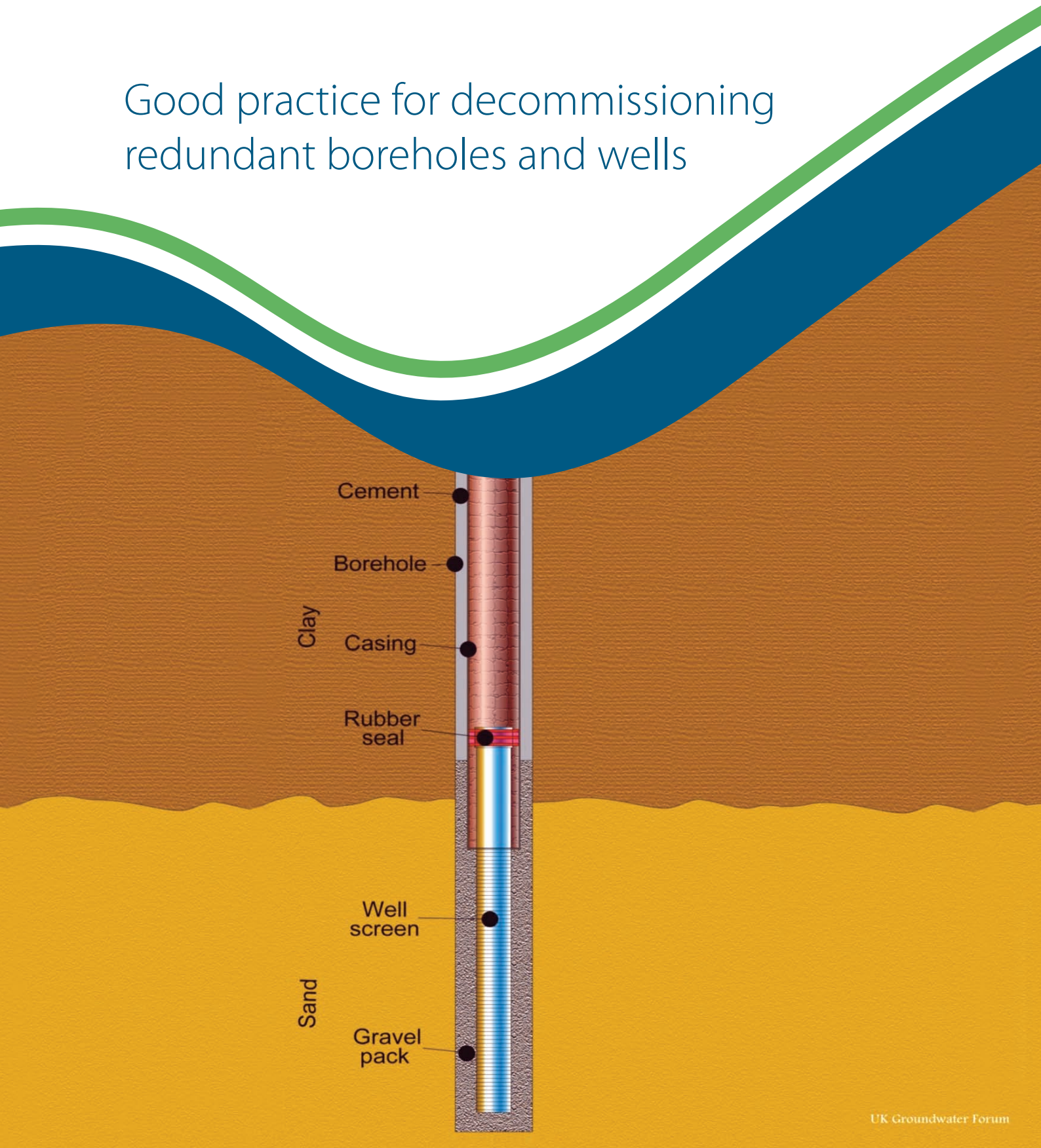
natural scotland
SCOTTISH GOVERNMENT

SEPA
Scottish Environment Protection Agency

Good practice for decommissioning redundant boreholes and wells



1. Scope

This guidance is intended to protect groundwater, when decommissioning redundant boreholes or wells, by suggesting a number of good practice options. However, while this guidance is useful, other factors – such as ground and site conditions, or health and safety issues – must also be carefully considered before any final decisions are made and expert site-specific advice should also always be sought. It must also be remembered that boreholes near landfills or other sources of soil gas may also require an opening to the air to prevent the build-up of noxious, explosive or flammable gas.

2. Legal framework

The Scottish Environment Protection Agency (SEPA) has a duty under the Water Environment and Water Services (Scotland) Act 2003 to promote the sustainable use of water. The Water Environment (Controlled Activities) (Scotland) Regulations 2005, as amended, enable SEPA to prevent and limit the input of pollutants into groundwater*, including via groundwater supplies – eg contaminated run-off directly entering groundwater via an uncapped borehole.

*Groundwater is defined as water which is below the surface of the ground in the saturated zone and is in direct contact with the ground or subsoil.

3. Introduction

Boreholes and wells are constructed for a variety of purposes including the abstraction of water, de-watering excavations, collecting geological information and investigating or sampling soils and groundwater. Many old wells and boreholes are redundant as they are found on properties that are now connected to a mains water supply.

Improperly abandoned boreholes and wells may act as preferential pathways for groundwater or contaminant movement. This may result in the contamination of groundwater, the mixing of groundwaters of variable quality from different aquifers, or contribute to the loss of aquifer yield and water pressure (potentiometric head) as groundwater flows out of the system. They may also present a physical hazard.

Artesian boreholes are those where groundwater in a confined aquifer is at sufficient pressure to cause water to discharge either at the ground surface or into another overlying aquifer without any pumping. These present different problems and require special attention to prevent wastage of groundwater resources, either by the flow of water from one aquifer unit into a poor quality unit, or by mixing clean groundwaters with polluted ones.

Boreholes and wells that no longer need to be made safe and structurally stable should also be backfilled or sealed to prevent groundwater pollution and flow of water between different aquifer units. However, in certain circumstances they may be adapted for use as a groundwater monitoring facility. Wells and boreholes should not be used as soakaways for foul and contaminated surface water drainage because they provide a direct discharge route into groundwater and, as such, pose a risk of groundwater pollution that is prohibited by the amended Water Environment (Controlled Activities) (Scotland) Regulations 2005.

4. Borehole or well construction

When considering how best to backfill and seal a borehole or well, or whether it can be put to an alternative use – for example as a groundwater monitoring facility – it is necessary to obtain information on the geological strata encountered by the borehole and its completion details. These will include the depth, diameter and construction details and can be obtained from site records, the original driller's log, SEPA or the British Geological Survey. Only once all available information has been collated and assessed can the most appropriate course of action be determined.

5. Conversion to groundwater monitoring points

Redundant boreholes have the potential for conversion into groundwater monitoring points if the data collection exercise described in Section 4 (above) indicates that they intersect appropriate aquifer units (in terms of resource and quality), and if they are constructed so that representative groundwater samples may be collected, or water levels measured.

There are many good reasons for collecting groundwater samples or measuring groundwater levels and the information can, for example, validate the success of any remedial works being undertaken on the site. As a result, before decommissioning a borehole you should consider whether you wish to retain it as a private monitoring facility. If not, contact SEPA, who will carry out an assessment as to whether the borehole can be modified to a groundwater monitoring facility.

If the borehole is not going to be converted then it should be abandoned using the guidelines in Section 6 (below) and the British Geological Survey should be informed.

The ideal borehole construction and completion is dictated by its intended use and the geological strata encountered. Boreholes that intersect a single aquifer unit may be cased through the unsaturated zone, but open hole (or screened) below the water table. Boreholes in complex geologies are likely to require casing over most of their depth, with the exception of any aquifer units of interest (see Fig 1(A)). These details must be established when considering conversion of the borehole to a monitoring point.

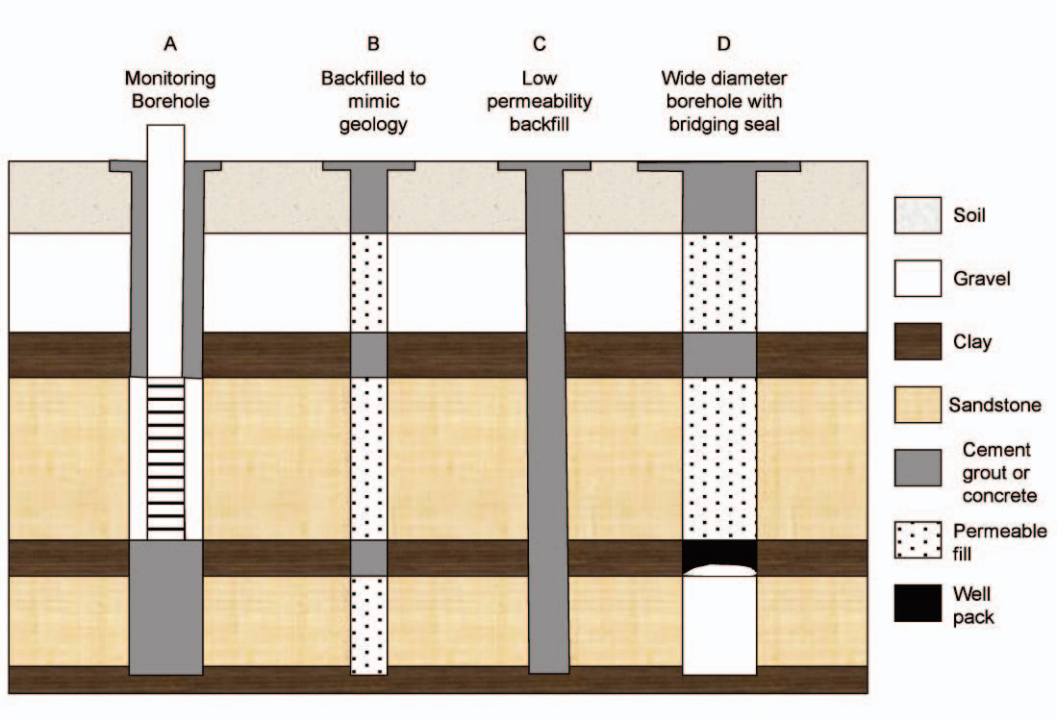


Figure 1: Schematic options for decommissioning wells and boreholes

6. Decommissioning redundant boreholes and wells

If conversion to a groundwater monitoring point is not possible or necessary, the following borehole abandonment procedures are recommended. However, every borehole and well is different and may require variation in the detail of the approach. For the best results, the employment of a proficient well contractor with a good knowledge of the local geology and well abandonment procedures is recommended.

a) Defining the objectives

Each borehole or well has its own particular characteristics which must be considered when planning how to decommission it, but the method used should be capable of achieving a minimum of each of the following objectives:

- Remove the hazard of an open hole (safety issues).
- Prevent the borehole acting as a conduit for contamination of groundwater.
- Prevent the mixing of contaminated and uncontaminated groundwater from different aquifers.
- Prevent the flow of groundwater from one geological horizon to another.
- Prevent the wastage of groundwater from overflow from artesian boreholes.

b) Removing headworks and casing

It is crucial to ensure that the borehole or well is free from all obstructions that may interfere with the sealing of the hole. In particular, the pump and pipework should be removed, together with any other infrastructure (dip tubes etc). The condition of any borehole casing and grout must be examined to ascertain whether its retention in the hole would prejudice any of the objectives of the abandonment. For many holes, examination of the casing from the ground surface will be adequate. However, deep boreholes may require the use of a closed-circuit television (CCTV) to examine the casing at depth.

Where the casing has corroded or broken, or the grouting has failed, it may be necessary to remove those materials in order to prevent any flow of groundwater around the outside of the borehole. Care should be taken, however, to ensure that removal of the well casing does not result in the collapse of the borehole walls (particularly in unconsolidated materials) and possible subsidence at ground level. If the well casing needs to be removed, a specialist well contractor can advise on the appropriate technique to be used at the site.

c) Backfilling the hole

i) General information

For most purposes the ground should be restored as closely as possible to its pre-drilled condition. The borehole or well should be backfilled with clean (washed), uncontaminated, or excavated materials so that the permeability of the selected materials are similar to the properties of the geological strata against which they are placed. The backfilled borehole will then mimic the surrounding natural strata and groundwater flow and quality will be protected.

Restoration will require a variety of materials to be used so that permeable aggregates (eg pea gravel, sand) are positioned adjacent to aquifer horizons, whilst low permeability materials (eg clay, bentonite cement grout, or concrete) are positioned adjacent to low permeability horizons (see Fig. 1(B)). Alternatively, the entire borehole or well can be backfilled with low permeability materials that will prevent significant vertical or horizontal movement of groundwater through or along the borehole (see Fig. 1(C)).

The materials used to backfill must be clean, inert and non-polluting. Suitable materials include pea gravel, sand, shingle, concrete, bentonite, cement grout and uncontaminated rock.

N.B. UNDER NO CIRCUMSTANCES SHOULD MATERIALS WHICH ARE LIKELY TO CAUSE POLLUTION BE USED AS INFILL.

Consideration should also be given to the geochemical environment into which these materials will be placed, as the behaviour of materials may change under different environmental conditions (eg phenol contamination may prevent bentonite grouts curing).

Aggregates (pea gravel, shingle, sand etc) should be selected such that they have a grain size that allows easy delivery into the borehole and should be introduced in a controlled manner to ensure that accidental 'bridging' does not occur within the borehole. Concrete and grouts that are introduced in a liquid form should be introduced through an appropriate delivery pipe (eg tremmie pipe), to ensure that voids do not form.

Boreholes that penetrate highly fissured aquifers, such as some limestones, present additional problems. Liquid grouts (particularly those injected under pressure), or fine-grained aggregates (eg sand) may be transported out of the

borehole into the body of the aquifer through fissures. Careful monitoring of the process is required if these techniques are used, and in these cases it may be more appropriate to use coarser aggregates such as gravel as a backfill.

Where the site is in a very sensitive location (eg within 50 metres of a potable abstraction) consideration should be given to disinfecting the materials prior to their use as infill. Care must be taken, however, to ensure that the disinfectant does not itself present a groundwater pollution risk. The advice of SEPA and disinfectant manufacturers should be sought in such circumstances and further information on disinfecting boreholes is available on SEPA's web pages.

ii) Deep and wide boreholes/wells

In the case of very deep boreholes and wells with wide diameters (note, this does not apply to mine shafts), the volume of material needed to backfill the hole may be very large. In such circumstances it may be appropriate to adopt an alternative strategy, as long as this will not prejudice any of the original objectives.

Provided that the long-term structural stability of the borehole can be demonstrated, it is acceptable to place a permanent bridging seal, or plug, within the borehole and then to infill above this level using the approach given in Section 6 c) (see Fig. 1(D)). The bridging seal should ideally be positioned below the lowest aquifer horizon. However, where this is not possible, it is important that the open borehole beneath the bridging seal penetrates no more than a single aquifer unit, thereby preventing the flow of groundwater between different aquifers.

The material commonly used as a bridging seal is cement, although a combination of a mechanical plug and cement is acceptable. Cement seals must be allowed to set (cure) in place before backfilling is continued and completed. The advice of a specialist well contractor should be sought for the most appropriate technique.

iii) Artesian boreholes

For artesian boreholes, the decommissioning process should aim to confine the groundwater to the aquifer from which it came – in order to prevent loss of confining pressure and the loss of water resources to the surface or other formations. The first step is to control the artesian flow.

There are a number of ways to accomplish this depending, in part, on the water pressure in the confined aquifer and the depth to which the water level must be lowered. These include:

- Pumping the borehole to produce the necessary drawdown.
- Pumping nearby boreholes.
- Extending the casing above ground level beyond the elevation to which water will rise in the borehole (the potentiometric surface).
- Introducing dense, non-polluting fluids into the borehole.
- Introducing a pre-cast plug at an appropriate level within the hole.
- Using an inflatable packer and pressure grouting the void space below it.

Decommissioning of artesian boreholes is likely to be easiest in late summer, when groundwater levels and artesian flows are at their lowest. Decommissioning artesian boreholes is a specialist job and requires expert advice.

The importance of the potential pathways in and around the casing should also be considered.

d) Sealing the top of the borehole

In order to prevent potentially contaminated surface run-off or other liquids entering the backfilled borehole, it is necessary to complete the backfilling of all boreholes with an impermeable plug and cap. The top two metres (or two meters below plough depth in agricultural areas) should be filled with cement, concrete or bentonite grout. A concrete cap of suitable strength, with a diameter at least one metre greater than the width of the backfilled borehole (see Fig. 2), should then be installed.

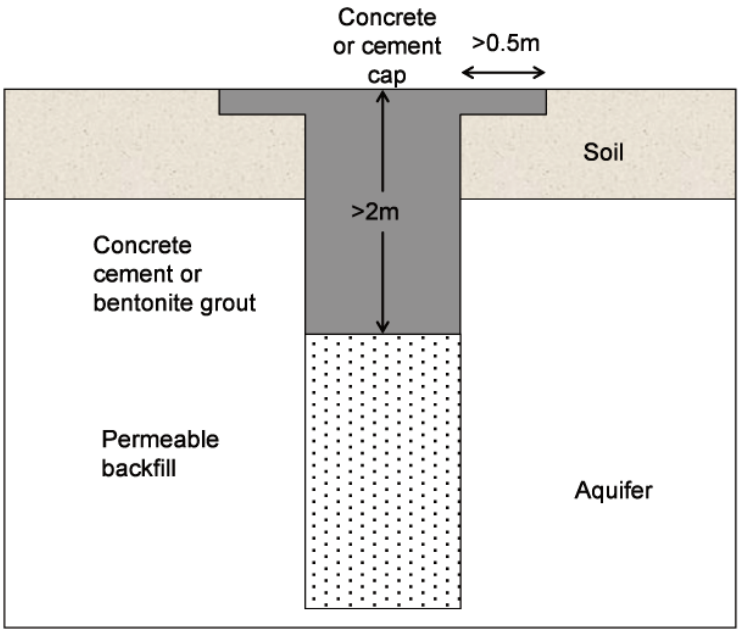


Figure 2: Schematic diagram for borehole seal and cap

e) Recording details on site plan

Complete and accurate records should be kept of the abandonment procedures for future reference. These records should include the following:

- The reasons for abandonment (eg water quality problems).
- Measurement of groundwater level prior to backfilling.
- The depth and position of each layer of backfilling and sealing materials.
- The type and quantity of backfilling and sealing materials used.
- Any changes made to the borehole/well during the abandonment (eg casing removal).
- Any problems encountered during the abandonment procedure.

Abandoned borehole and well locations should be marked on site records and, if possible, on the ground. Details of any decommissioning or modifications to borehole construction should also be forwarded to the British Geological Survey.

7. Conversion to soakaways

Wells and boreholes should not be converted to soakaways, as these allow the direct discharge of contaminants into groundwater without any potential for attenuation and can result in groundwater pollution.

The direct discharge of pollutants to groundwater, such as sewage discharge via a borehole, is now prohibited by the amended Water Environment (Controlled Activities) (Scotland) Regulations 2005.

8. Specialist advice

It is recommended that the advice of a specialist well contractor and local SEPA staff should always be sought, and the specific characteristics of a site should be given full consideration when determining the best borehole abandonment solution. Details of specialist drilling contractors can be obtained from The British Drilling Association.

Further advice can be obtained from your local SEPA office.

9. Further guidance and references

- American Society for Test and Materials (ASTM) *D5299 - 99(2005) Standard Guide for Decommissioning of Ground Water Wells, Vadose Zone Monitoring Devices, Boreholes, and Other Devices for Environmental Activities*
- Driscoll, F.G., 1986. Groundwater and Wells. Second Edition, Johnson Division.
- Scottish Environment Protection Agency, 2009, Groundwater Protection Policy for Scotland v3.
- British Geological Survey. National Geosciences Data Centre (NGDC), Keyworth, Nottingham, NG12 5GG. Tel: 0115 936 3143.
- The British Drilling Association, Wayside, London End, Upper Boddington, Daventry, Northamptonshire, NN11 6DP. Tel: 01327 264 622, email: office@britishdrillingassociation.co.uk

10. Acknowledgements

This document has been modified from an Environment Agency publication. SEPA gratefully acknowledges the use of the Environment Agency document to produce this Scottish version.