SECTION D:
THE ARTIFICIAL RECHARGE STRATEGY

D.1 THE ARTIFICIAL RECHARGE STRATEGY

The document up to this point is intended to provide a basis for the artificial recharge strategy. It has provided an overview of artificial recharge, looked at key issues affecting its application and it has recommended a process for implementing and authorising schemes. This section presents the artificial recharge strategy – the recommended approach for creating an enabling environment for artificial recharge to become an integral part of the country's water resource management philosophy.

The strategy is presented in the following manner:

The Vision:	The long-term goal
The Themes:	Areas that need to be addressed in order to realise the Vision
The Management Objectives:	The objective of each Theme
The Situation Assessments:	The current status ("where we are now") in relation to the Management Objectives
The Strategic Approach:	Key focus areas that need to be addressed in order to reach the Management Objectives
Actions:	The tasks required to fulfil the Strategic Approach
Responsibility:	The organisation responsible for implementing the Actions
Priority:	The order of implementing the Actions

Table D.1 presents the Vision, Themes and Management Objectives, and the following pages provide a full description of each Theme.

Table D.1 Artificial recharge Vision, Themes and Management Objectives

VISION	
To use natural sub-surface storage as part of Integrated Water Resource Management wherever technologically, economically, environmentally and socially feasible.	
Artificial recharge themes	**Management objectives**
1. Knowledge Theme	To create awareness and provide education on artificial recharge.
2. Legislation and Regulation Theme	To enable water management and water services institutions to adopt and regulate artificial recharge as part of IWRM.
3. Planning Theme	To facilitate the use of artificial recharge in achieving sustainable, efficient and cost effective water resource use and management.
4. Implementation Theme	To support water management and water services institutions in implementing artificial recharge.
5. Management Theme	To optimise the management of artificial recharge schemes.
6. Research Theme	To develop a body of knowledge that supports efficient and effective implementation and operation of artificial recharge schemes.
7. Strategy Implementation Theme	To implement and update the artificial recharge strategy.

Theme 1 Knowledge	
Management Objective	Create awareness and provide education on artificial recharge.
Situation Assessment	The concept of transferring surface water to be held in underground storage is usually more efficient than above-ground storage. Evaporation losses are negligible and the risk of contamination is a less than in surface reservoirs. However, artificial recharge is not well known and so far, has not been adopted on a wide scale. Since 1998 two Water Research Commission reports and one booklet have been published on case studies and the factors that affect the viability of artificial recharge schemes. This information has been presented at national water conferences, lectures in major urban centres, and it has had limited coverage in magazines, newspapers and radio. The hydrogeological sector, and to a lesser extent, the broad water sector, have been given access to the artificial recharge concept and its applicability. Once-off lectures on artificial recharge have been given at universities, but it has not been incorporated their curricula.
Strategic Approach	The strategic approach should aim to: 1. Make the artificial recharge strategy accessible; 2. Spread the awareness of artificial recharge to a diverse audience; and 3. Educate people on artificial recharge. A flagship project for awareness and educational purposes should be developed to assist in achieving these aims. More specifically: 1. **Accessible:** Make the artificial recharge strategy broadly accessible by advertising it and presenting it throughout the country. 2. **Awareness:** Broaden awareness on artificial recharge amongst the water and planning sectors and amongst governmental departments other than DWAF. 3. **Educate:** Educate students, government officials and practising professionals on the value, applicability, feasibility, implementation and operation of artificial recharge schemes. 4. Develop a **flagship project** to demonstrate the value and operation of an artificial recharge scheme and serve as an educational centre.

Management Actions, Responsibility & Priority		
Actions	**Responsibility**	**Priority**
1. Make the artificial recharge **Strategy** accessible.		
1.1 Place it on DWAF's website and print hard-copies. Release it to the media: 1. Professional media, including newsletters, magazines and journals from municipal, water, engineering, planning, environmental, agricultural, mining and industrial sectors. 2. Popular media, including newspapers, television and radio.	DWAF HO	1
1.2 Present the strategy in 10 centres around the country: Pretoria, Cape Town, Durban, Port Elizabeth, East London, Kimberly, Bloemfontein, Upington, Polokwane and Nelspruit. The target audience should include: Municipalities, DWAF Regional Offices, CMAs, DEAT Regional Offices, academic/training institutions and engineering, planning, hydrogeological and hydrological consultants.	DWAF HO	2
1.3 Present the strategy at national water, municipal and development planning conferences (eg WISA and IMIESA); and at an international artificial recharge conference(ISMAR).	DWAF HO	2
2. Broaden **awareness** on artificial recharge.		
2.1 Produce posters for DWAF, DEAT and Municipalities. These should include the types of artificial recharge, their benefits and the criteria for successful implementation.	DWAF HO	2
2.2 Produce billboards at existing artificial recharge sites. These should inform people that artificial recharge is practiced in the area and of its main purposes.	DWAF RO	2
2.3 Produce information on artificial recharge. This should include booklets, journal articles and magazine articles. The subject matter should include the types of artificial recharge, their benefits and the criteria for successful implementation. The target audiences should include Government Departments (eg DWAF, DEAT), Local Government, Mines and Energy and Agriculture, Catchment Management Agencies, Water User Associations, Municipal Associations (eg Water Services Authorities and Water Services Providers), Farming Associations, Water Boards and engineering/water science professionals.	DWAF HO & WRC	2

3. Promote artificial recharge **education**.		
3.1 Develop a training course on implementing and operating artificial recharge schemes. Include all the issues that need to be assessed in feasibility studies and the implementation stages, as well as general operation and maintenance procedures. The course should be housed at the information centre of the flagship project.	DWAF HO	3
3.2 Artificial recharge should be incorporated into university curricula. The target disciplines should include development planning, engineering, hydrology and hydrogeology. Presentations and notes need to be developed and made accessible to teaching staff.	WRC	3
4. Promote a **flagship project**.		
4.1 Identify and assist a municipality in developing an artificial recharge scheme that can be used as a demonstration site.	DWAF HO	3
4.2 Develop an information centre at the municipality and train staff as guides for the information centre and field visits. Aim to demonstrate the value of artificial recharge in one or more of the following: Capturing and storing surplus runoff, bridging the peak summer water demand period, providing security against droughts, minimising evaporation losses, improving water quality, enhancing the catchment's water Reserve, improving the ecological status of the area.	DWAF HO	3

Priority 1	Immediate
Priority 2	Within 2 years
Priority 3	Within 5 years

Theme 2 Legislation and Regulation	
Management Objective	Enable water management and water services institutions to adopt and regulate artificial recharge as part of IWRM
Situation Assessment	Artificial recharge with fresh water is not mentioned specifically in the National Water Act but is referred to indirectly in the regulations promulgated in terms of the Act. The regulations effectively state that the storage of any volume of water underground requires licensing. However current application forms are not suited to artificial recharge, as they are geared towards storage in dams. Artificial recharge with waste water is mentioned in the NWA. The discharge of wastewater into an aquifer is regulated and requires registration and licensing in all cases. The only other reference to artificial recharge is in a Government Gazette (No 26187a), in the context of stream flow reduction activities and altering a watercourse. It lists artificial recharge structures as one of the types of infrastructure that is covered by those regulations. The National Environmental Management Act (NEMA) and associated regulations describe a number of activities that would "trigger" the need for either a basic assessment or a full environmental study, comprising a scoping study and an environmental impact assessment. Many of these trigger activities may be part of an artificial recharge scheme, like building roads, a dam etc., but only listed activity 13 is groundwater specific. This stipulates that a basic assessment is required if the volume of groundwater abstracted is greater than the amount authorised under a general authorisation. In summary, artificial recharge is not listed but groundwater abstraction above the general authorisation is a listed activity for a basic assessment and most artificial recharge schemes will trigger a basic assessment on that basis. Once triggered, the environmental study would typically include the assessment of the impact of the project on natural, cultural and socio-economic environments.
Strategic Approach	Under the current legislation artificial recharge projects can be implemented and authorised. However, authorisation will be problematic because the terms and definitions used in current legislation are open to various interpretations when applied to artificial recharge projects. This should be addressed by undertaking the following actions: 1. Clarify the current legal requirements for authorising artificial recharge projects. 2. Clarify the authorisation process and provide guidance and training on this. 3. Review the current legislation and establish whether amendments or new regulations are needed.

Management Actions, Responsibility & Priority		
Actions	**Responsibility**	**Priority**
1. Clarify the current **legal requirements** for authorising artificial recharge projects.		
1.1 Based on the requirements of the National Water Act and the National Environmental Management Act identify the legal requirements for authorising artificial recharge schemes.	DWAF HO	✓ Section C.2
1.2 Update Item 1.1 above after experience has been gained in authorising artificial recharge schemes.	DWAF, Legal Services	3
1.3 Draft a booklet for planners, engineers, environmentalists and hydrogeologists on how to interpret the legal requirements for implementing artificial recharge.	DWAF HO / WRC	3
2. Clarify the **authorisation process** and provide guidance and training on this.		
2.1 Provide guidance on the artificial recharge authorisation process.	DWAF HO	✓ Section C.2
2.2 Produce an artificial recharge authorisation guideline.	DWAF HO	3
2.3 Produce a document to assist regulators in approving / rejecting / improving artificial recharge applications. The document should include the types of conditions that should accompany artificial recharge authorisation. Required supportive documents are listed below and in Objectives 4 and 5.	DWAF HO / WRC	3
2.3.1 Develop principles regarding the modification of natural groundwater taking into account the Resource Quality Objectives as specified by DWAF.	DWAF HO	3
2.3.2 Produce artificial recharge monitoring guideline documents. The documents needed are: 1. Guidelines on water level monitoring; 2. Guidelines on water quality monitoring (including recharge water quality objectives and recovered water minimum quality requirements); 3. Environmental monitoring requirements (including ecological baseline data requirements). The guidelines must relate to the artificial recharge implementation stages and to the scale of artificial recharge schemes.	DWAF HO	3
2.3.3 Define public and environmental health risk assessment needs and management requirements. This relates strongly to the use of reclaimed wastewater and liabilities associated with water quality issues.	DWAF HO	3

2.3.4 Develop principles regarding the right to use artificially recharged water, and how to incorporate this right in the licence agreement.	DWAF HO	3
2.4 Train regulatory authorities in assessing and processing artificial recharge scheme applications and in reviewing the effectiveness of artificial recharge schemes. The main target audience should be DWAF and CMAs.	DWAF HO	3
2.5 Provide a preliminary framework for the institutional arrangements and reporting requirements.	DWAF HO	✓ Section C.1.10
2.6 Update the framework on institutional arrangements to include complex scenarios such as multiple user schemes (eg competing agricultural and domestic users)	DWAF HO	3
3. Review the current **legislation** and establish whether amendments or new regulations are needed.	DWAF, Legal Services	3

Priority 1	Immediate
Priority 2	Within 2 years
Priority 3	Within 5 years

Theme 3 Planning	
Management Objective	Facilitate the use of artificial recharge in achieving sustainable, efficient and cost effective water resource use and management
Situation Assessment	Artificial recharge has many uses. The two prime uses in South Africa are water storage and water conservation. Aquifers, like dams, can be used to store water, and in doing so, water that would otherwise be lost to evaporation or outflow to the oceans, can be conserved for later use. To date, maximising sub-surface storage through artificial recharge has not been considered by water sector planners. This Strategy document provides the first attempt to address this. During the course of developing this Strategy document, the artificial recharge potential at the Water Management Area (WMA) scale was estimated. Only areas with known high permeability were used, as these areas are favourable for rapidly recharging and abstracting groundwater. The total water volume that could be stored over and above existing natural groundwater storage is estimated to be 8 000 Mm^3 (see Chapter B.4). The water conservation concept is prevalent amongst water resource planners and is reflected in most planning documents. Artificial recharge, however, is rarely mentioned, although it is recommended in some Internal Strategic Perspective documents (ISPs). Listed below are a number of strategic documents where water conservation and the wise use of existing water resources are encouraged. • National Water Resource Strategy (NWRS) (DWAF, 2004). The NWRS encourages all forms of water conservation. Artificial recharge, although not mentioned in the NWRS, is one way of achieving conjunctive water use and water conservation. • National Water Conservation and Water Demand Management Strategy (DWAF, 2004a). A National Water Conservation and Water Demand Management Strategy (WC/WDM) was developed by DWAF's Directorate: Water Use and Efficiency, and incorporated into the National Water Resource Strategy (NWRS). One of the roles of the WC/WDM Strategy is to: "promote the use of new technologies which will raise the level of water use efficiency in all sectors". Artificial recharge, although not a "new technology", is an under-utilised, innovative approach to water use efficiency. • Catchment Management Strategies (CMS), once completed, will form the next (lower) level of water resource planning. WC/WDM and groundwater use and management need to be incorporated into the CMSs, and artificial recharge should be mentioned as one form of integrating and maximising available water resources. • Internal Strategic Perspectives (ISPs) were developed as an interim measure for each Water Management Area (WMA) or sub-WMA. Recommendations pertaining to artificial recharge are given in some of the ISPs, for example "Aquifer Storage and Recovery could be used to boost recharge during infrequent periods of surplus flow, taking advantage of aquifer storage". Aquifer Storage and Recovery is an artificial recharge term used specifically for borehole injection. • At the Water Services Level, the documents that include the principles of artificial recharge are: - Integrated Development Plans (IDPs). These are the strategic plan for the development of municipalities.

	- Water Services Development Plans (WSDPs). WSDPs form part of the IDPs, and describe current and planned water resource use and management. South Africa's oldest and largest artificial recharge scheme, Atlantis, is not mentioned in Cape Town's WSDP even though it provides about a third of the water requirements for Atlantis town. Likewise, artificial recharge has not been considered as a potential alternative technology in Cape Town's WSDP or mentioned in its section on Integrated Water Resource Management (IWRM). This reflects the current reality in South Africa, where artificial recharge is not recognised as an effective or potentially effective from of water resource management. DWAF has developed a guide for developing WSDPs, and the latest version includes artificial recharge (DWAF's Guide, Framework and Checklist for the Development of WSDPs, Version 10). - Three separate documents: Water Conservation and Water Demand Management Strategy for the Water Services Sector; the Agricultural Sector; and the Industry, Mining and Power Generation Sector. Artificial recharge, while not mentioned in these documents, is a recognised water conservation measure in the water services sectors.
Strategic Approach	Planning for artificial recharge needs to be accommodated at national, regional and local levels. The following areas should be targeted: 1. Artificial recharge needs to be adequately addressed in strategy and planning documents. Planning tools that include artificial recharge also need to be developed for water resource management institutions and water services institutions. Artificial recharge needs to target two spheres within the water sector: • The Water Resource Management Sphere, and • The Water Services Sphere. 2. The artificial recharge potential per WMA and sub-areas needs to be quantified. Existing figures presented in this document need to be updated using localised data sets and the methodology needs to be verified with case studies. 3. Localised areas where artificial recharge is needed should be identified. This should include areas where water tables have dropped due to high groundwater abstraction, where a suitable source water is available, and where aquifer hydraulics and water quality characteristics are favourable for artificial recharge. 4. Identify specialised planning areas and purposes where artificial recharge could have significant impact. For example, areas where artificial recharge could assist in mitigating the effects of climate change (such as areas vulnerable to an increasing variability in rainfall); and areas where artificial recharge could augment the Reserve. 5. There is a need to better understand the economics of artificial recharge. Internationally, artificial recharge has been found to be far cheaper and more cost effective than other water resource development options.

Management Actions, Responsibility & Priority		
Actions	**Responsibility**	**Priority**
1. Ensure that artificial recharge is incorporated in relevant IWRM documents.		
1.1 Ensure that artificial recharge is incorporated in relevant **National scale** IWRM documents.		
1.1.1 Incorporate artificial recharge in updated versions of the NWRS.	DWAF HO	3
1.1.2 Incorporate artificial recharge in updated versions of the National WC/WDM Strategy.	DWAF HO	3
1.1.3 Incorporate artificial recharge in updated versions of the WC/WDM Strategies for the Water Services, Agriculture and Industry, Mining and Power Generation Sectors.	DWAF HO	3
1.1.4 Incorporate artificial recharge in DWAF's Guide, Framework and Checklist for the Development of WSDPs.	DWAF HO	✓ Section D.2
1.1.5 Incorporate artificial recharge in updated versions of Water Services Feasibility Studies: Applications Procedures, Checklist and Minimum Standards.	DWAF HO	✓ Section D.2
1.1.6 Incorporate artificial recharge in updated versions of Water Services Planning Framework.	DWAF HO	3
1.1.7 Incorporate artificial recharge in updated versions of Implementation Guidelines for Water Conservation and Demand Management in Agriculture: Development of Water Management Plans.	DWAF HO	3
1.1.8 Incorporate artificial recharge in updated versions of Guidelines for Catchment Management Strategies.	DWAF HO	3
1.1.9 Incorporate artificial recharge in updated versions of strategic documents pertaining to environmental affairs and sustainable development (eg A Strategic Framework for Sustainable Development in South Africa: Draft for Review, 2006)	DEAT	3
1.2 Ensure that artificial recharge is incorporated in relevant **Catchment / Water Management Area scale** IWRM documents.		

1.2.1 Incorporate artificial recharge in Catchment Management Strategies.	DWAF HO / CMAs	2
1.3 Ensure that artificial recharge is incorporated in relevant **Municipal scale** IWRM documents.		
1.3.1 Ensure that artificial recharge is included in WSDPs.	DMs	3
2. Assess the artificial recharge potential at the WMA and Local scale.		
2.1 Undertake a preliminary assessment of artificial recharge storage potential at the WMA scale.	DWAF HO	✓ Section B.4
2.2 Undertake a detailed assessment of artificial recharge storage potential at the WMA scale (update item 2.1).	DWAF ROs / CMAs	2
2.3 Identify aquifers with an artificial recharge storage potential of 250 – 500 Mm^3, 500 – 750 Mm^3 and 750 – 1 000 Mm^3.	WRC / DWAF HO: Options Analysis	2
2.4 Quantify the surplus surface water that could be used for artificial recharge	WRC / DWAF HO: Options Analysis	2
2.5 Develop an updated yield balance per WMA and reconciliation figures that include artificial recharge.	CMAs	3
3. Identify localised areas where artificial recharge is needed.		
3.1 Establish areas where water tables have dropped due to high groundwater abstraction, where suitable source waters are available, and where aquifer hydraulics and water quality characteristics are favourable for artificial recharge. Identify Local Municipalities with artificial recharge potential and initiate a localised groundwater monitoring programmes.	CMA / DWAF	2
4. Identify specialised planning areas and purposes for artificial recharge.		
4.1 Identify areas where artificial recharge could be beneficial for purposes such as climate change mitigation and Reserve augmentation.	DWAF HO	3
5. Undertake an economic assessment of artificial recharge.		
5.1 Establish artificial recharge implementation and operation costs and develop an economic model to compare artificial recharge with other water resource development options.	DWAF HO	3

Priority 1	Immediate
Priority 2	Within 2 years
Priority 3	Within 5 years

Theme 4 Implementation	
Management Objective	Support water management and water services institutions in implementing artificial recharge
Situation Assessment	The current status of artificial recharge projects and schemes in South Africa is listed below. Operational schemes: • Atlantis • Kharkams Unplanned scheme: • Polokwane Emergency water supply scheme: • Calvinia Feasibility studies: • Langebaan • Plettenberg Bay • Prince Albert The biggest implementation problem is not whether the country has the skills and resources to implement artificial recharge schemes, but the lack of borehole water level and abstraction data in areas of high groundwater use. Without these it is not possible to rapidly establish whether artificial recharge is necessary or not. The challenge is to upgrade nation-wide water level monitoring for all groundwater-dependant users. In the cases of Plettenberg Bay and Prince Albert existing data was inadequate to establish how the aquifers have responded to large-scale abstraction. According to the pump operators', certain boreholes had "run dry". While artificial recharge may be the most appropriate solutions for both towns, data is required to know this. Boreholes had to be properly equipped for monitoring, staff needed to be trained and borehole data loggers had to be installed. Artificial recharge schemes have to be well designed and appropriate for the level of management expertise in order for them to be efficient and effective. This relates to infrastructure (water supply, water treatment, and recharge and abstraction infrastructure) as well as operation and management capacity. During the feasibility stage, the appropriate level of technology must be established to match current and future operational and management expertise.

Strategic Approach	The approach to supporting the implementation of artificial recharge schemes should follow five key areas: 1. Support groundwater monitoring. 2. Provide guidance on the technical aspects around assessing the viability of schemes, on implementing schemes and on technical aspects regarding authorising schemes. 3. Create an incentive mechanism for local government authorities to adopt artificial recharge. The aim should be to encourage the wise use of existing water resources and infrastructure before developing more costly new sources. 4. Develop support mechanisms for implementing artificial recharge schemes. 5. Develop a training course on implementing artificial recharge schemes.

Management Actions, Responsibility & Priority

Actions	Responsibility	Priority
1. Support groundwater monitoring		
1.1 Ensure that groundwater monitoring at the local, groundwater user level is incorporated in the National Groundwater Strategy.	DWAF HO	1
2. Produce guideline documents on assessing the feasibility of artificial recharge schemes and implementing artificial recharge schemes. The documents should cover all the criteria for successful implementation and operation. Some of the key guidelines are listed below.		
2.1 Develop a guideline on water quality requirements for artificial recharge. This should include pre- and post-treatment in relation to both health issues and clogging prevention. The guideline should include water quality standards (with respect to turbidity, microbial quality, chemistry, etc) for the different recharge techniques and water types, to prevent, for example, clogging of the filtration surface and the aquifer.	DWAF HO	3
2.2 Develop a guideline on environmental requirements for authorising and monitoring the impact of artificial recharge schemes.	DWAF HO	3
2.3 Develop a procedure for undertaking artificial recharge feasibility studies.	DWAF HO / DEAT	2
3. Create an incentive mechanism for local government authorities to adopt artificial recharge.		
3.1 Develop an incentive mechanism for water resource management and services institutions to adopt artificial recharge as a form of water conservation. Consider ways to discount water resource management costs (for example, by basing it on the premise that water conserved through artificial recharge creates the potential for additional licences for other users).	DWAF HO	3

4. Develop support mechanisms for implementing artificial recharge schemes.		
4.1 Establish an Advisory Committee to assist artificial recharge applications (consider funding sources like the incentive scheme mentioned in 2.1 above).	DWAF HO	3
4.2. Identify local and international institutions/resources that could be approached to support artificial recharge initiatives.	DWAF HO	3
5. Develop a training course on implementing artificial recharge schemes.		
5.1 Develop a training course on implementing and operating artificial recharge schemes. Include all the issues that need to be assessed in feasibility studies and the implementation stages. The course should be housed at the information centre of the flagship project (See objective 1).	DWAF HO	3

Priority 1	Immediate
Priority 2	Within 2 years
Priority 3	Within 5 years

Theme 5 Management	
Management Objective	Optimise the management of artificial recharge schemes
Situation Assessment	All artificial recharge schemes require management and an operation and maintenance budget. They require staff that are dedicated to optimising the efficiency and effectiveness of schemes. The following tasks are common to most artificial recharge schemes: transferring the source water to the artificial recharge facility, treating the source water, operating the artificial recharge infrastructure, preventing and managing clogging, monitoring the aquifer's response to artificial recharge, optimising abstraction after recharge, and monitoring and managing the recovered water quality. Depending on the size and nature of the scheme, these tasks may be very simple or fairly sophisticated, but either way, they all require management if schemes are to run optimally. In addition to these technical tasks, reporting is required to meet licence agreements. The Atlantis Water Resource Management Scheme has dedicated staff assigned to operating and managing the artificial recharge facilities, and the City of Windhoek appointed a full-time hydrogeologist to manage the Windhoek aquifer and artificial recharge scheme. In addition to support in managing artificial recharge schemes, it is evident that they need to be regulated. Associated with this is the need for regular reviewing of the operational procedures and the effects of artificial recharge. This is particularly important when water of marginal quality is used as the source water for recharge. The aim should be to ensure that water of unacceptable quality is not used for recharge. Performance monitoring is also important where the environmental consequences of mismanagement are severe, for example, in dolomitic aquifers where sink holes can form from groundwater over-abstraction.
Strategic Approach	The approach to enhance capacity to manage artificial recharge schemes needs to focus on three key areas: 1. Provide guidance and support mechanisms for effectively operating artificial recharge schemes. This needs to include identifying the skills required to operate schemes, a mechanism for assessing the performance of schemes, and a system to support data capture and management. 2. Develop a training course on the operation and maintenance of artificial recharge schemes. 3. Develop standards pertaining to the operation and management of artificial recharge schemes.

Management Actions, Responsibility & Priority		
Actions	**Responsibility**	**Priority**
1. Develop a support mechanism for water supply institutions that operate artificial recharge schemes.		
1.1 Develop a checklist of the skills required to operate and manage the various types of artificial recharge schemes. Identify key performance indicators and develop a mechanism for assessing them.	DWAF HO	1
1.2 Develop a system for supporting institutions and staff involved in operating artificial recharge schemes.	DWAF HO	2
1.3 Develop a system for supporting data management.	DWAF HO	2
2. Develop a training course on the operation and maintenance of artificial recharge schemes.		
2.1 Develop a training course on artificial recharge scheme operation and maintenance. The course should be housed at the information centre of the flagship project (see Objective 1).	DWAF HO	3
3. Develop standards relating to the operation and performance of artificial recharge schemes.		
3.1 Develop standards relating to the operation and performance of artificial recharge schemes, and a reporting system that accommodates an annual review of the scheme performance (including data on source- and groundwater quality, volumes recharged and abstracted, and aquifer water levels). The standards should include source water quality (quality limitations suitable for the various types of recharge and end-user use), source water quality monitoring, groundwater level monitoring and groundwater quality monitoring. The standards should be developed with licensing requirements in mind – so that licence conditions can be linked to the standards.	DWAF HO	2

Priority 1	Immediate
Priority 2	Within 2 years
Priority 3	Within 5 years

Theme 6 Research	
Management Objective	Develop a body of knowledge that supports efficient and effective implementation and operation of artificial recharge schemes
Situation Assessment	Two Water Commission Research (WRC) reports have been published in recent years: *Artificial Recharge: A Technology For Sustainable Water Resource Development* (Murray and Tredoux, 1998) and *Pilot Artificial Recharge Scheme: Testing Sustainable Water Resource Development in Fractured Aquifers* (Murray and Tredoux, 2002). In addition to these reports, the WRC published a booklet for the layperson: *Artificial Groundwater Recharge: Wise Water Management for Towns and Cities* (Murray, 2004). Since 1998, numerous papers on artificial recharge have been presented at local and international conferences, and the WRC supported presentations at many cities and towns throughout South Africa. Southern Africa is leading the world in applying artificial recharge to fractured aquifers. New questions will arise as this technology is increasingly applied to different types of fractured aquifers, and research will need to be geared towards developing efficient scheme designs and operating procedures. International research has largely focussed on water quality issues, and in particular, the use of treated waste water for recharge, the prevention and management of clogging in boreholes and infiltration basins, and the prevention of hydrochemical risks. South Africa needs to remain well connected to international researchers and contribute towards in the international knowledge pool. A key challenge for South Africa at the moment is to provide the means to authorise well designed artificial recharge schemes in a timeous and cost-effective manner. The most pressing research needs relate to authorisation and regulation. Officials need guidance on topics such as: the water quality limits acceptable for recharge; the extent to which natural groundwater can be modified (which relate to DWAF's Resource Quality Objectives); acceptable aquifer water level fluctuations, etc. These topics require research that is grounded in international experience and modified to suit South Africa's particular hydrogeological and management conditions. The key water quality research areas that are of immediate relevance are clogging in iron-rich groundwaters, clogging in fractured aquifers and the use of treated effluent as a source water for artificial recharge.
Strategic Approach	There are three areas where research that is particular to South Africa is required: 1. That which is geared towards developing principles or guidelines to assist officials in authorising schemes and setting licence conditions. This theme should focus largely on water quality issues and environmental impacts. 2. Particular water quality issues such as hydrochemical risks and clogging in iron-rich, and fractured aquifers. 3. Issues pertaining to the use of using treated waste water as a source for artificial recharge.

Management Actions, Responsibility & Priority		
Actions	**Responsibility**	**Priority**
1. Research requirements.		
1.1 Establish and prioritise the key research requirements (some of which are listed below).	WRC	1
2. Artificial recharge authorisation		
2.1 Identify the knowledge constraints that could cause lengthy delays in authorising schemes and in establishing licence conditions (eg environmental monitoring requirements).	WRC	1
3. Water quality issues.		
3.1 Research water quality issues pertaining to clogging in iron-rich groundwaters and clogging in fractured aquifers.	WRC	3
3.2 Identify social and environmental requirements for using treated effluent as source water for artificial recharge.	WRC	3

Priority 1	Immediate
Priority 2	Within 2 years
Priority 3	Within 5 years

Theme 7 Strategy Implementation	
Management Objective	Implement and update the artificial recharge strategy
Situation Assessment	This is South Africa's first national artificial recharge strategy and its development has followed a process of compiling two draft versions for review and comment. During the course of developing the strategy, some of the key actions required to create an enabling environment for implementing artificial recharge schemes have been completed. These have been included in the listed actions in this strategy so that progress on strategy implementation can be assessed. The actions listed below are geared to ensure that the strategy is implemented and periodically updated.
Strategic Approach	The artificial recharge strategy will be successful if people from diverse professional backgrounds consider artificial recharge as an option to address water supply, water quality and environmental issues. That is, awareness regarding the benefits and applications of artificial recharge need to reach a wide audience. The focus of implementing the artificial recharge strategy should be to reach this diverse audience and to ensure that the necessary "tools" (technical, legal, etc) are in place for artificial recharge to be implemented efficiently and timeously. This will require artificial recharge champions from DWAF who drive the implementation of the strategy and who are proactive in incorporating artificial recharge within other strategies and planning documents, such as Catchment Management Strategies, Water Conservation and Demand Management Strategies, Water Services Development Plans, etc.

Management Actions, Responsibility & Priority		
Actions	**Responsibility**	**Priority**
1. Find a driver for the artificial recharge strategy		
1.1 Find a home and a champion for the artificial recharge strategy and a funding source for implementing it.	DWAF: Water Resource Planning Systems	✓
2. Facilitate high-level inter-departmental awareness of the strategy		
2.1 Develop an information sheet on the artificial recharge strategy, and inform the Director Generals of the strategy.	DWAF HO	1
3. Ensure that DWAF staff are aware of the strategy and its purpose.		
3.1 Circulate an information sheet on the strategy to all DWAF staff above Deputy Director level.	DWAF HO	1
4. Implement the strategy		
4.1 Develop an artificial recharge implementation plan	DWAF HO	1
4.2 Implement the strategy starting with the 1st Action in Objective 1.	DWAF HO	1
4.3. Develop a plan to ensure that the strategy is reviewed and updated.	DWAF HO	3

Priority 1	Immediate
Priority 2	Within 2 years
Priority 3	Within 5 years

D.2 APPROACH TO INCORPORATE ARTIFICIAL RECHARGE IN WATER RESOURCE PLANNING

D.2.1 Artificial recharge in the context of Water Conservation and Water Demand Management

DWAF recognises that water demand management, water resource management and water conservation need to play a major role in balancing the availability of our country's water resources and future demand. In year 2000, 10 of the 19 Water Management Areas (WMAs) had negative water balances, and the total surplus for the entire country was 186 Mm^3/a (NWRS, 2004). Predictions for year 2025 also indicate that 10 of the 19 WMAs will have negative water balances, but the total balance for the country is estimated to be -234 Mm^3/a. The potential for development is quantified at 5 410 Mm^3/a (NWRS, 2004).

DWAF relates water conservation and water demand management to the efficient and effective use of water and minimising the loss and wastage of water. The challenge lies in developing realistic plans to incorporate artificial recharge as a viable form of water conservation, wherever possible. Although it is not expected that artificial recharge will provide huge water savings in the national water balance, it is envisaged that the savings in certain stressed areas will be highly beneficial. These savings may be small or large, depending on the area. Artificial recharge should be seen as providing a significant conservation measure in strategic areas and not as a form of regional, large-scale water conservation. Artificial recharge should also be seen as a potential cost-effective and natural form of treatment for "polishing" the water. The main advantage, however, is sub-surface storage.

A National Water Conservation and Water Demand Management Strategy (WC/WDM) was developed by DWAF's Directorate: Water Use and Efficiency (DWAF, 2004a), and incorporated into the National Water Resource Strategy (NWRS). One of the roles of the WC/WDM Strategy is to: *"promote the use of new technologies which will raise the level of water use efficiency in all sectors*" (DWAF, 2004a). At this stage of the WC/WDM strategy development, the key water use sectors have been targeted:

- Water services (DWAF, 2004b)
- Agriculture (DWAF, 2004c)
- Industry, mining and power generation (DWAF, 2004d).

These strategies outline measures and interventions aimed at encouraging and supporting water institutions and water users to increase the efficiency of their water use. The concept of artificial recharge as a water conservation measure will need to be incorporated into these strategy documents. For example, where "Dam storage optimisation" is mentioned as a Typical Water Conservation Activity (DWAF, 2004a), artificial recharge or "Aquifer storage optimisation" should also be included.

DWAF has the responsibility of supporting water institutions and helping them to develop and implement strategies that suit their own circumstances and which are economically coherent and financially sound with regard to the cost and benefit of the proposed measures (NWRS, 2004). In this regard, DWAF will support water institutions that include artificial recharge as a water

conservation measure. The water services institutions include (National Water Act, 1998 and Water Services Act, 1997):

- Catchment Management Agencies (CMAs)
- Water User Associations (WUAs)
- Water Services Authorities (WSAs)
- Bulk and Retail Water Services Providers (WSPs), such as Water Boards.

The final artificial recharge strategy will target two levels within the water sector:

- The Water Resource Level, and
- The Water Services Level.

Within each level, existing and planned documents are identified for necessary incorporation of the artificial recharge strategy. These documents are:

- Water Resource Level:
  - NWRS
  - Catchment Management Strategies
  - Internal Strategic Perspectives.

- Water Services Level:
  - Integrated Development Plans
  - Water Services Development Plans (and supporting documents)
  - WC/WDM Strategy for the Water Services Sector
  - WC/WDM Strategy for the Agricultural Sector
  - WC/WDM Strategy for the Industry, Mining and Power Generation Sector.

D.2.2 Artificial recharge strategy at the Water Resource Level

D.2.2.1 National Water Resource Strategy

At this stage of artificial recharge development, artificial recharge needs to be incorporated into one section of the NWRS - Chapter 3, Part 3: Water Conservation and Water Demand Management. It is also worth considering incorporating artificial recharge into Chapter 5: National Planning and Co-ordination, and International Co-operation in Water Management. The mention of artificial recharge in Section 1.4: Integrated Water Resource Management (IWRM), is not necessary, as this section only covers the very broad aspects of IWRM and does not detail methodologies, technologies and approaches that could be adopted.

As part of the artificial recharge strategy, it is recommended that the following inclusions be made within the NWRS:

Section 3.3.3: The Principles of Water Conservation and Water Demand Management

In this section of the NWRS, it states that the National WC/WDM Strategy is based on three

fundamental principles:

- Water institutions should strive to supply water efficiently and effectively, minimise water losses and promote WC/WDM among their consumers
- Users should not waste water and should strive to use it efficiently
- WC/WDM should be an integral part of the planning process for water resources management, water supply and the provision of water services.

Within these principles, it is stated that water conservation should be implemented, and the broad concept of wise water use should be practised. Phrases are used such as: "Water institutions …should…*develop and implement measures to promote WC/WDM*"; "…the Department will work closely with water institutions…..to *facilitate better management* and regulation of water use"; and, "The participatory and consultative approaches to implementing WC/WDM will…require water institutions and water users to share responsibility for *ensuring the efficient use of water*". In relation to potential inter-basin transfers, it is a requirement that: "…water currently available be *used optimally*, and reasonable measures be taken to *conserve water* before the transfer is effected".

While these are sound principles, the concept of utilising existing water resources optimally could possibly be encouraged more strongly. In this regard, it is recommended that either a fourth principle be added, or that a further message be included in the third principle. The message needing to be conveyed can be stated as follows:

"Water institutions should strive to utilise all available water optimally. This should include, where feasible, integrated water resource management, the re-use of waste water, the storage of surplus water in the subsurface, and the use of sub-surface environments to treat water."

D.2.2.2 Catchment Management Strategies (CMSs)

The NWA provides for the decentralisation and devolution of the responsibility and authority of water resource management from DWAF to 19 Catchment Management Agencies (CMAs). The core purpose of the CMAs is to manage and ensure the sustainable use of water resources in their areas of operation. Once established, each CMA must develop a Catchment Management Strategy (CMS) that is aligned with the NWRS for the water resources within its Water Management Area (WMA). The CMS will form the most important instrument for the integrated management of water resources in each WMA, and this document should capture the CMA's approach to incorporate artificial recharge as part of its integrated water resource development and conservation strategy.

Until such time that the CMAs are established and their CMSs developed, and in order to provide an interim guide to DWAF Regional Offices in water resource management, DWAF has embarked on an exercise of developing Internal Strategic Perspectives (ISPs) for each WMA or sub-area of an WMA.

D.2.2.3 Internal Strategic Perspective (ISPs)

ISP documents typically contain Situation Assessments that describe the water resources of an area, together with its water requirements. As part of their purpose as interim planning documents, they include recommendations regarding Water Use Management Strategies and Water Demand Management Strategies. Water conservation measures are recommended within these strategies. For example, the ISPs for the Amatole-Kei Area of the Mzimvubu to Keiskamma WMA, 2004, and the Tsitsikamma to Coega Area of the Fish-Tsitsikamma WMA, 2004, recommend the following:

> *"Ensure that the WSDPs of local authorities highlight the need to implement local water conservation and demand management strategies prior to the development of new schemes."*

The ISP for the Gouritz WMA, 2004, specifically mentions the concept of AR:

> *"Aquifer Storage and Recovery could be used to boost recharge during infrequent periods of surplus flow, taking advantage of aquifer storage."*

Recommendations such as these should ultimately be incorporated into the CMSs, and in the interim, be encouraged by DWAF Regional Offices.

D.2.3 Artificial recharge strategy at the Water Services Level

D.2.3.1 Integrated Development Plans (IDPs)

Government has legislated that all Local Authorities undertake an Integrated Development Planning (IDP) process (Municipal Systems Act, No. 32 of 2000), and that Water Services Authorities (WSA) undertake a Water Services Development Planning (WSDP) process (Water Services Act, No. 108 of 1997).

An IDP is a strategic plan for the development of the municipality, and it serves to guide all planning, budgeting, management and decision-making within the municipality. This plan needs to integrate and co-ordinate different sector plans into a single strategic planning tool. The Water Services Act states that the WSDP should be part of the municipality's IDP process and should inform the IDP regarding specific requirements in terms of water and sanitation. In the same way, the IDP must inform the municipality's WSDP of the key issues and objectives derived from the IDP process, as they relate to water- and sanitation-specific issues. Municipal planning is thus an iterative process whereby the multi-sectoral IDPs can both inform and take direction from the WSDPs.

The main components of an IDP are:

- Assessment of current realities
- Vision
- Goals
- Situation analysis
- Integrated framework for development

- Development strategies
- Implementation: institutional plan of action
- Implementation: financial plan of action
- Monitoring, evaluation and revision
- Submission of land-development objectives for provincial approval.

Integrated water resources management, including artificial recharge (where appropriate), should be mentioned in the IDP's Integrated Framework for Development and Development Strategies as one of the means to achieve the municipality's vision. This would be relevant to aspects of the vision pertaining to environmental sustainability and economic development. While it may not be necessary to describe specific artificial recharge projects in the IDPs, they should be identified in the Water Services Development Plans.

D.2.3.2 Water Services Development Plans (WSDPs)

All WSAs must prepare WSDPs (Section 12(1) of the Water Services Act). These plans form part of the IDPs, and they must also be accounted for in the responsible authority's Catchment Management Strategy. The main goals regarding water services are:

- Delivery of sustainable water services (including provision of basic services, free basic water and sanitation and higher levels of services and associated needs)
- Integrated water resource management (protection and management of the water resources)
- Efficient and effective Water Services Authority (institutional arrangements for water services provision).

In line with the delivery of sustainable water resources and integrated water resource management, the WSDPs should contain details of water demand management and water conservation measures. Artificial recharge should be considered as one option to promote these sound environmental and management principles.

DWAF has developed several documents to provide guidance and support for those responsible for developing WSDPs and related documents. These include:

- DWAF's Guide, Framework and Checklist for the Development of WSDPs
- Water Services Feasibility Studies: Applications Procedures, Checklist and Minimum Standards
- Water Services Planning Framework.

D.2.3.2.1 DWAF's Guide, Framework and Checklist for the Development of WSDPs (DWAF, 2004)

This document provides the framework on how a WSDP should "look". It includes guidelines and checklists on information requirements and how this information should be presented. It is planned, laid-out and colour-coded to facilitate a simple and logical approach to compiling WSDPs.

Each section that needs to be covered in the document should be described according to the following four "Key Activities":

- Situation assessment
- Future trends and goals
- Strategic gap analysis
- Implementation strategies.

The sections that need to be described are:

- Socio-economic profile
- Service level profile: Technical option
- Water resource profile
- Water conservation/demand
- Water services infrastructure profile
- Water balance
- Water services institutional arrangements profile
- Customer services profile
- Financial profile
- List of projects.

Artificial recharge activities should be included in the Water Conservation/Demand section. Within this section, under the heading *Water Resource Management Interventions (Section 4.1),* it has been recommended that an additional sub-section be added that encourages consideration of conjunctive water use. As the document currently stands, this would become Section 4.1.1.9.:

> *"Section 4.1.1.9: Conjunctive use of surface- and groundwater*
>
> *Water can be conserved by integrating the management of surface- and groundwater. This can be obtained, by minimising groundwater abstraction during periods of excess surface water (i.e. resting the aquifers), or by artificially recharging aquifers whenever possible. Storing water in aquifers could, for example, minimise evaporation from dams, or provide a means to re-use treated waste water. Describe means to conserve water by means of conjunctive use."*

D.2.3.2.2 Water Services Feasibility Studies: Applications Procedures, Checklist and Minimum Standards (DWAF, 2005)

This guideline document aims to assist planners and managers to conduct feasibility studies on water services developments projects. It encourages planners to consider all critical factors affecting water resource use and water services within the broader economic, social and environmental development goals.

The document is organised into six parts, of which artificial recharge could be included in the sixth:

- Project application procedures
- Project handling procedures
- Project flow chart
- Feasibility specifications
- Feasibility flow chart and checklists for feasibility studies

- Minimum standards and guidelines for feasibility studies.

Artificial recharge practices should be included within the section: *"Minimum standards and guidelines for feasibility studies."*

D.2.3.2.3 Water Services Planning Framework

The two documents described above are sufficiently generic to include artificial recharge in their water conservation strategies. The information required in the Water Services Planning Framework (WSPF) is specific to each WSA, and thus, once the potential for artificial recharge has been assessed at this level of detail, such plans should be included within the WSPF.

The WSPF includes the topics listed below and the potential for specific artificial recharge schemes should be incorporated into the sections on Water Resource Development and Water Conservation and Demand Management:

- General
- Physical and Socio-Economic Development
- Service Level Development
- Water Resource Development
- Water Conservation and Demand Management
- Water Services Infrastructure
- Water Services Authority Institutional Arrangement
- Customer Service
- Financial Profile
- Project Development.

D.2.3.3 Water Conservation and Water Demand Management Strategy for the Water Services Sector

The water supply and sanitation services sector accounts for about 15 percent of total national water use, and it is the sector with the highest expected growth in demand (NWRS, 2004). Water services institutions are expected to determine their own targets and benchmarks for efficient water use (NWRS, 2004). These are included in the WSDPs, and will be reviewed by the responsible authority (DWAF or CMA) during the water use and licensing process.

DWAF has developed the following guideline document for the Water Services Sector to facilitate efficient water use: *Water Conservation and Water Demand Management Strategy for the Water Services Sector (DWAF, 2004b)*.

Paragraph B.4.3 covers the key issues pertaining to the potential for artificial recharge as a water conservation measure, and is not discussed further here.

D.2.4 Water Conservation and Water Demand Management Strategy for the Agricultural Sector

Many farmers throughout South Africa have constructed earth dams for the purpose of enhancing groundwater reserves. The benefit of such efforts has not been assessed, and thus it is not known whether they have had the planned effect. It is likely that, in many cases, the rate of infiltration is very low due to the accumulation of clay minerals at the base of the dam. It is even possible that, with high rates of evaporation from some of the dams, salt concentrations have increased significantly, with the negative effect of recharging saline water into the subsurface.

As yet, no formal attempt has been made to introduce artificial recharge into the farming sector. However, with the increasing need for conserving water, this should change, particularly in areas where the benefits of artificial recharge would be high. Such areas include alluvial aquifers, where there are potentially significant benefits relating to security of supply and maintaining the Reserve. Other areas are those where farmers are over-utilising the groundwater resources.

Irrigated agriculture accounts for about 62 percent of water used in South Africa. The potential for large-scale savings is thus greatest within this sector. DWAF has produced both a strategy and guideline documents that outline WC/WDM measures for the Agricultural Sector:

- Water Conservation and Water Demand Management Strategy for the Agriculture Sector (DWAF, 2004c).
- Implementation Guideline for Water Conservation and Demand Management in Agriculture: Development of Water Management Plans (DWAF, 2000a)

Compliance with this guideline document is necessary for the approval of Water Management Plans which is the (additional) document required for water use licence applications.

It is likely that many future large-scale agricultural artificial recharge schemes will fall under the management of Water User Associations (WUAs), which, in turn, require Water Management Plans. The inclusion of artificial recharge into future, updated guideline documents on Water Management Plans will encourage the consideration of this water conservation measure within the agricultural sector. This not only makes sense for the farming community, but is also recognised in the NWRS as an important factor in maintaining the Reserve.

D.2.5 Water Conservation and Water Demand Management Strategy for the Industry, Mining and Power Generation Sector

This sector accounts for about 15 percent of the total water used in South Africa. In order to facilitate efficient water use, DWAF has developed the following guideline: *Water Conservation and Water Demand Management Strategy for the Industry, Mining and Power Generation Sectors* (DWAF, 2004d).

Artificial recharge and subsurface storage has potential in three main areas of application. The first is for preventing contaminated mining and industry groundwater from migrating away from the point of contamination. This can be achieved by creating a hydraulic mound around, or down-gradient of, the contaminant plume using the techniques of infiltration or borehole injection. In this way, the plume can be contained and managed. For a description of the regulations pertaining to

the protection of water resources, refer to Government Notice No. 704, Operational Guideline No. M6.1: Guideline Document for the Implementation of Regulations on Use of Water for Mining and Related Activities aimed at the Protection of Water Resources (DWAF 2000b).

The second potential artificial recharge application is for the purpose of waste water treatment and reuse. Water of impaired quality can be recycled through artificial recharge for particular uses within the industry, thereby limiting the need for additional water supply and minimising the negative environmental effects of waste water discharge.

The third potential application is in the storage of water in disused mines. This is not strictly an artificial recharge activity, as mines are not aquifers, but there is potential for sub-surface storage in disused mines. The key concern in mine storage relates to water quality issues, in relation to both water blending and water-rock interactions.

The artificial recharge challenge within this sector lies in creating awareness of the potential benefits of subsurface storage and the water treatment that artificial recharge can offer.

D.2.6 Awareness and education

Artificial recharge's potential value and diverse uses need to reach a wide audience if this water conservation and treatment approach is to gain acceptance amongst water resource planners. Artificial recharge should be promoted as a means of contributing towards integrated, sustainable development. In areas where artificial recharge awareness is high, such as in Adelaide, Australia, urban developments have incorporated recharge facilities into the layout of these developments. The principles of artificial recharge should therefore be incorporated into DWAF's strategy on promoting education and awareness in water conservation.

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