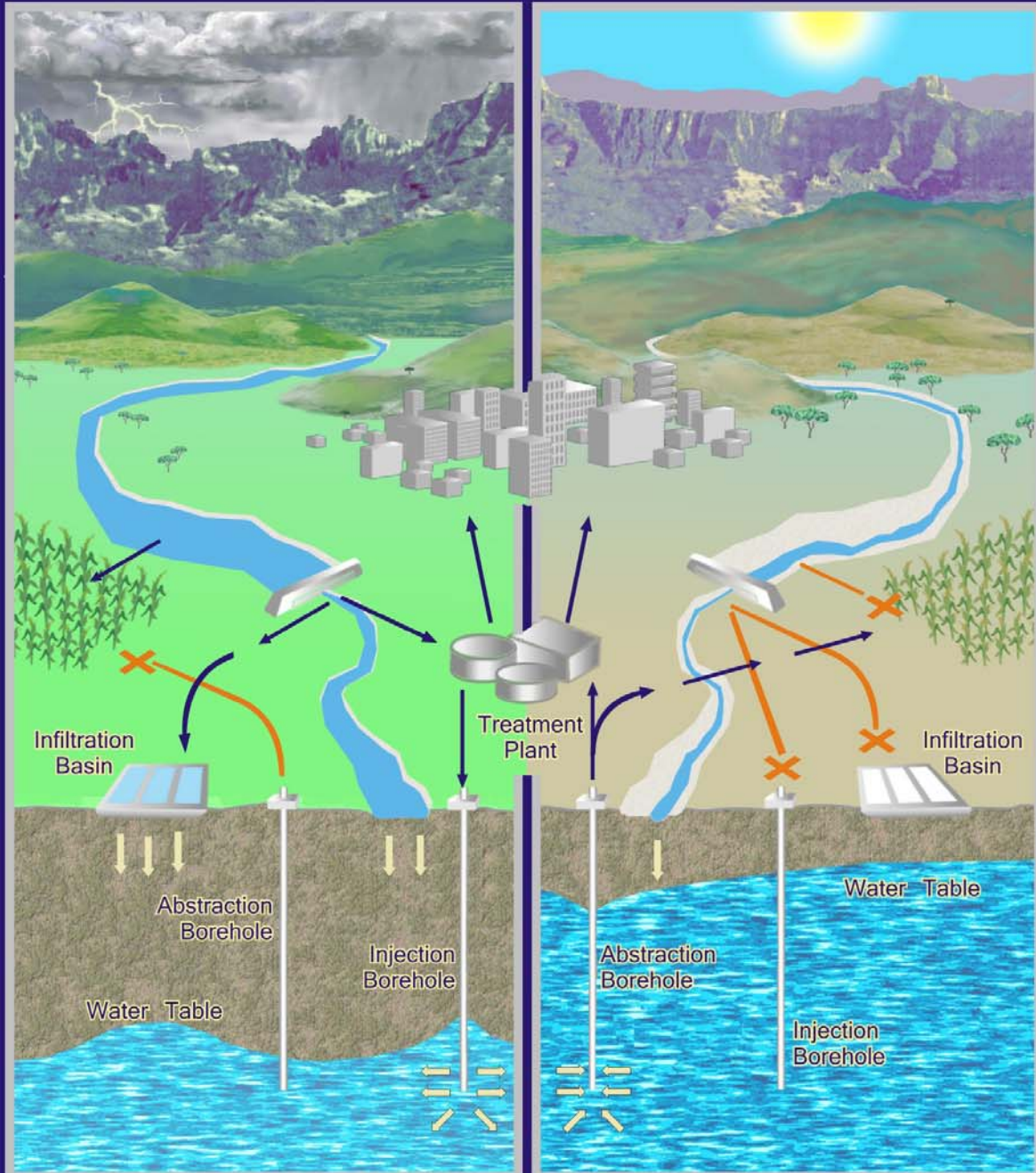


# ARTIFICIAL RECHARGE STRATEGY

Version 1.3 - June 2007



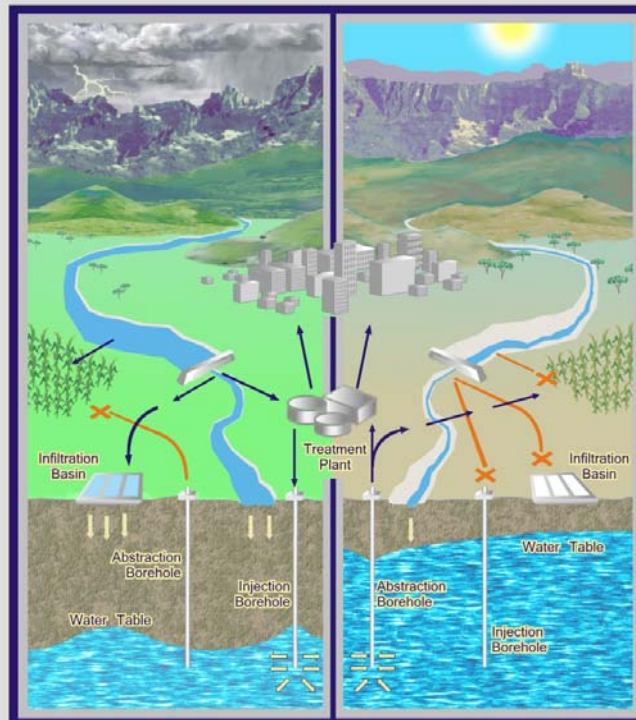
**water & forestry**

Department:  
Water Affairs & Forestry  
REPUBLIC OF SOUTH AFRICA



Water  
Research  
Commission

When surplus water is available, it is transferred underground via infiltration basins or boreholes. The aquifers are rapidly replenished and the water is held in storage for later use.



In times of need, the stored water is pumped from the aquifer via boreholes to the users.

# ARTIFICIAL RECHARGE STRATEGY

*Version 1.3*

June 2007

<i>Progress towards this report:</i>	
<i>Draft Report:</i>	June 2005
<i>Version 1.1:</i>	February 2006
<i>Version 1.2:</i>	April 2007
<i>Version 1.3:</i>	June 2007



**water & forestry**

Department:  
Water Affairs & Forestry  
**REPUBLIC OF SOUTH AFRICA**

# Approval

<i>Report title:</i>	Artificial Recharge Strategy: Version 1.3
<i>Date:</i>	29 June 2007
<i>Authors:</i>	Ricky Murray, Gideon Tredoux, Phillip Ravenscroft, Fanie Botha
<i>Project title:</i>	Strategy Development: A National Approach to Implement Artificial Recharge as Part of Water Resource Planning
<i>Supporting institutions:</i>	Department of Water Affairs and Forestry Water Research Commission
<i>Lead consultant:</i>	Groundwater Africa
<i>Format:</i>	MSWord

*Approved for Groundwater Africa:*



*Dr R Murray*

*Approved for the Department of Water Affairs  
and Forestry by:*



*Mr C Moseki*

*Director:  
Water Resources Planning Systems*

# Acknowledgements

The development of South Africa's artificial recharge strategy is a process that involved many people and organisations. The Department of Water Affairs & Forestry provided the vision and leadership; the Water Research Commission (WRC) supported this and has supported research into artificial recharge for many years; and the CSIR and Groundwater Africa are key role-players in promoting, supporting and undertaking research in artificial recharge. During the course of developing this strategy document the project team worked closely with the Prince Albert Municipality during the Prince Albert Artificial Recharge Feasibility Study and with the Bitou Municipality during the Plettenberg Bay Artificial Recharge Feasibility Study, and we gained valuable insights from discussions with the City of Cape Town regarding the Atlantis Water Resource Management Scheme. The project team would like to acknowledge the support of these municipalities.

The Project Steering Committee played a crucial role in guiding the project and reviewing this report. It consisted of:

- C Moseki (DWAF)
- F Botha (DWAF)
- A Brown (DWAF)
- E van Wyk (DWAF)
- M Smart (DWAF)
- P Viljoen (DWAF)
- J Baron (DWAF)
- A Muir (DWAF)
- H van Kleef (DWAF)
- W Kloppers (DWAF)
- S Veltman (DWAF)
- F Fourie (DWAF)
- H Goossens (DWAF)
- S Naidoo (DWAF)
- K Pietersen (Water Research Commission)
- S Adams (Water Research Commission)
- G Tredoux (CSIR)
- P Engelbrecht (CSIR)
- P Ravenscroft (Maluti GSM)
- D Gqiba (Groundwater Africa)
- R Murray (Groundwater Africa)

The authors would also like to acknowledge the specialist input received from Roger Parsons of Parsons and Associates Specialist Groundwater Consultants, Zahn Munch of GEOSS - Geohydrological & Spatial Solutions International (Pty) Ltd., Sue Milton of Sukaroo, and Ashwin West and Mike Luger of Ninham Shand (Pty) Ltd.

# Contents

Approval .....	i
Acknowledgements .....	ii
List of Figures .....	vi
List of Tables .....	vii
Acronyms .....	viii

## SECTION A: INTRODUCTION I

<b>A.1 INTRODUCTION.....</b>	<b>2</b>
A.1.1 Purpose of a national strategy.....	2
A.1.2 Introduction to the document.....	3
<b>A.2 LEGISLATIVE FRAMEWORK .....</b>	<b>5</b>
A.2.1 Policy.....	5
A.2.2 Legislation.....	6
A.2.3 Strategy.....	7

## SECTION B: THE ARTIFICIAL RECHARGE CONCEPT, ITS APPLICATION AND POTENTIAL 9

<b>B.1 WHAT IS ARTIFICIAL RECHARGE? .....</b>	<b>10</b>
B.1.1 Types of artificial recharge .....	10
B.1.2 Aquifer and artificial recharge storage.....	12
B.1.3 Applications, benefits and constraints of artificial recharge .....	14
<i>B.1.3.1 Applications and benefits.....</i>	<i>14</i>
B.1.3.1.1 Maximise natural storage.....	15
B.1.3.1.2 Water quality management.....	16
B.1.3.1.3 Physical management of the aquifer .....	16
B.1.3.1.4 Ecological benefits .....	16
B.1.3.1.5 Management of water distribution systems .....	17
B.1.3.1.6 Other benefits .....	17
<i>B.1.3.2 Constraints, risks and disadvantages .....</i>	<i>18</i>
<b>B.2 INTERNATIONAL EXPERIENCE.....</b>	<b>20</b>
B.2.1 ASR in the USA.....	20
<i>B.2.1.1 Introduction .....</i>	<i>20</i>
<i>B.2.1.2 Peace River, Florida: Large scale ASR in a limestone aquifer .....</i>	<i>24</i>
<i>B.2.1.3 Kerrville, Texas: ASR in a sandstone and conglomerate aquifer .....</i>	<i>26</i>
<i>B.2.1.4 Main lessons from the USA.....</i>	<i>27</i>
B.2.2 USA: Conjunctive Management of Surface and Ground Water in Utah .....	29
B.2.3 India: Master Plan for Artificial Recharge to Ground Water in India .....	30
<i>B.2.3.1 Overview of the Master Plan .....</i>	<i>30</i>
<i>B.2.3.2 Background and the need for artificial recharge.....</i>	<i>32</i>
<i>B.2.3.3 Areas suitable for artificial recharge .....</i>	<i>32</i>
<i>B.2.3.4 Case study: The basalts of Warud Taluka .....</i>	<i>33</i>
B.2.4 The Netherlands.....	33
B.2.5 Australia .....	34
B.2.6 Germany .....	35
B.2.7 Israel .....	36

## ARTIFICIAL RECHARGE STRATEGY

B.2.8	Palestine .....	37
B.2.9	Sweden .....	37
B.2.10	Switzerland.....	38
B.2.11	United Kingdom.....	38
<b>B.3</b>	<b>SOUTHERN AFRICAN EXPERIENCE.....</b>	<b>38</b>
B.3.1	Atlantis: Urban stormwater and treated domestic wastewater recharge .....	39
B.3.2	Polokwane: Wastewater recharge since the 1970s.....	43
B.3.3	Omaruru River Delta (Omdel), Namibia: River runoff.....	45
B.3.4	Kharkams: Capturing runoff for borehole injection since 1995.....	46
B.3.5	Windhoek: Water banking and integrating artificial recharge into bulk supplies .....	47
B.3.6	Calvinia: Dam water recharge and storage for emergency supplies .....	50
B.3.7	Sand storage dams: Artificial aquifers created in river beds (Namibia) .....	52
B.3.8	Langebaan: Is borehole injection feasible in a confined sandy aquifer? .....	53
B.3.9	Plettenberg Bay: Can natural subsurface storage be used to augment the summer peak demand? .....	53
B.3.10	Prince Albert: Can the the aquifer be filled during the single month when surface water is available for recharge?.....	55
<b>B.4</b>	<b>ARTIFICIAL RECHARGE POTENTIAL IN SOUTH AFRICA .....</b>	<b>56</b>
B.4.1	Potential users and role players .....	56
B.4.2	Artificial recharge's potential role in water use .....	57
B.4.3	Artificial recharge's potential role in water conservation.....	57
B.4.4	Regional scale artificial recharge planning potential .....	59
B.4.4.1	<i>Criteria for site selection</i> .....	59
B.4.4.2	<i>Aquifer type and hydraulic conductivity</i> .....	60
B.4.4.3	<i>Aquifer storage</i> .....	61
B.4.4.4	<i>Existing groundwater use</i> .....	68

## SECTION C: IMPLEMENTATION AND AUTHORISATION 70

---

<b>C.1</b>	<b>CRITERIA FOR SUCCESSFUL IMPLEMENTATION.....</b>	<b>71</b>
C.1.1	A clearly defined need.....	71
C.1.2	The quantity and reliability of the source water .....	72
C.1.3	Aquifer hydraulics.....	73
C.1.3.1	<i>Aquifer geology and geometry</i> .....	74
C.1.3.2	<i>Storage potential</i> .....	74
C.1.3.3	<i>Hydraulic conductivity</i> .....	77
C.1.3.4	<i>Hydraulic gradient and flow directions</i> .....	77
C.1.4	Water quality .....	77
C.1.4.1	<i>Quality of groundwater</i> .....	78
C.1.4.2	<i>Blending of source water and natural groundwater</i> .....	78
C.1.4.3	<i>Water-rock interactions</i> .....	79
C.1.4.4	<i>Clogging</i> .....	79
C.1.4.5	<i>Pre-treatment prior to artificial recharge</i> .....	81
C.1.4.6	<i>In situ treatment (including soil aquifer treatment)</i> .....	81
C.1.4.7	<i>Post-treatment</i> .....	82
C.1.4.8	<i>Water quality monitoring strategy</i> .....	82
C.1.4.9	<i>Public and environmental health risk</i> .....	83
C.1.5	Artificial recharge method and engineering issues .....	83
C.1.6	Environmental issues .....	86
C.1.7	Legal and regulatory issues .....	89
C.1.8	Economics.....	89
C.1.9	Management and technical capacity .....	91
C.1.10	Institutional arrangements .....	92

## ARTIFICIAL RECHARGE STRATEGY

<b>C.2</b>	<b>PROJECT STAGES, LEGISLATION AND AUTHORISATION .....</b>	<b>94</b>
C.2.1	Project stages .....	94
C.2.1.1	<i>Pre-feasibility Stage</i> .....	95
C.2.1.2	<i>Feasibility Stage</i> .....	97
C.2.1.3	<i>Implementation Stage</i> .....	98
C.2.1.4	<i>Operation and Maintenance Stage</i> .....	98
C.2.2	Legislation .....	98
C.2.2.1	<i>National Water Act (NWA)</i> .....	98
C.2.2.2	<i>National Environmental Management Act (NEMA)</i> .....	101
C.2.3	Authorisation Process .....	103
<b>C.3</b>	<b>GUIDELINE DOCUMENTS .....</b>	<b>107</b>
C.3.1	General artificial recharge guideline documents .....	107
C.3.1.1	<i>Draft Code of Practice for Aquifer Storage and Recovery</i> .....	107
C.3.1.2	<i>Standard Guidelines for artificial recharge of Groundwater</i> .....	108
C.3.1.3	<i>Groundwater Recharge and Wells: A Guide to Aquifer Storage and Recovery</i> .....	109
C.3.1.4	<i>Artificial Recharge of Groundwater: Hydrogeology and Engineering</i> .....	110
C.3.1.5	<i>Artificial Recharge: A Technology for Sustainable Water Resource Development</i> .....	111
C.3.1.6	<i>Artificial Groundwater Recharge</i> .....	112
C.3.1.7	<i>Guide on Artificial Recharge to Ground Water</i> .....	112
C.3.2	Issue-based artificial recharge guideline documents .....	112
C.3.2.1	<i>Clogging and artificial recharge of groundwater</i> .....	112
C.3.2.2	<i>Guidelines on the Quality of Stormwater for Injection into Aquifers for Storage and Re-use</i> .....	113
C.3.2.3	<i>Guidelines for the Use of Reclaimed Water for Aquifer Recharge</i> .....	113
C.3.2.4	<i>Artificial Groundwater Recharge – State of the Art</i> .....	114
C.3.2.5	<i>The Potential for Aquifer Storage and Recovery in England and Wales</i> .....	114
C.3.2.6	<i>Groundwater Licensing Guide – application procedure for the development and use of groundwater</i> .....	115
C.3.3	Environmental guideline documents relevant to artificial recharge .....	116
C.3.3.1	<i>Guidelines for involving hydrogeologists in EIA processes</i> .....	116
C.3.3.2	<i>Guideline on the interpretation of the listed activities requiring environmental authorisation</i> .....	116

## **SECTION D: THE ARTIFICIAL RECHARGE STRATEGY** **I 18**

<b>D.1</b>	<b>THE ARTIFICIAL RECHARGE STRATEGY .....</b>	<b>119</b>
<b>D.2</b>	<b>APPROACH TO INCORPORATE ARTIFICIAL RECHARGE IN WATER RESOURCE PLANNING .....</b>	<b>139</b>
D.2.1	Artificial recharge in the context of Water Conservation and Water Demand Management .....	139
D.2.2	Artificial recharge strategy at the Water Resource Level .....	140
D.2.2.1	<i>National Water Resource Strategy</i> .....	140
D.2.2.2	<i>Catchment Management Strategies (CMSs)</i> .....	141
D.2.2.3	<i>Internal Strategic Perspective (ISPs)</i> .....	142
D.2.3	Artificial recharge strategy at the Water Services Level .....	142
D.2.3.1	<i>Integrated Development Plans (IDPs)</i> .....	142
D.2.3.2	<i>Water Services Development Plans (WSDPs)</i> .....	143
D.2.3.2.1	DWAF's Guide, Framework and Checklist for the Development of WSDPs .....	143
D.2.3.2.2	Water Services Feasibility Studies: Applications Procedures, Checklist and Minimum Standards .....	144
D.2.3.2.3	Water Services Planning Framework .....	145
D.2.3.3	<i>Water Conservation and Water Demand Management Strategy for the Water Services Sector</i> .....	145
D.2.4	Water Conservation and Water Demand Management Strategy for the Agricultural Sector .....	146
D.2.5	Water Conservation and Water Demand Management Strategy for the Industry, Mining and Power Generation Sector .....	146
D.2.6	Awareness and education .....	147
References	.....	150

## List of Figures

Figure B.1:	Schematic of types of management of aquifer recharge _____	11
Figure B.2:	Typical ASR recharge, storage and recovery operation _____	21
Figure B.3:	Historical development of ASR schemes in the USA _____	21
Figure B.4:	Uses of ASR schemes _____	22
Figure B.5:	Use of ASR schemes in relation to duration of storage _____	22
Figure B.6:	Source water for ASR schemes _____	23
Figure B.7:	Pre-injection treatment methods at potable water ASR schemes (beyond existing treatment) _____	23
Figure B.8:	Post-injection treatment methods at potable water ASR schemes _____	24
Figure B.9:	Peace River Water Supply System Model _____	25
Figure B.10:	Satisfaction with ASR schemes _____	27
Figure B.11:	Uses of artificial recharge in Germany _____	35
Figure B.12:	Southern Africa's artificial recharge sites _____	39
Figure B.13:	One of Atlantis' infiltration basins _____	40
Figure B.14:	Satellite image showing large-scale centre-pivot irrigation down-stream from the Polokwane Waste Water Treatment Works (This water is abstracted from the hard-rock aquifer that is recharged with waste water) _____	43
Figure B.15:	Infiltration basins at Omdel _____	45
Figure B.16:	Sand filter with injection and abstraction borehole (pump house) in the background _____	46
Figure B.17:	Probabilities of the volume of storage in the aquifer _____	48
Figure B.18:	Windhoek, the rise in groundwater level due to borehole injection (Observation borehole number, location and distance from the injection borehole is indicated) _____	49
Figure B.19:	Injection and abstraction boreholes in Calvinia _____	51
Figure B.20:	Sand storage dam, Namibia _____	52
Figure B.21:	Borehole water levels in Plettenberg Bay _____	54
Figure B.22:	Prince Albert _____	55
Figure B.23:	Areas of artificial recharge potential based on aquifer type and areas of high hydraulic conductivity (borehole yields) _____	61
Figure B.24:	Top of the aquifer _____	62
Figure B.25:	Water levels and surfaces used for the calculation of artificial recharge storage potential _____	63
Figure B.26:	Theoretical artificial recharge storage potential in $m^3/km^2$ _____	64
Figure B.27:	Potentially favourable artificial recharge areas based on aquifer storage and hydraulic conductivity (areas of high borehole yields) _____	65
Figure B.28:	Total groundwater use per quaternary catchment in areas of potential artificial recharge _____	68
Figure B.29:	Municipal groundwater use per quaternary catchment in areas of potential artificial recharge _____	69
Figure B.30:	Agricultural groundwater use per quaternary catchment in areas of potential artificial recharge _____	69
Figure C.1:	Suitability of an aquifer to receive artificially recharged water (Murray and Tredoux, 1998) _____	74
Figure C.2:	Infrastructure components of artificial recharge schemes _____	84
Figure C.3:	Levels of water pricing (after Heyns, 1998) _____	90
Figure C.4:	Proposed artificial recharge project authorisation process _____	105

## List of Tables

Table A.1:	Roadmap of the Artificial Recharge Strategy _____	4
Table B.1:	Factors affecting technology choice for water supply _____	14
Table B.2:	Applications and benefits of artificial recharge _____	15
Table B.3:	Aquifer storage potential _____	17
Table B.4:	Key features of the Peace River Water Supply System _____	25
Table B.5:	Key features of the Kerrville, Texas, ASR Scheme _____	26
Table B.6:	Cost of implementing artificial recharge on a national scale _____	31
Table B.7:	Expected water demand and supply in Mm <sup>3</sup> _____	37
Table B.8:	Artificial recharge sites in Southern Africa _____	39
Table B.9:	Key features of the Atlantis artificial recharge scheme _____	41
Table B.10:	Key features of the Polokwane wastewater recharge scheme _____	44
Table B.11:	Key features of the Omdel artificial recharge scheme _____	45
Table B.12:	Key features of Kharkams artificial recharge scheme _____	47
Table B.13:	Results of Financial Cost Benefit Analyses of Augmentation Options _____	48
Table B.14:	Key features of the Windhoek artificial recharge scheme _____	49
Table B.15:	Key features of the Calvinia artificial recharge scheme _____	51
Table B.16:	Key features of the Langebaan Artificial Recharge Feasibility Study _____	53
Table B.17:	Key features of the Plettenberg Bay Artificial Recharge Feasibility Study _____	54
Table B.18:	Key features of the Prince Albert Artificial Recharge Feasibility Study _____	56
Table B.19:	National Water Conservation/Water Demand Management Strategy framework objectives and the role of artificial recharge _____	58
Table B.20:	The role of artificial recharge in the spheres of water conservation _____	59
Table B.21:	Factors for identifying potential areas for artificial recharge application _____	60
Table B.22:	Theoretical potential artificial recharge storage _____	66
Table B.23:	Natural groundwater storage and theoretical potential artificial recharge storage _____	67
Table C.1:	Water sources for AR _____	73
Table C.2:	Potential negative environmental impacts of artificial recharge schemes _____	87
Table C.3:	Institutional framework for artificial recharge management _____	93
Table C.4:	Recommended artificial recharge project stages, key activities and authorisation requirements _____	96
Table C.5:	Water uses recognized in Section 21 of the NWA that may be applicable to artificial recharge projects _____	100
Table C.6:	Activities that require Basic Assessment, as stipulated in NEMA Regulation 386 _____	101
Table C.7:	Activities that require a Scoping Study and an EIA, as stipulated in NEMA Regulation 387 _____	102
Table C.8:	Summary of tasks for proposed artificial recharge authorisation _____	106
Table D.1:	Artificial recharge Vision, Themes and Management Objectives _____	119

# Acronyms

<i>AOC</i>	Assimilable Organic Carbon	<i>IMIESA</i>	Institution of Municipal Engineering of South Africa
<i>AR</i>	Artificial Recharge	<i>ISP</i>	Internal Strategic Perspective
<i>ARMS</i>	Artificial Recharge Management and Storage	<i>IWRM</i>	Integrated Water Resource Management
<i>ASCE</i>	American Society of Civil Engineers	<i>MAR</i>	Mean Annual Runoff
<i>ASR</i>	Aquifer Storage and Recovery	<i>MAR</i>	Managed Aquifer Recharge
<i>ASTR</i>	Aquifer Storage, Transfer and Recovery	<i>MARS</i>	Managed Aquifer Recharge and Storage
<i>AWWA</i>	American Water Works Association	<i>MFI</i>	Membrane Filter Index
<i>BCM</i>	Billion Cubic Metres (1000 000 000 m <sup>3</sup> )	<i>MHa</i>	Million Hectares
<i>CBA</i>	Cost Benefit Analysis	<i>Mm<sup>3</sup></i>	Million cubic metres
<i>CMA</i>	Catchment Management Agency	<i>NamWater</i>	Namibia Water Corporation (Ltd)
<i>CMS</i>	Catchment Management Strategy	<i>NEMA</i>	National Environmental Management Act (Act 107 of 1998)
<i>CSIR</i>	Council for Scientific and Industrial Research	<i>NGDB</i>	National Groundwater Data Base
<i>CSIRO</i>	Commonwealth Scientific and Industrial Research Organisation (Australia)	<i>NWA</i>	National Water Act (Act 36 of 1998)
<i>DBP</i>	Disinfection By-Products	<i>NWCDMS</i>	National Water Conservation and Water Demand Strategy
<i>DEADP</i>	Department of Environmental Affairs and Development Planning	<i>NWP</i>	National Water Policy (for South Africa)
<i>DEAT</i>	Department of Environmental Affairs and Tourism	<i>NWRS</i>	National Water Resource Strategy
<i>DNDE</i>	Department of National Development and Energy, Australia	<i>SAT</i>	Soil Aquifer Treatment
<i>DO</i>	Dissolved Oxygen	<i>SWECO</i>	SWECO International (Consulting Company)
<i>DOC</i>	Dissolved Organic Carbon	<i>TDS</i>	Total Dissolved Solids
<i>DWAF</i>	Department of Water Affairs and Forestry	<i>THM</i>	Trihalomethanes
<i>EAP</i>	Environmental Assessment Practitioner	<i>TOC</i>	Total Organic Carbon
<i>EC</i>	Electrical Conductivity	<i>WB</i>	Water Board
<i>Eh</i>	Oxidation-reduction potential, mV	<i>WC</i>	Water Conservation
<i>EIA</i>	Environmental Impact Assessment	<i>WDM</i>	Water Demand Management
<i>ENVES</i>	Environmental Engineering Services	<i>WMA</i>	Water Management Area
<i>EPA</i>	Environmental Protection Agency (USA)	<i>WRC</i>	Water Research Commission
<i>GIS</i>	Geographical Information System	<i>WSA</i>	Water Services Authority
<i>GRA II</i>	Groundwater Resource Assessment Phase II (DWAF)	<i>WSDP</i>	Water Services Development Plan
<i>HAA</i>	Halo-Acetic Acids	<i>WSI</i>	Water Services Institution
<i>HACCP</i>	Hazard Analysis and Critical Control Point Plan	<i>WSP</i>	Water Services Provider
<i>IDP</i>	Integrated Development Plans	<i>WSPF</i>	Water Services Planning Framework
		<i>WUA</i>	Water User Association

# **SECTION A: INTRODUCTION**

## A.1 INTRODUCTION

### A.1.1 Purpose of a national strategy

Artificial recharge (AR) is the process whereby surface water is transferred underground to be stored in an aquifer. The most common methods used involve injecting water into boreholes and transferring water into spreading basins where it infiltrates the subsurface. Underground water storage is an efficient way to store water because it is not vulnerable to evaporation losses and it is relatively safe from contamination. Internationally, artificial recharge is becoming an increasingly recognised form of water storage and conservation. South Africa has one major established artificial recharge scheme, however, this technology is underutilised and together with proper groundwater management, artificial recharge can contribute significantly towards maximising the use and sustainability of available water resources.

The purpose of the national artificial recharge strategy is captured in the vision statement:

### *Vision*

*To use natural sub-surface storage as part of Integrated Water Resource Management wherever technologically, economically, environmentally and socially feasible.*

In order to realise this vision, the Department of Water Affairs and Forestry (DWA) has identified seven themes that require attention. These themes are listed below and described in Section D which presents the artificial recharge strategy.

### *Themes*

1. Knowledge Theme
2. Legislation and Regulation Theme
3. Planning Theme
4. Implementation Theme
5. Management Theme
6. Research Theme
7. Strategy Implementation Theme

Artificial recharge or Managed Aquifer Recharge (an alternative term that is commonly used), has many purposes. The most common is to store water in the subsurface for later use, this usually being achieved by allowing water to infiltrate the subsurface via infiltration basins or by injecting water via boreholes into the aquifer. In this context, it is a form of water conservation, in that water that would otherwise be lost through evaporation and evapotranspiration from dams and

rivers, or from outflows to the sea (fresh or waste water), would be captured and made available for later use. Other common uses are to prevent sea water intruding into coastal aquifers by creating hydraulic barriers at the coastline, and to use aquifer media for water treatment, like a large-scale sand filter. A potential use in South Africa may also be to maintain the Reserve, whereby surplus water (fresh or waste) would feed areas where the Reserve is considered to be under threat due to large-scale groundwater or surface water abstraction.

DWAF intends to incorporate artificial recharge as part of water resource planning - both at the Water Resource Level and at the Water Services Level. At the Water Resource Level, this will mean incorporating artificial recharge within Catchment Management Strategies (CMSs) and the National Water Resource Strategy (NWRS); and at the Water Services Level, it will mean including artificial recharge in Integrated Development Plans, in Water Services Development Plans and in the various Water Conservation and Water Demand Management Strategies.

*The main aim of this document is to provide a national strategy on how to create an enabling environment for implementing artificial recharge.*

For this strategy to be effective, that is, for it to enable authorities to include artificial recharge as a feasible option when assessing, planning and managing water resources, it will need to accomplish four critical objectives:

- It will need to promote awareness on artificial recharge
- It will need to pave the way for artificial recharge to be included in various levels of water resource planning
- It will need to provide basic information on the factors that affect the viability of artificial recharge schemes
- It will need to provide guidance on how to obtain approval from DWAF for implementing artificial recharge projects.

### *A.1.2 Introduction to the document*

The Artificial Recharge Strategy has four main components (Table A.1):

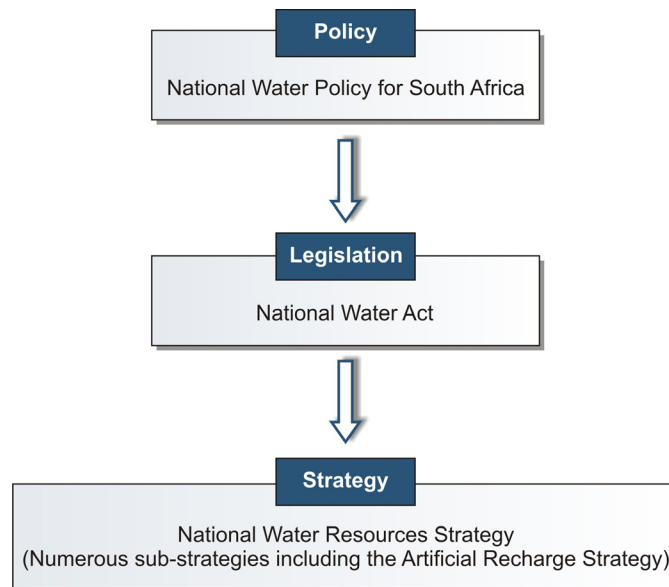
- A: Introduction
- B: The artificial recharge concept, its application and potential
- C: Implementation and authorisation
- D: The Artificial Recharge Strategy

Table A.1: Roadmap of the Artificial Recharge Strategy

SECTION	PURPOSE
<b>A: Introduction</b>	
<p><b>Introduction</b> This section describes the purpose of the Artificial Recharge Strategy, provides the artificial recharge vision and the seven objectives to realise the vision.</p>	To provide a brief explanation of why the Artificial Recharge Strategy is necessary.
<p><b>Legislative framework</b> Artificial recharge is contextualised within existing national strategies and legislation.</p>	To see where artificial recharge fits in the “big picture”.
<b>B: The Artificial Recharge Concept, Its Application and Potential</b>	
<p><b>What is artificial recharge</b> The types of artificial recharge schemes are described as well as their benefits.</p>	To give the reader a rapid overview of what the artificial recharge concept entails.
<p><b>International and Southern African experience</b> Describes existing schemes internationally and within Southern Africa.</p>	To highlight the role that artificial recharge plays in integrated water resource management and to illicit key lessons from operational schemes.
<p><b>Artificial recharge potential in South Africa</b> This section assesses the potential role of artificial recharge in South Africa and quantifies the volume of water per WMA that could be stored using the artificial recharge approach.</p>	To provide an initial assessment of the potential of artificial recharge in relation to the country’s total water resources.
<b>C: Implementation and Authorisation</b>	
<p><b>Criteria for successful implementation</b> Lists and describes the criteria for assessing the viability of artificial recharge schemes.</p>	To provide guidance on the factors that affects the implementation of a successful artificial recharge project.
<p><b>Project stages, legislation and authorisation</b> This section describes the process of assessing, implementing and authorising artificial recharge projects.</p>	To provide guidance on the process of implementing an artificial recharge project and the legal requirements. This section is aimed at both implementing agents and regulatory authorities.
<p><b>Guideline documents</b> Provides an overview of artificial recharge guideline documents.</p>	To provide awareness on existing support material.
<b>D: The Artificial Recharge Strategy</b>	
<p><b>The Artificial Recharge strategy</b> The Artificial Recharge Strategy includes the artificial recharge vision and seven themes. Each theme contains one objective and the actions required to meet the objective. The current status of each theme is described as well as the strategic approach to address each objective.</p>	To describe in detail the Artificial Recharge Strategy
<p><b>Approach to incorporate artificial recharge in water resource planning</b> This section lists government documents into which artificial recharge should be incorporated.</p>	To provides an initial approach to incorporate artificial recharge in water resource planning.

## A.2 LEGISLATIVE FRAMEWORK

This section describes the foundation of this strategy document – the principles, the legislation and the overarching water resource strategy. The diagram below shows how the Artificial Recharge Strategy falls within the legislative framework.



### A.2.1 Policy

The National Water Act, 1998 (No 36 of 1998), is based on the **National Water Policy for South Africa** (NWP), which in turn was guided by 28 Fundamental Principles and Objectives for a New South African Water Law. Three of these principles are pertinent to artificial recharge – Principles 7, 13 and 14:

<b>Principle 7:</b>	<i>The objective of managing the quantity, quality and reliability of the Nation’s water resources is to achieve optimum, long-term, environmentally sustainable, social and economic benefit for society from their use.</i>
<b>Principle 13:</b>	<i>As custodian of the Nation’s water resources, the National Government shall ensure that the development, apportionment, management and use of those resources is carried out using the criteria of public interest, sustainability, equity and efficiency of use in a manner which reflects its public trust obligations and the value of water to society while ensuring that basic domestic needs, the requirements of the environment and international obligations are met.</i>
<b>Principle 14:</b>	<i>Water resources shall be developed, apportioned and managed in such a manner as to enable all user sectors to gain equitable access to the desired quantity, quality and reliability of water. Conservation and other measures to manage demand shall be actively promoted as a preferred option to achieve these objectives.</i>

The terms reliability, sustainability and conservation, as contained in these Principles, provide the basis for pursuing artificial recharge as one of the means to meet the Nation's water supply and management objectives.

Three fundamental objectives for managing South Africa's water resources arise from these principles:

- To achieve equitable access to water, that is, equity of access to water services, to the use of water resources, and to the benefits from the use of water resources.
- To achieve sustainable use of water by making progressive adjustments to water use with the objective of striking a balance between water availability and legitimate water requirements, and by implementing measures to protect water resources.
- To achieve efficient and effective water use for optimum social and economic benefit.
- The concepts of sustainability and efficient and effective use are captured within these objectives. These are also fundamental principles for AR.

### *A.2.2 Legislation*

The **National Water Act (NWA)**, 1998 (No 36 of 1998), is the principal legal instrument relating to water resources management in South Africa and contains provisions for the protection, use, development, conservation, management and control of South Africa's water resources. In addition to the NWA, there are many other policies and laws administered by a number of Departments that affect water resources. Of particular relevance are:

- The **Water Services Act**, 1997 (No. 108 of 1997), which relates to the provision of water services by water services institutions including the safe disposal of effluent. The Water Services Act also requires that Water Services Authorities (WSA's) produce an annual water audit including details of water conservation measures.
- The **National Environmental Management Act**, 1998 (No. 107 of 1998) is relevant to the management of water resources within the context of national environmental principles and legislation.

The **National Environmental Management Act** (No. 107 of 1998) (NEMA) and as amended (No. 56 of 2002 and No. 8 of 2004) provides for the control of listed activities. The Government Notices R. 385, R. 386, and R. 387 published in Government Gazette No. 28753 on the 21st April 2006, and promulgated under Section 24(5) of NEMA, have replaced the environmental impact assessment (EIA) regulations that were promulgated in terms of the Environment Conservation Act, 1989 (Act No. 73 of 1989) in 1997 and introduce new provisions regarding environmental impact assessments.

The **Environment Conservation Act** (No. 73 of 1989) (ECA) previously provided for the control of certain listed activities that 'may have a detrimental effect on the environment'. These activities were listed in Government Notice R1182 of 5 September 1997 (as amended). The Act further prohibits such activities until written authorisation was obtained from the Minister or his delegated authority. The regulations published in terms of the National Environmental Management Act have replaced the ECA Environmental Impact Assessment regulations with effective from 3 July

2006. However the ECA remains in force as it relates to waste disposal, and the Outeniqua Sensitive Coastal Areas regulations.

While the NWA and the NEMA are the two primary acts that govern artificial recharge projects in South Africa, there is other legislation and local bylaws that may apply to specific projects. These include:

- Water Services Act (Act 108 of 1997)
- National Environmental Management: Biodiversity Act (Act 10 of 2004)
- National Environmental Management: Protected Areas Act (Act 57 of 2003)
- Mineral and Petroleum Resources Development Act (Act 28 of 2002)
- Dam Safety Regulations (published in Government Notice R. 1560 of 25 July 1986)
- Conservation of Agricultural Resources Act, 1983 (Act 43 of 1983)
- Promotion of Administrative Justice Amendment Act (Act 53 of 2002)
- National Heritage Resources Act (Act 25 of 1999).

### A.2.3 Strategy

As required by the NWA, a **National Water Resource Strategy** (NWRS) has been developed (DWA, 2004). The purpose of the NWRS as stated in the NWA (Part 1 – Sections 5 - 7) is to “...provide the framework for the protection, use, development, conservation, management and control of water resources for the country as a whole”. The final artificial recharge strategy will form part of the NWRS. Artificial recharge is one of the many ways in which water resources can be protected, used, conserved, managed and controlled.

The National Water Policy discusses the need for an integrated approach to water resource management, and the NWRS provides the context in which this should happen. Artificial recharge is a good example of an approach that integrates the use of surface and groundwater in an environmentally sustainable manner. Whether the source water is from rivers or dams, or whether it is recycled water (e.g. treated waste water), sub-surface storage and blending with groundwater is an effective way to integrate and optimise the use of various water sources.

**Integrated water resources management** (IWRM) is defined in the NWRS as more than just the joint management of surface and groundwater. It is seen as the holistic management of natural resources within the context of sustainable and equitable social, economic and environmental principles. The NWRS defines IWRM as “...a process which promotes the co-ordinated development and management of water, land and related resources in order to maximise the resultant economic and social welfare in an equitable manner without compromising the sustainability of vital ecosystems”. In this context, artificial recharge schemes generally fare favourably when compared with other water development options. A good example is the way in which artificial recharge combines the aspects of both natural water treatment and storage. This is a common goal in many parts of the world where the soils or aquifer media are suitable for both these purposes.

In most cases, artificial recharge schemes are cheaper or more cost-effective than the development of new surface water schemes (Pyne, 1995). This is usually because either they can be implemented incrementally (in phases) as the demand increases, or the capital costs are less, not requiring the construction of new water treatment works and reservoirs, and frequently

being located near the point of use. Further, the environmental costs are usually favourable because the “foot print” on the landscape is relatively small compared with those of new surface water schemes.

The NWRS recognises that instituting IWRM is a complex and challenging process. In this regard, the Catchment Management Agencies (CMAs) will be tasked with, amongst other issues, ensuring that their water-related plans are consistent with the plans of all other role players in their particular catchments. This will require co-operation between all relevant institutions, organisations and individuals. Where groundwater resources (that have been artificially recharged) are accessible to a number of potential users who are located on or near the aquifer, such cooperation will be vital in order to prevent the misuse of the scheme.

At the local level, artificial recharge can be a significant tool in water conservation. Its advantages over dam development include smaller economic sizes and, in arid areas, significantly reduced evaporation losses and avoidance of the growth of blue-green algae that produce toxins. The concept of “wise use” and conservation is common to many internationally recognised goals. By creating an enabling environment for implementing artificial recharge schemes, South Africa is contributing to a number of international development goals and plans. Examples of these are:

*Millennium Development Goals*, which state among other goals that there should be environmental sustainability by 2015.

*World Summit on Sustainable Development, Plan of Implementation*, where it was agreed, among other issues, to develop IWRM plans by 2005 that would incorporate national/regional strategies, plans and programmes with regard to integrated river basin, watershed and groundwater management, and to introduce measures to improve the efficiency of water infrastructure to reduce losses and to increase recycling of water.

*Southern African Vision for Water, Life and the Environment in the 21st Century*, which strives towards, among other issues, a southern Africa where there is equitable and sustainable planning, use, development and management of water resources.