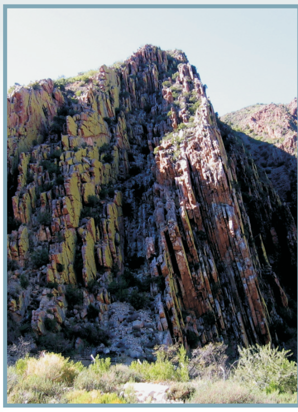
A check-list for implementing successful artificial recharge projects



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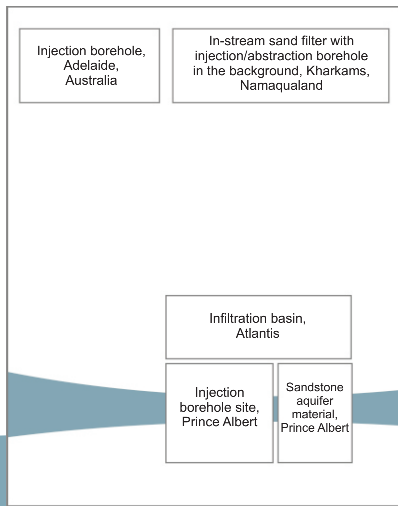

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1. Introduction

This booklet provides a check-list of items that must be covered in order to implement a successful artificial recharge scheme. Artificial recharge projects follow the normal water supply project development stages of planning, design, authorisation and implementation. They cannot be considered simple interventions whereby excess surface water is transferred underground on an ad hoc basis in the hope that this will solve water shortage problems. If the project is not properly planned, it is unlikely that it will have the expected benefits. Artificial recharge projects differ from conventional water supply infrastructure development projects in two significant ways:

- A significant period of testing is almost always required prior to developing the design and implementation plan.
- Artificial recharge projects are site specific and each project will have its own particular objectives.

While testing helps to understand the project specific conditions, it is also important to start relatively small and have incremental increases in capacity as the variables of the particular situation are monitored and better understood.

This booklet lists the key tasks for assessing the feasibility of an artificial recharge scheme and is aimed at the implementer. DWA's responsibilities are outlined in DWA's Artificial Recharge Strategy (DWAF, 2007), downloadable from: http://www.artificialrecharge.co.za and http://www.dwa.gov.za/groundwater)

2. Project stages

Artificial recharge project stages, key activities and authorisation requirements are summarised in Table 1. The recommended authorisation process is described in detail in DWA's Artificial Recharge Strategy (DWAF, 2007).

This booklet provides a check-list for the pre-feasibility and feasibility stages and should be read in conjunction with DWA's Artificial Recharge Strategy (DWAF, 2007).

Table 1: Artificial recharge project stages, key activities and authorisation requirements

Project Stage	Key Activities	Authorisation requirements
Pre-feasibility Stage	Identify the potential AR project and describe the information currently available.	None
	Based on existing information, comment on the feasibility of the project.	
	Describe the work required for the Feasibility Stage and estimate the cost of undertaking the feasibility study.	
	Establish existing water use licence conditions and authorisation requirements from DWA.	
Feasibility Stage	If needed, obtain a water use licence and environmental authorisation for the recharge tests.	None, or a short-term water use licence for AR testing and possibly environmental authorisation for AR testing
	Conduct the feasibility study. This should include AR testing (eg injection tests, infiltration tests, pumping tests, water quality assessments, etc)	
	Develop a preliminary infrastructure design.	
	Identify the project implementation phases if a phased approach is necessary (eg starting small and expanding after successive recharge cycles).	
	Estimate the costs of the project.	
	Identify funding sources	
	Compile a detailed project implementation plan.	
Implementation Stage	Obtain the necessary water use licence and environmental authorisation for the AR scheme.	Water use licence and possibly environmental authorisation
	Drilling and testing new injection and abstraction boreholes or infiltration basins	
	Set up the groundwater and recharge water monitoring system	
	Develop the detailed infrastructure design, carry out the tendering processes, and construct the project.	
	Compile monitoring, operation & maintenance procedures.	
Operation and Maintenance Stage	Carry out performance monitoring during production.	Compliance monitoring and reporting.
	Modify operation & maintenance procedures based on scheme performance.	
	Develop final monitoring and reporting system.	

3. The pre-feasibility study check list

The pre-feasibility study, while giving an initial indication of the viability of the project, should present a project plan and budget for the feasibility study. It should outline what needs to be established in the feasibility study and how this should be done. The pre-feasibility study check list is given in Table 2.

More information on the "Success Criteria" and key issues is provided in DWA's Artificial Recharge Strategy (DWAF, 2007).

Table 2: The pre-feasibility study check list

SUCCESS CRITERIA	CHECK LIST
1. The need for an artificial recharge scheme	1. What are the primary and secondary objectives? (Eg Primary: increase security of supply by ensuring aquifers are full prior to the onset of the dry season; secondary: water treatment) 2. Is artificial recharge the best option to meet the primary objective? (Better options may be, for example, to expand the existing wellfield, develop a new aquifer or introduce better water conservation measures). 3. Will artificial recharge meet the primary objective? (Eg If the aquifer is full prior to the onset of the dry season, will it provide the envisaged security?)
2. The source water	1. Roughly what volume of water is available for recharge? 2. When is it available?
3. Aquifer hydraulics	1. Will the aquifer receive the water? a) Is there sufficient space in the aquifer to receive the water? (Eg. If you need to store 1 Mm^3 before the onset of the dry season, will the aquifer be able to receive that volume?). b) Is the aquifer permeable enough to receive it at the planned supply rate? (Eg If you need 10 x 10L/s injection boreholes, are there enough drilling targets or existing boreholes that will allow for these rates?). 2. Will the water be retrievable when you want it? Or will it flow down gradient and away from the planned abstraction area?
4. Water quality	1. Is the source water quality suitable for recharge? Eg. Is the water not too turbid, saline or rich in organic material? Are there any particular worrying determinands, like heavy metals, disinfection by-products, etc, that could affect the final water quality? 2. Describe the natural groundwater quality. 3. Will *in situ* blending likely improve the natural groundwater quality or make it worse? Estimate the concentrations of key determinands in the final water quality. 4. Comment on clogging concerns.
5. The artificial recharge method and engineering issues	1. How will the water be transferred into the aquifer? 2. What infrastructure will be needed to treat, recharge and extract the water? 3. What are the engineering challenges and how significant are they?
6. Environmental issues	1. What are the potential environmental benefits, risks and constraints?
7. Legal and regulatory issues	1. Are there legal constraints? Eg Securing source water rights, etc. 2. Is there an existing groundwater licence and what are the conditions regarding use? 3. What type of authorisation is required from DWA to do the feasibility tests?
8. Economics	1. How much will the feasibility study cost? 2. Roughly, how much will the scheme cost? 3. Roughly, how much will 1 m^3 of supplied water cost and how does this compare to other options for water supply?
9. Management and technical capacity	1. What skills will be necessary to manage, operate and maintain the scheme and are they available or obtainable?
10. Institutional arrangements	1. Who will be responsible for supplying the source water? 2. Who will pay for the source water? 3. Who will ensure that it's quality is suitable for recharge? 4. Who will regulate the scheme?

4. The feasibility study check list

The feasibility study should establish:

i. Whether the project will be a success or not
ii. The key factors that affect its success
iii. A project implementation plan
iv. A budget for construction and a cost estimate for operation and maintenance
v. Information (data) that needs to be gathered during operation in order to optimize the scheme (some tests cannot be done during the feasibility study, eg far-field water level monitoring or large-scale in situ water quality monitoring, and need to be incorporated into the initial operation period).

Table 3: The feasibility study check list

Success Criteria	Check list
1. The need for an artificial recharge scheme	1. List the primary and secondary objectives. 2. Describe how the scheme will work to meet the primary objective. Describe the artificial recharge and abstraction cycle in relation to expected source water availability and recovered water needs. 3. Define the minimum (annual) injection volume that would make the project worthwhile. 4. Quantify the additional assured yield of the aquifer with AR.
2. The source water	1. Quantify the source water's assured yield (per month). Discuss risks of under-supply.
3. Aquifer hydraulics	1. Will the aquifer receive the water? a) Quantify the volume of water the aquifer is able to receive when water is available for recharge. This should be based on historical water level and abstraction data. b) Quantify the artificial recharge rates. Depending on the artificial recharge method, this should be done by soil infiltration tests or borehole injection tests. If injection tests are not possible (because of the logistics of getting source water to boreholes), then pumping tests should be done. The purpose and method of all tests must be clearly defined. 2. Describe the groundwater flow regime and comment on envisaged losses down-gradient of the wellfield.
4. Water quality	All aspects that define water quality need to be assessed, including chemistry (organic and inorganic), microbiology and physical characteristics such as turbidity, etc. 1. Describe the source water quality. 2. Describe the groundwater quality. 3. Discuss whether there are concerns around the expected blended water quality, and if so, assess them. 4. Discuss whether there are concerns around water-rock interactions, and if so, assess them. 5. Estimate the concentrations of key determinands in the final water quality. 6. Describe expected types of clogging and prevention and management considerations. 7. Establish whether pre-treatment is necessary and if so, what form. 8. Describe whether post-treatment will be required and if so, what form. 9. The purpose and method of all tests must be clearly defined.
5. The artificial recharge method and engineering issues	1. Identify the project implementation phases if a phased approach is necessary. 2. Develop a preliminary infrastructure design for the treatment and conveyance infrastructure, and for the recharge facility. 3. Describe how the design will minimise clogging. 4. Compile a detailed project implementation plan.
6. Environmental issues	1. Identify environmental benefits, risks and constraints. Certain tests may need to be designed specifically to establish environmental impacts. 2. Discuss unforeseen risks, such as the use of reclaimed water for any purposes that were not intended, discharge of a recharged, full aquifer into the environment, etc.
7. Legal and regulatory issues	1. Describe the current legal status and new requirements for an artificial recharge scheme. 2. Obtain authorisation, if needed, from DWA to do the feasibility tests. 3. Establish authorisation requirements for full-scale operation.
8. Economics	1. Cost the project based on the preliminary infrastructure design. 2. Establish the cost per 1 m^3 of supplied water. 3. Compare these costs to those of other supply options. 4. Describe (or cost) other quantifiable and non-quantifiable economic benefits that relate to the secondary objectives.
9. Management and technical capacity	1. Describe the skills needed to operate the scheme. Include management, scheme maintenance, hydrogeological, etc. 2. List the available skills and shortfalls. 3. Articulate the outstanding skills needed to operate a successful scheme.
10. Institutional arrangements	1. Describe the institutional arrangements and include: 2. Who will be responsible for supplying the source water. 3. Who will pay for the source water. 4. Who will ensure that it's quality is suitable for recharge. 5. Who will do the necessary monitoring (water levels and quality). 6. How the scheme will be regulated in terms of the licence conditions (particularly relating to source water quality, final water quality, water levels, recharge rates and environmental monitoring requirements).

5. Conclusions and Recommendations

Key points are:

- All ten "success criteria" have to be addressed in planning and design.
- Schemes have to be designed according to current and future management capabilities.
- Well planned schemes will succeed and poorly planned schemes will fail.

These check-lists are based on the information contained in DWA's Artificial Recharge Strategy Version 1.3, 2007, Section C (downloadable from http://www.artificialrecharge.co.za and http://www.dwa.gov.za/groundwater).

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