APPENDIX 6.8
AQUIFER STORAGE AND RECOVERY

ASHFORD STRATEGIC DEVELOPMENT
WATER ISSUES
Aquifer storage and recovery

Introduction

The options of groundwater recharge by borehole injection with treated effluent are considered to address:

- Augmentation of summer water supply capacity by allowing increased groundwater abstraction from the aquifer
- Augmenting river baseflow (ALF)

The following is a review of the potential for recharging aquifers in the Ashford area with treated sewage effluent and is based primarily on published reports of research (Refs. 2,3,4) carried out by the British Geological Survey (BGS) Wallingford co-funded by UKWIR and a Foresight LINK award from the Office of Science and Technology (OST).

Artificial recharge (AR) supplements the natural infiltration of water into the ground through either basins or boreholes. Traditionally the technique has utilised aquifers containing potable water (Ref.2). It can be used strategically where an aquifer is overexploited such that no further abstraction would be allowed or where lack of natural recharge prevents its utilisation. The water abstracted is not necessarily the same water that was injected and the injection and abstraction boreholes may be some distance apart.

Aquifer storage and recovery (ASR) is a subset of AR and comprises one or more of the following:

- Storage of water in suitable aquifer (through wells) during times when water is available and recovery of water from the same well when needed
- Normally achieved by using dual purpose boreholes
- Injection of water into an aquifer containing non potable water
- Abstraction of the same water that was injected
- Utilisation of a confined aquifer to minimise potential environmental impacts

The water is stored locally to the borehole and provides water storage, improves resource management and has operational advantages. Water is recharged into the aquifer during periods of low demand and then recovered during periods of high demand.

Areas where ASR could be considered rather than AR would be in parts of confined aquifers that have not been used for productive water supply because of poor quality (Ref.2). The use of ASR in areas of outcrop of potable aquifers is less likely as the aquifer may be fully licensed, natural recharge will occur and the groundwater-surface water interaction will be more immediate and hence have environmental impacts (Ref.4).

There is the opportunity for AR of the unconfined Lower Greensand aquifer and to a lesser extent the unconfined Chalk aquifer and alluvial sand and gravel deposits or ASR of the confined parts of the Lower Greensand aquifer.

Constraints

The key constraints on the development of ASR identified by the research (Ref. 2) include:

- Recovery efficiency, a measure of how much is recovered against how much is put in, less significant where both recharged and native waters are potable and of similar quality

- Clogging issues, including air entrainment, suspended sediment, bacterial growth, chemical reactions, gas production and compaction of clogging layer
- Water quality changes, chemical components of the recharged water reacting with groundwater and aquifer particularly the organochlorine compounds in the treated recharge water
- Hydraulic properties of aquifers
- Operational issues, including variability in volume and quality of water available for recharge but less significant when treated effluent is used, variation in daily and weekly demand in relation to average monthly or annual demand and site selection
- Regulatory issues

In UK, the constraints to development of ASR are posed by diffuse mixing in the fissured and dual porosity of the Chalk aquifer and potential chemical reactions between native groundwater and the injected water and aquifer mineralogy (Ref.2). These issues were addressed by flow modelling studies and are reported in the Assessment of the Impacts of ASR Schemes report (Ref.3).

In dual porosity aquifers the bulk of flow takes place in the fractures while storage is provided by the matrix (Ref.3). The important parameter in this type of aquifer as far a solute transport is concerned are the fracture and matrix porosity, the spacing between fractures and the diffusion coefficient that is the measure of the rate at which solutes can penetrate the matrix blocks as a result of concentration gradients.

A single porosity aquifer means that the same void spaces, as reflected by the porosity, control both the permeability and the storage.

Of particular environmental concern is the possible impact on water levels in adjacent aquifers or in the target aquifer. ASR schemes are designed to result in no net change in abstraction from the aquifer. In the long term there may be some net change but this should be small in relation to the overall resource. A scheme that injects and then abstracts the same volume of water, as a long-term steady state average, will have no impact on local or regional groundwater levels. However, the seasonality of the scheme means that local water levels will first be increased and then reduced. The timing and absolute value of these changes are important in assessing the eventual impact and will need to be determined by site specific model studies or field trials.

Potential receptors for treated sewage effluent

The potential receptors of recharge water in the Ashford area are:

1. The Lower Chalk outcrop to the north is the nearest part of the Chalk aquifer. The aquifer is a dual porosity aquifer.

2. The Lower Greensand (LGS) aquifer outcrops across the area and comprise the Folkestone beds – sands/sandstone sequence, is a porous non fissured aquifer and the Hythe beds – limestone/sandy limestones where fissure flow predominates.

3. The alluvium deposits may also be a potential receptor if they are granular (sands and gravel). However, the outcrop area, storage volume and hydraulic continuity of these deposits may be restricted.

The first two are major aquifers used for potable supply and any water introduced by AR or ASR methods would have to be compatible and of equal or better quality to the groundwater within the aquifer.

Where the alluvial deposits are separated from potable aquifers by clayey horizons that restrict water movement (aquiclude) they could be considered for recharge with treated effluent.

Before any scheme is considered there will have to be further site specific investigation into the constraints identified by the research and listed above. Simple models have been developed that will allow decisions to be made on how to proceed and what additional information is required.

Water quality

The proposal is to consider the injection of surplus potable treated water into the aquifer either underlying the treatment works or transferred to a location away from the works. The injected water will form a "bubble" that can be subsequently recovered.

<u>Lower Greensand aquifer</u>
Bubble formed, mixing limited to the edge of the bubble, less interaction with native water but stronger injection water-rock interaction

<u>Chalk aquifer</u>
Diffuse exchange leading to larger bubble with larger mixing area, strong native component in recovered water, strong chemical interaction

The water quality from the Chalk and Lower Greensand aquifer (particularly the Folkestone Beds) are significantly different.

Regulatory issues

The following issues were identified in the research report by BGS (Ref.4).

<u>Groundwater Regulations 1998 (GWR</u>**)**
Authorisation is required for discharges of listed substances to groundwater.
Regulation 6 of the GWR makes provision for authorisation of AR – subject to **no risk of pollution of groundwater.**

Direct discharge to groundwater may be consented under the Water Resources Act 1991 and these consents also act as authorisations under the GWR.

The GWR, reflecting the EU Groundwater Directive, requires no entry of List I substances and no pollution by List II. Under Regulation 2 of the GWR, the EA can determine whether a discharge can be excluded from the GWR by virtue of the quantity and concentration of listed substances in the discharge. This is case specific. The DETR guidance on the GWR says that drinking water and similar standards may be used as a benchmark for such assessments.

If discharge contains only non-listed constituents but nevertheless polluting matter (bacteriological) it may still possibly require a discharge consent under the Water Resource Act, 1991.

Consideration of options

Augmenting water available for groundwater abstraction during the summer for water supply by recharging the groundwater aquifer during the winter:

Advantage

- Allows better management of water resources by recharging with surplus water during low demand periods and recovering during high demand periods
- Allows further abstraction from "over-abstracted" aquifer

Disadvantage

- Only treated potable water is to be recharged
- There is to be no risk of pollution from the recharge water
- Short term effects as a result of seasonally raised and lowered groundwater levels on environmentally sensitive sites (wetlands)
- the general public perception of using treated effluent for recharge to potable supply aquifers
- additional study and trials required to determine feasibility and possible effects

Augmenting river baseflows as a consequence of groundwater recharge

Advantages

- Allows better management of water resources by recharging with surplus water during high flow periods
- Raises low flows in the summer, provided that the timing and movement of recharge water is appropriate, with consequent environmental benefits

Disadvantages

- only applicable where recharging an unconfined aquifer in hydraulic continuity with the surface water system (springs or river channel inflow)
- additional study and trials required to determine feasibility and possible effects

On balance, it would appear to be more cost effective and appropriate to use treated effluent to discharge directly into the river system rather than injection and subsequent abstraction from aquifers.

- augments low flow characteristic of surface water system
- use treated water to appropriate surface water discharge standard rather than potable water standard
- allows for subsequent abstraction downstream for supply
- Public perception for reuse of surface water including treated effluent more positive

Application to the Ashford study area

It appears that the major constraint to the use of treated effluent for recharge to the aquifers of the area is the requirement for there to be no risk of pollution. Sufficient safeguards will have to be put in place in the process and operation of such scheme to ensure this and that may not be possible at the present.

REFERENCES

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2. Jones H K, Gaus I, Williams A T, Shand P and Gale I N (1999). ASR-UK. A review of the status of research and investigations. British Geological Survey Report WD/99/54. British Geological Survey, Keyworth Nottingham NERC 1999
3. Williams A T, Barker J A and Griffiths K J (2001). Assessment of the Environmental impacts of ASR Schemes. British Geological Survey Commercial Report CR/01/153. British Geological Survey, Keyworth Nottingham NERC 2001
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Existing operational schemes or under consideration

Investigation of AR in potable aquifers that have been recharged with seasonal surplus water have included the following (Ref.1):

1. North London Artificial Recharge Scheme (NLARS), Thames Water operational scheme injecting surplus treated water with the target aquifers being the Chalk and Lower London Tertiaries.
2. Edwinstowe & Clipstone (Nottingham), an investigation into AR through basins or boreholes of the Triassic sandstone aquifer using chlorinated groundwater.
3. Hardham (Sussex), trial injection of fully treated river water into a borehole in the Folkestone beds of the LGS.
4. Stourbridge, an investigation of the Triassic sandstone aquifer
5. Stockbury (Kent), full scale trial operated by Mid Kent Water injecting treated Upper Chalk water or River Medway water into the confined Folkestone beds of the LGS. Investigating geochemical reactions and possible clogging issues.
6. Farnham, South East Water carried out a desk study into LGS scheme
7. Sompting borehole into the Folkestone beds of LGS. Southern Water are considering a multi-site ASR system utilising the LGS along the south coast storing winter water excess for the summer peak. The sites include confined LGS on the south coast, confined Chalk and confined LGS along the north Kent coast