Pergamon

Wat. Sci. Tech. Vol. 39, No. 10–11, pp. 353–356, 1999

0273–1223/99 $20.00 + 0.00

PII: S0273-1223(99)00309-1

MANAGING URBAN WASTEWATER FOR MAXIMISING WATER RESOURCE UTILIZATION

Gideon Tredoux*, Peter King** and Lisa Cavé*

* *CSIR, P.O. Box 320, Stellenbosch 7600, South Africa*
** *Cape Metropolitan Council, P.O. Box 16548, Vlaeberg 8018, South Africa*

ABSTRACT

The Atlantis Water Resource Management Scheme uses artificial recharge of urban stormwater and treated wastewater to augment the natural groundwater resource. The key to the success of the scheme is the fractionation of the stormwater into components of distinctly different quality, and the separate treatment of domestic and industrial wastewater for different end-uses. The groundwater exploitation strategy is largely controlled by water quality requirements. Reuse of domestic and industrial wastewater depends on quality parameters. Tertiary treated domestic effluent is destined for indirect reuse via the aquifer, while treated industrial wastewater is used together with spent regenerant brine and stormwater from the noxious trade area for preventing seawater intrusion. Both residential and industrial stormwater is separated into the base flow and storm flow components and utilised for various purposes. The sustainable operation of the water resource scheme serves as a prototype for the optimal use of water and protection of the environment. © 1999 Published by Elsevier Science Ltd on behalf of the IAWQ. All rights reserved

KEYWORDS

Artificial recharge; groundwater; stormwater; wastewater; water resource management.

INTRODUCTION

The town of Atlantis is situated along the semi-arid west coast, approximately 50 km north of Cape Town. Atlantis boasts a unique water supply system, utilising natural groundwater augmented by artificially recharged urban stormwater run-off and treated wastewater. This system has been in operation for nearly two decades and has grown into a comprehensive water management and quality protection scheme (CMC, 1995).

Atlantis was intended to receive surface water from the Berg River system via a 70 km long pipeline from the Withoogte water treatment plant. Groundwater was only planned as an interim option until surface water could be provided. The economic viability and success of this groundwater supply scheme has prompted measures to ensure its sustainability and it has become a permanent feature of the Atlantis infrastructure (Tredoux and Tworeck, 1984). This has enabled the indefinite postponement of the costly surface water supply.

This paper outlines the measures taken to:

- augment the supplies by artificial recharge
- decrease salinity in the system
- distribute groundwater recharge and abstraction for preventing saline groundwater intrusion
- protect the aquifer against pollution.
- separate urban stormwater and wastewater into fractions of different quality to ensure optimum benefit from artificial recharge.

THE ATLANTIS WATER RESOURCE MANAGEMENT SCHEME

The Cape Metropolitan Council, as operators of the system form part of a multi-disciplinary team of specialists managing the aquifer. Scientists, engineers and environmentalists have combined their skills in the development of a comprehensive Water Resource Management Scheme for the sustainable exploitation of this valuable natural resource. The scheme deals with all aspects of water and wastewater management with the objective of maximising utilization of the limited resources in an essentially closed system (Fig.1).

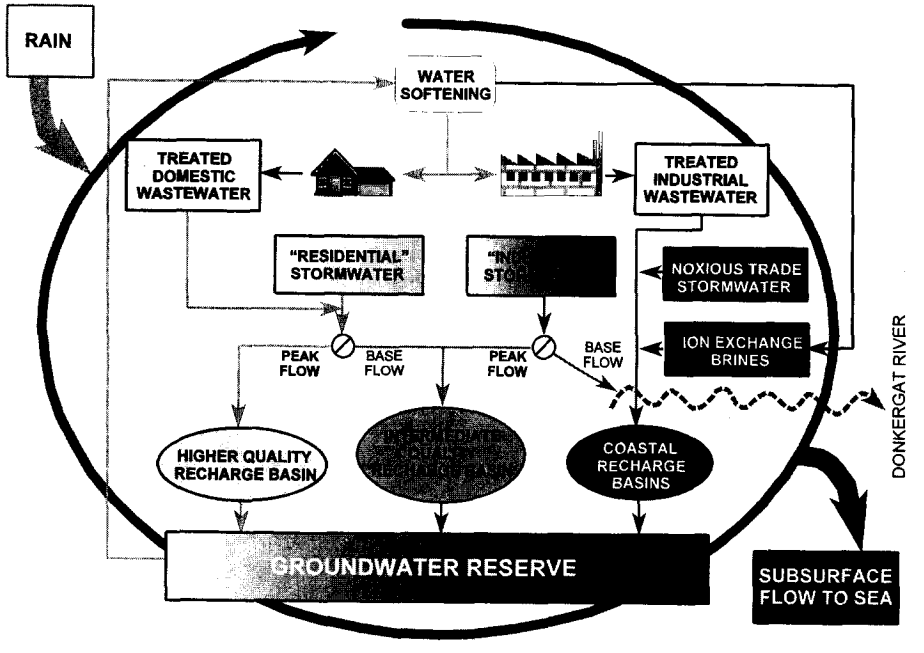

Figure 1. Atlantis Water Resource Management Scheme.

Features of the Atlantis Water Resource Management Scheme are:

- Carefully designed production wellfields at Witzand and Silwerstroom where potable water is abstracted economically from the local coastal aquifer. An exploitation strategy has been developed to ensure sustainability of the resource by placing limits on abstraction areas and pumping rates.
- An ion exchange softening plant which enables groundwater of lesser quality to be softened and blended to the required standards. The sulphuric acid-based softening process has reduced the high sodium load to the wastewater system by eliminating private water softening by individual industries.
- Separate collection and treatment of domestic and industrial wastewater for recharge in different portions of the aquifer. This permits the most beneficial use of the treated wastewater. Stringent adherence to the industrial effluent by-laws is enforced. These operate on a "polluter pays principle" and place restrictions on the quality of discharge to the wastewater system.

- A highly flexible stormwater collection system utilizes the higher quality stormwater runoff for artificial recharge while safely diverting the lower quality stormwater base flow into the Donkergat River. A system of stormwater detention basins has allowed for the introduction of pollution reduction features such as reed beds. The detention basins reduce peak flow volumes, obviating the need for an expensive disposal conduit to the sea which would have caused a loss of valuable fresh water. (Wright, 1991).
- Artificial recharge facilities which augment the natural recharge ensuring sustainability of the groundwater supply. The higher quality storm flows are diverted into the northern recharge basin while the intermediate quality stormwater, together with the treated domestic effluent is fed into the southern recharge basin. This recharge also counters the encroachment of naturally poorer quality groundwater.
- Coastal infiltration basins for the safe recharge of treated industrial effluent, softening plant regenerant liquors and noxious trade area stormwater. The recharge produces a subsurface hydraulic mound which acts as a barrier against seawater intrusion and increases the exploitable groundwater level up-gradient.

MANAGEMENT STRATEGY FOR SUSTAINABLE RESOURCE UTILIZATION

The strategy behind the Atlantis Water Resource Management Scheme takes into consideration both the water quantity which can be abstracted and the maintenance of groundwater quality, particularly with regard to salinity, which is the limiting factor in groundwater exploitation. The essence of the management strategy is:

- separation of stormwater and wastewater into components of different quality.
  - high quality peak storm flow is diverted from the lower quality base flow.
  - domestic and industrial wastewater are collected and treated separately from source.
- artificial recharge at strategic locations for
  - augmentation of fresh water supplies at abstraction zones.
  - countering saline groundwater encroachment and seawater intrusion.
- aquifer protection involving
  - a comprehensive monitoring programme for the collection of water quality data.
  - regular evaluation and investigation of the threat posed by industrial spills and illegal discharges.
  - groundwater quality monitoring at the disused domestic waste disposal site.
  - an environmental impact assessment for well field expansion (KHH, 1994) and the design of an environmental management system for the recharge zone and wellfields (KHH, 1996).

The main recharge and abstraction areas form part of a specially proclaimed nature reserve. An integrated nature conservation management plan incorporating alien vegetation eradication and fynbos protection, provides for beneficial utilization of the area and aquifer protection. A public information and involvement programme is also under way to ensure full cooperation for maximum source protection.

RESULTS

Applying a scientifically-based artificial recharge strategy has ensured that the minimum volume of useable water is lost from the system (Table 1), and also that the natural quality of the groundwater has been maintained and, in certain areas, even improved (Table 2).

Table 1. Typical volumes for the Atlantis Water Management Scheme (Cavé *et al.*, 1996)

Uses	5.5*	Groundwater
Generates	3.6	Wastewater
	2.6	Stormwater
Discharges	3.0	Recharged - reuse
	2.2	Recharged - counter saline intrusion
	1.0	Irrigation and seepage

* Volumes in millions of m^3 per annum

Table 2. Long-term effect of artificial recharge on groundwater salinity at the southern basin

Sampling point	April 1987*	April 1997*	% Change
WP51	116	83	-28
WP52	106	80	-25
WP49	94	75	-20
WP48	97	82	-15

* Values are electrical conductivity readings in mS/m at 25°C

CONCLUSIONS

The innovative approach of the Atlantis Water Resource Management Scheme serves as a model for the beneficial use of urban stormwater and wastewater. Careful separation and balancing of components of different water quality has enabled the urban developers to address the problem of water supply in a region where surface water is limited, while at the same time eliminating the need for costly wastewater disposal options. The success of the scheme is demonstrated by its sustainable operation over the last two decades without significant detriment to the natural groundwater system. Artificial recharge management has succeeded in improving groundwater quality near the abstraction zones.

ACKNOWLEDGMENTS

The authors are grateful to the Cape Metropolitan Council and its predecessors for funding of the groundwater management project and permission to publish this paper and to its councillors and officials for their enthusiasm and support. The project technical staff are thanked for their diligent data collection.

REFERENCES

Cavé, L.C., van der Voort, I and Tredoux, G. (1996). *Atlantis groundwater management review 1995/96.* Report No. ENV/S-C96070, Environmentek, CSIR, Stellenbosch.

CMC (1995). *The Atlantis water resource management scheme - an overview.* Compiled by Cape Metropolitan Council, Liebenberg & Stander and Watertek, CSIR.

KHH (1994). *An initial environmental impact assessment for the Witzands water scheme, phase 3.* Report No. RSC 02 C, Knight Hall Hendry & Associates, Cape Town.

KHH (1996). *Atlantis water scheme environmental management system.* Report No. CMC 06 C, Knight Hall Hendry & Associates, Cape Town.

Tredoux, G. and Tworeck, W. (1984). Artificial recharge of an unconfined aquifer at Atlantis. *Proc. Int. Conf. Groundwater Technology*, Johannesburg, 101-126.

Wright, A. W. (1991). *The artificial recharge of urban stormwater run-off in the Atlantis coastal aquifer.* M.Sc. Thesis, Rhodes University, Grahamstown *(unpubl.).*