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STORING WATER IN THE ROCKS

Why build dams when nature provides them for us?

By Mike Wills

As pressure on water resources increases across the country and most potential surface water storage sites have been utilised, industry specialists are becoming increasingly aware of the potential for artificial recharge (AR).

The concept of transferring river or dam water underground into appropriate aquifers by means of infiltration basins or borehole injection has been utilised in various parts of the world with great success for many years (the idea was implemented centuries ago by nomads in Turkmenistan when they diverted infrequent surface run-off from clay-rich areas via long trenches to pits dug in more porous sandy areas) but until recently the take-up has been relatively limited in Southern Africa.

Dr Ricky Murray, who has been involved in the implementation of successful AR schemes at Karkams in Namaqualand and for the city of Windhoek, is convinced that water resources in the region could be far more effectively conserved if greater consideration were given to the idea of AR because many of our local geological formations contain appropriate aquifers.

The Department of Water Affairs (DWAF) agrees and its Directorate: Water Resource Planning Systems has recently published a strategy that's designed to encourage municipalities to explore this option and also to provide a regulatory framework for implementation.

The department believes that irrespective of any water demand management objectives every Water Services Authority must also consider water conservation objectives given that South Africa is a water-scarce country. The primary benefit is that water that would otherwise be lost as runoff, evaporation or evapotranspiration, can be captured and safely stored underground. Additional benefits include the reduction of the dangers of contamination to the supply, the replenishment of the water table and a much reduced environmental impact compared to dams. The technique is primarily applicable as a localised solution for a town or a farming area but it also has some broader regional applications.

AR is particularly valuable in providing a contingency supply from opportunistic water flows for droughts and other emergencies. The city of Polokwane with a population of over half a million people relies extensively on its groundwater in times of peak demand or water shortage. The local water authority treats its wastewater over several weeks in a series of maturation ponds before discharging it via the ephemeral Sand River into the area's alluvial and granite-gneissic aquifers which are weathered and fractured to a depth of 60m. The extraction boreholes penetrate this deeper, hard-rock aquifer and recover up to 4 million cubic metres per year much of which would otherwise be lost to evapotranspiration or extraneous usage.

Recent national estimates of AR potential (contained within the department's AR strategy), indicate that about 9 billion cubic metres could theoretically be stored in the sub-surface. These estimates were based on maximising available aquifer storage in areas of high hydraulic conductivity in both primary intergranular aquifers (suitable for surface infiltration) and from fractured and weathered hard-rock aquifers (ideal for borehole injection). The northern and north-western parts of the country appear to have the highest potential, but broad swathes of the Western Cape, Eastern Cape and KZN could also prove promising.

In the management of AR schemes Dr Murray highlights water quality and clogging issues as the primary concerns. The source water should be compatible to that already in the aquifer to prevent water quality problems, although higher quality water can be utilised to upgrade an aquifer – in this regard converting saline aquifers to useable resources is becoming increasingly popular in other parts of the world.

Murray warns that there are possible chemical reactions between the highly-oxidised surface water and the often anaerobic groundwater that need to be carefully monitored.

Clogging, or plugging as it is sometimes called, refers to the reduction in permeability of the filtration surface of the recharge facility or the reduction in available pore volume and permeability in the aquifer itself and is a problem on as much as 80% of AR sites around the world. The phenomenon is complex and is a due to a combination of physical, biological and chemical processes but the main cause is often low quality source water, especially when it is nutrient rich, resulting in a build-up of the filtered suspended solids. The effect of filtration surface clogging is relatively easy to monitor and reverse however, injection boreholes can be irreversibly clogged if poor quality water is used. Clogging within the aquifer itself is more difficult to detect as it occurs gradually, and for this reason, it is critical that only water of appropriate quality be used for AR.

There are various methods of running pilot recharge tests for determining the clogging potential of a particular site and there is a Fouling Index (MFI) which can provide an accurate predictor of problems. Treating the recharge water by removing the suspended solids through flocculation is an obvious measure to reduce clogging.

With injection schemes, air entrapment and gas concentration can be a potential major problem if the injection infrastructure is incorrectly designed.

One broader issue that is the subject of much debate is the long-term negative effects of large-scale groundwater abstraction. There are implications of both artificially lowering and raising groundwater levels including vegetation dieback, land subsidence, flooding and changes in wildlife habitats.

Any environmental impact study of an AR scheme needs to assess site-specific factors especially in sensitive areas like wetlands. Where necessary, restrictions on the margins of water level variations can be imposed. Aquifers which are well understood and well managed carry the least risk and extensive work has been done, especially in the USA where AR schemes are widespread, on defining the concepts of “safe yield”, “sustainable yield” and “optimal yield”. The damage done by any groundwater scheme also has to be counter-balanced against the usually massive environmental impact of a new dam or an extensive pipeline.

Windhoek represents probably the most powerful case-study of AR in Southern Africa. A series of borehole injection sites in the highly fractured quartzite aquifer in the mountains surrounding the city are being used to replenish a declining water table and provided a source of water during droughts and the capacity to meet seasonal high demand in summer. The scheme is being expanded and has saved the city over a billion rand that would otherwise have been spent on a pipeline from the Okavango.

Given favourable hydrogeolical conditions there is no reason why South African municipalities cannot replicate this success.

DWAF’s Artificial Recharge Strategy *is available for downloading from their website (http://www.dwaf.gov.za). Go to “Documents" and two-thirds down the long list of DWAF documents, you’ll find the strategy under "Other: Integrated water resource planning – National Documents".*