributed over an aquifer, these volumes of groundwater could theoretically be abstracted on a sustainable basis.

The normal annual potential supply of groundwater takes into account limits imposed by recharge (including its variability due to rainfall fluctuation), variations imposed by borehole yield which affect the practicality of abstraction (“exploitation factor”), groundwater contribution to river baseflow, and the ecological Reserve. Existing abstractions are included in this volume.

UGEP does not take into account perceived limitations due to poor groundwater quality (which could be remedied by water treatment, as with surface water). Nor does it take into account that some of this water is too far from demand and may never be used. This means that **Utilisable Groundwater Exploitation Potential** could be more than **Utilisable Yield** – which may be a

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##### Some tips for users, and especially Municipalities

- (i) All water use must be licensed. It is more likely that a groundwater source will be approved given that there is less likely to be an impact on the environment and on other users.
- (ii) All water is public water. Groundwater for municipal use may be abstracted not only from municipal lands, but from any other property within reach - provided this does not prejudice existing lawful water use by that landowner. One way of managing the expected objections of some landowners would be to pay - not for the water, but for the service in providing that water (borehole monitoring, management and maintenance, pipeline maintenance etc.)

##### Some Strategic Messages

- Groundwater is often available and can be sourced in sustainable quantities.
- The use of groundwater reduces the pressure on surface water sources, and on available water to other users. This favours the licensing of groundwater use.
- Groundwater should always be explored as an option before other sources of water are utilised.
- If a scoping study indicates the possible use of groundwater then further work

lesser volume given the 'possibility of use' constraint.

**Borehole yield** is the pumping capacity of a borehole - that is the capacity of the borehole to deliver water. This is not the same as the yield of the aquifer. Borehole yield is determined by the size of the borehole and the rate at which the aquifer is able to deliver water to that borehole. If one sees an aquifer as equivalent to a dam it may take several, or even several hundred, boreholes to serve as the outlet works in delivering the water to users of the aquifer. This would be like a big dam with many small outlet pipes. Boreholes must be sized and situated to match the nature and transmissivity of the aquifer.

**Note 1:** Groundwater Yield reflects a volume of sustainably accessible water; it is not the speed or tempo at which groundwater can be abstracted.

**Note 2:** There is a strong "borehole element" to the volume of groundwater that can be made available. The degree to which an aquifer can be utilised will depend on the geohydrology and whether boreholes can be sited to make optimum use of depth, distribution and areas of preferential recharge; this in addition to the availability of power to run the pumps, and the proximity of users. Spacing of boreholes will depend on how the geology impacts on borehole delivery volume.

[1] In the National Water Resource Strategy the actual yield or use of groundwater at that time, was taken as a surrogate value for 'available yield' (water available for use), which differs from potentially available groundwater, or 'utilisable yield'.

## Groundwater Recharge

The availability of groundwater is dependent on recharge from rainfall, just as river flow is dependent on rainfall. Most of South Africa's groundwater is distributed in cracks and fissures in the underlying geology. Like rivers, this water is constantly replenished, and can be used continuously and sustainably, although it too can be over-exploited.

The management task is to ensure that utilisation stays within the limits imposed by rainfall and recharge. Groundwater differs from rivers in that the response to rainfall is not "flashy" but reflects over a period of months or even years. The response to droughts is also much slower, with groundwater therefore a far more buffered resource than surface water.

Surface characteristics and geology can result in 'preferential recharge areas' and it is important to know and understand these. Artificial recharge is where additional water (sometimes previously used) is added to the system.

Recharge rates have been determined for the whole country, as shown in the map below. This provides a very useful spatial indicator of the rate at which water may be sustainably abstracted.

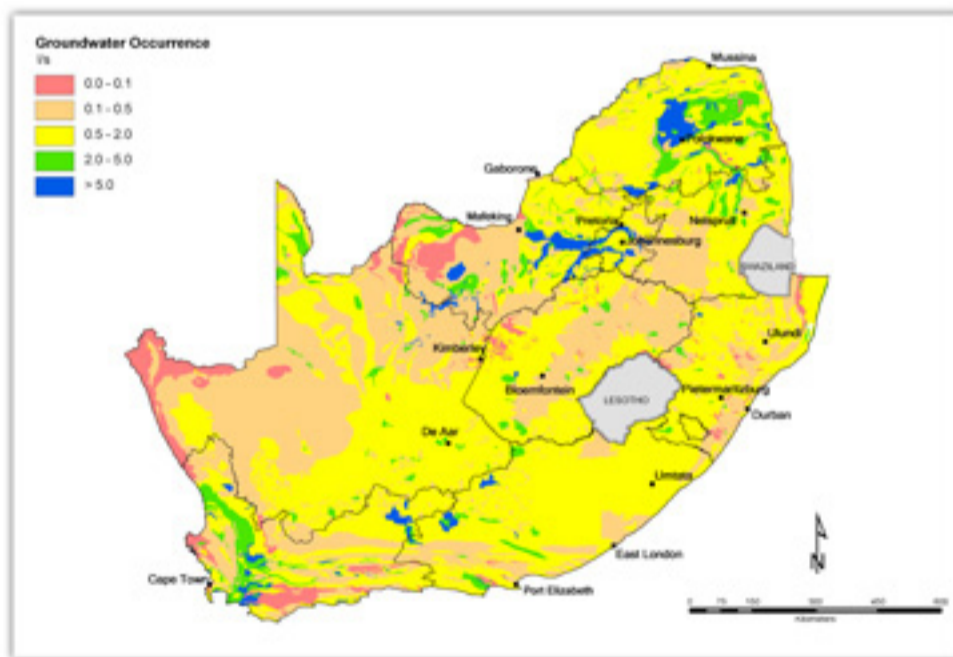


Figure 1 Groundwater recharge in mm/annum (Source GRA 2)

## GW:SW Interaction

The most frequently asked question is "How does the use of groundwater affect our surface water resources, and where does this groundwater go if it is not utilised?" As noted above this has already been considered and accounted for in terms of surface water availability. There certainly can be, but is not always, an interaction between groundwater and surface supplies. The most obvious interaction is in the water flowing in some springs, and particularly the dolomitic eyes. Drawing groundwater can reduce the artesian head and lead to flow reductions.

Groundwater also surfaces, to a greater or lesser degree, as baseflow in many rivers, and

should be accompanied by a cost: benefit analysis (financial, environmental, and opportunity cost:benefit).

## References

Middleton, B.J., and Bailey A.K., 2009. *Water Resources of South Africa, 2005 Study (WR2005)*. WRC Report TT380/08, Water Research Commission, Pretoria.

Woodford, A., Rosewarne, P., and Girman, J., 2005. *How much groundwater does South Africa have?* ~SAN CIAHS Conference, Midrand, South Africa.

## Some useful conversions

- 1 litre/second~86 m3/day and 30 000 m3/ annum
- 5 litres/second ~ 150 000 m3/annum
- 30 litres/second ~ 1 million m3/annum
- Wind pumps – can pump up to 400l/hr or 3 500m3/yr if pumping continuously at maximum rate.

## Your feedback

Your inputs on this topic, or any other aspect related to the future of Groundwater in South Africa, would be much appreciated.

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## Archives

National Groundwater Strategy Newsletter #6: Artificial Recharge

excessive utilisation could be expected to reduce this. Nevertheless there is a very strong inherent efficiency in utilising groundwater, with the volumetric impact far lower than the commensurate volumetric groundwater yield, and also greatly smoothed out over time. Groundwater sources are, to all intents and purposes, highly efficient dams, with no evaporation. And if there is deep subterranean leakage to the ocean, then all the more reason to utilise it.

### So – How Much Groundwater Do We Have?

What planners and water managers need to know is the annual volume of groundwater that is potentially available for use without impacting on surface water availability. Also required is the distribution of this water and, critically, how much can be economically and effectively put to use.

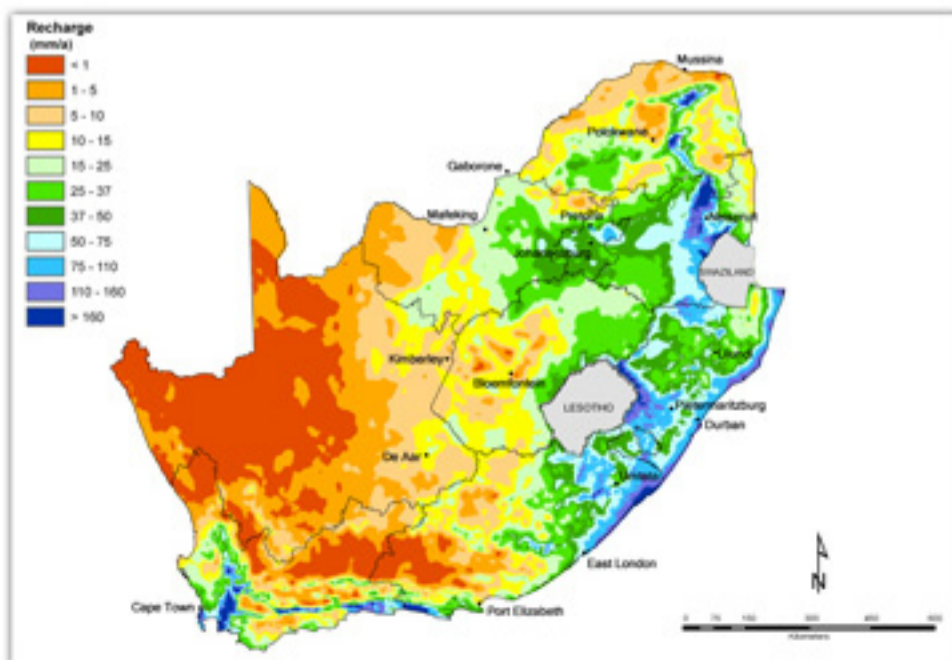
Confident estimates of how much groundwater South Africa has, and how much can be used sustainably, can now be made. The most recent estimate of Utilisable Groundwater Exploitation Potential in South Africa is 10 300 million m<sup>3</sup>/a (Middleton and Bailey, 2009). In a drought year (not clearly defined but taken as equivalent to surface water, with a 1:50 year assurance of supply) this drops to 7 500 million m<sup>3</sup>/a. As defined above, Utilisable Groundwater Exploitation Potential represents a management restriction on the volumes that may be abstracted based on a defined “maximum” allowable water level drawdown.

The distribution of Utilisable Groundwater Exploitation Potential (UGEP) is estimated for ‘normal’ and for ‘drought’ years – with the following table drawn from Middleton and Bailey (2009) and the GRA 2:

Water Management Area	UGEP normal rainfall (million m <sup>3</sup> /a)	UGEP drought years (million m <sup>3</sup> /a)
1 Limpopo	644	541
2 Luvuvhu and Letaba	309	233
3 Crocodile West and Marico	448	335
4 Olifants	619	413
5 Inkomati	669	503
6 Usutu to Mhlathuze (incl. Swaziland)	864	612
7 Thukela	513	376
8 Upper Vaal	564	388
9 Middle Vaal	398	276
10 Lower Vaal	652	501
11 Mvoti to Umzimkulu	705	532
12 Mzimvubu to Keiskamma	1386	1047
13 Upper Orange (incl Lesotho)	675	481
14 Lower Orange	308	239
15 Fish to Tsitsikamma	542	394
16 Gouritz	280	165
17 Olifants/Doorn	159	88
18 Breede	364	238
19 Berg	248	168
<b>TOTAL</b>	<b>10 345</b>	<b>7 530</b>

Table 1 Utilisable Groundwater Exploitation Potential by WMA

Utilisable Groundwater Exploitation Potential has been tabulated by WMA, but a more precise spatial representation is given in the map below. This indicates a far more detailed understanding of actual distribution, as does the map showing spatial distribution of borehole delivery rates – which also shows areas of especially high groundwater availability



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## How Much Groundwater Is Currently Used?

One would expect it to be easier to get an accurate estimate of actual groundwater use in South Africa. The long history of groundwater as 'private water' has, however, meant that there has been relatively little control of use, at least beyond areas that were set aside as 'subterranean groundwater control areas'. The Department of Water Affairs' Water Authorisation and Registration Management System data on registered use (WARMS) is the key source of information but, again as for surface water, urgently requires verification. Current estimates show groundwater use in the order of 2 000 million m<sup>3</sup>/a.

The National Water Resource Strategy (2004), along with other DWA water resource reconciliation strategies, considers groundwater 'availability' to be equivalent to actual use - so the groundwater reconciliation (availability minus use) balances out at zero. This does not account for readily available groundwater that has yet to be accessed. i.e. the utilisable yield.

We know that there is over-exploitation of some aquifers (e.g. Dendron, Tosca, the Sandveld) and here the reconciliation should be negative. We also know that in most cases utilisation does not approach the potentially accessible supply (utilisable yield).

Middleton and Bailey estimate 7 500 million m<sup>3</sup> of potentially utilisable groundwater in a drought year, less the 2 000 million m<sup>3</sup> already in use – leaving us with a utilisation potential of 5 500 million m<sup>3</sup>/a (see also table 1).

Putting the extent and value of South Africa's groundwater resources into perspective, South Africa's dams have a total capacity of some 32 400 million m<sup>3</sup>, and a total "assured yield" (that is water available through a drought period) from surface water sources of approximately 12 000 million m<sup>3</sup> per year. Almost all of this water has already been allocated.

The big question is "How much of the 5 500 million m<sup>3</sup> of total and still available groundwater, is actually and realistically and readily available, and is likely to be used. In other words, how much of this water can be built into the planning equations as additional "available water". This question has not yet been answered. It is the considered opinion of groundwater experts within the Department of Water Affairs that at least 3 500 million m<sup>3</sup> of additional groundwater (over and above, and almost double, the volume already in use) should minimally be utilisable and thus considered 'available' from a planning perspective.

With current national groundwater use at just over a quarter of the lowest estimate of total utilisation potential, and well under half of estimates of groundwater volume that could be economically, effectively and sustainably utilised, groundwater without doubt offers a major source of additional water to the country. Given that a large number of constraints and precautionary limitations have been built into current estimates, it is reasonable to work with this.

The task now becomes one of scaling these availability estimates down to individual aquifers and situations. There is also the task of establishing licensing principles that would make the use of this very large volume of available groundwater possible - on the basis of current information.

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## Putting "Available" Groundwater To Use

The widespread distribution of groundwater is both its core advantage and disadvantage. Groundwater is available almost everywhere. It is also available across many areas where there are no users and where there is no use for it – and this water, whilst part of the total overall utilisation potential, should not be considered in the total availability equation.

The nature of most of South Africa's geological substrate, with water residing in fractured rock aquifers providing a relatively low yield for any single borehole (the dolomitic aquifers and some of the very deep Table Mountain Aquifer fractures are exceptions) means that utilisation of groundwater can often only be through a large number of boreholes over a very wide area. This does not go down well with many town planners and municipal managers, who have grown to believe that the solution to water always lies in being served by surface water infrastructure schemes: large dams on few rivers with water distributed over great distances in very large volumes. This is a culture that has to change if the potential for groundwater is ever to be realised.

Estimates for surface water are made with the understanding that there are wide confidence limits. South Africa is estimated has a Mean Annual Runoff of 49 000 million m<sup>3</sup>, with a total storage capacity in major dams of 32 400 million m<sup>3</sup>. These volumes can also be reasonably accurately estimated for Water Management Areas and many larger catchments. Modelled estimates are also made at the scale of the quaternary catchment, but planning at these finer scales, and for any supply scheme, always requires further measurement and calculation. Groundwater is in much the same boat. Estimates of groundwater volumes are made at Water Management Area scale, and sometimes this can be reasonably estimated for specific aquifers. It is the volume within an aquifer that really matters, and, as with surface water, local estimates of sustainable use on that aquifer scale will always require more detailed local area studies.

The likely availability of accessible groundwater – per borehole and per km<sup>2</sup> - can be derived over very wide areas from these larger scale estimates, and far better from recharge and availability maps. This information can be used in provisional planning and in the commissioning of pre-feasibility and feasibility studies of actual availability.

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## Licensing Utilisable Groundwater

Whilst surface water availability is always calculated at catchment scale (for different levels of catchment), groundwater must be estimated at the scale or level of the independent aquifer. So, for example, Hermanus in the Western Cape has a licence for the abstraction of 1.6 million m<sup>3</sup> of water from the local aquifer. It is not a borehole that has been licensed, but use from an aquifer that has been estimated to sustainably yield a sufficient volume for this allocation, at a high level of assurance (in all but the very worst drought years). It could take 5, or 10 or 20 boreholes to deliver this volume of water from the aquifer to Hermanus – with the borehole density dependent on the underlying geohydrology.

This is a useful example: When the yield of an aquifer has been determined, it is reasonable to assume that licences within that aquifer could be issued up to the limits that can be supplied by that aquifer. Provided local scale and supply issues are understood, there is no hydrological reason why such licences should not be issued to applicants. Indeed, if the groundwater potential of this country is to be realised then licensing authorities will have to adopt this approach. As in the case of surface water there will be equity concerns, but with groundwater generally used fairly close to the point where it occurs, and with boreholes having an impact only over a relatively limited area, it should not be difficult to ensure that groundwater use applications do not transgress equity supply needs.

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## Meeting The Needs Of Small Towns

**The fact that groundwater has widespread, but often limited, availability means that:**

1. Groundwater is almost certainly available close at hand, but borehole delivery rates will depend on rainfall and geology.
2. Rouxville in the Free State requires 0.67 million m<sup>3</sup>/a or a delivery rate of 21 l/s. This in turn requires a recharge (or 'supply') area of 112km<sup>2</sup> or 11 by 12 km.
3. De Aar in the Northern Cape is much bigger, needing 2.7 million m<sup>3</sup>/a or 86 l/s. This can be provided off a recharge area of 1 108km<sup>2</sup> or 30 x 36km.
4. If there are other users within the recharge area of a town, then these requirements can be added and the "catchment area" expanded. The message is that, while a number of boreholes may be required, these can be spaced over the catchment or recharge area, with none very far from the town itself.

Towns such as De Aar and Willowmore and Steytleville are implementing this distributed supply approach. A cost: benefit analysis should be undertaken for towns that are using groundwater, for towns that aren't, and most importantly for towns that are insisting on surface water.

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## Where Lies The Future?

Some parts of the country are major users of groundwater and completely dependent on this resource. Major areas of use were previously controlled through declaration as subterranean groundwater control areas.

Whilst major agricultural users will continue to draw on existing large aquifers, these are mostly fully exploited. What lies ahead is spreading the use of groundwater to the many under-used aquifers across the country. Key beneficiaries of this water should firstly be small towns and villages, but also mines and other users often located far from surface supplies. So too, agricultural users will often be the only users that can make effective use of water that is sustainably available, and this should be made available for use as the requirement arises. **Two key steps are required to turn this water availability into a reality of use:**

- Municipal managers and planners for rural towns and villages must recognise the value and accessibility of groundwater, taking on the specific management challenges, but reaping the cost: benefit advantages.
- The Department of Water Affairs needs to establish principles and routines that allow for the licensing of groundwater to all sectors, where this has been found to be sustainably available without detriment to existing users.

Further aquifer-specific work (determining synergies between yield and requirement) will be necessary in some cases, but there is much that can go forward on the basis of current information.

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