

**National Groundwater and
Contaminated Land Centre**



**Groundwater Source
Protection Zones**

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**ENVIRONMENT
AGENCY**

Groundwater Protection Zones

Scope

This booklet aims to inform all stakeholders about the national dataset of **groundwater source protection zone** maps which are integral to the Agency's response to development enquiries. It is not intended to be a definitive guide but does highlight the strategy behind groundwater source protection zones and their place in best practice.



*Agency officer checking the groundwater level within a borehole

Introduction

In brief

The Environment Agency has a vision of a better environment for England and Wales. Through our work we aim to achieve major and continuous improvements in the quality of air, land and water.

Our interest in groundwater is driven by the fundamental role it plays in the life of most environments in England and Wales. Around one-third of all our drinking water is derived directly from groundwater. For lowland England this rises to over 50% and in some areas exceeds 80%. Importantly, if groundwater becomes polluted it can be very expensive and extremely difficult or impossible to clean.

The Agency's **Policy and Practice for the Protection of Groundwater** (PPPG) provides a risk-based framework for evaluating proposals for land developments which may impact on the underlying groundwater. The policy is supported by technical tools that allow a focused assessment of the risks to groundwater. These tools include

groundwater vulnerability maps that show the dangers from pollution to groundwater in a particular area. The maps have been published as a series of 53 maps covering the whole of England and Wales, and similar maps are also available for Scotland and Northern Ireland.

The PPPG is supported by another tool, **groundwater source protection zones** which provide additional protection for water sources. These are designated zones around public water supply abstractions and other sensitive receptors that signal there are particular risks to the groundwater source they protect.

The zones themselves are periodically reviewed to ensure they are kept up to date as licence conditions change or knowledge of local hydrogeology improves. Where necessary, the existing models from which the zones have been derived will be refined and the zones re-defined. The zones are based on an estimation of the time it would take for a pollutant which enters the saturated zone of an aquifer to reach the source abstraction or discharge point.

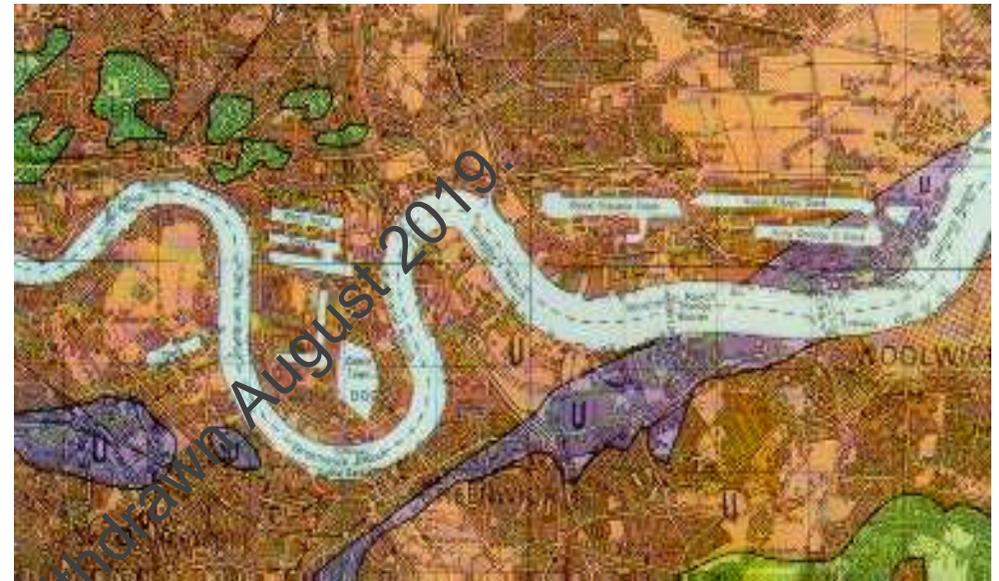
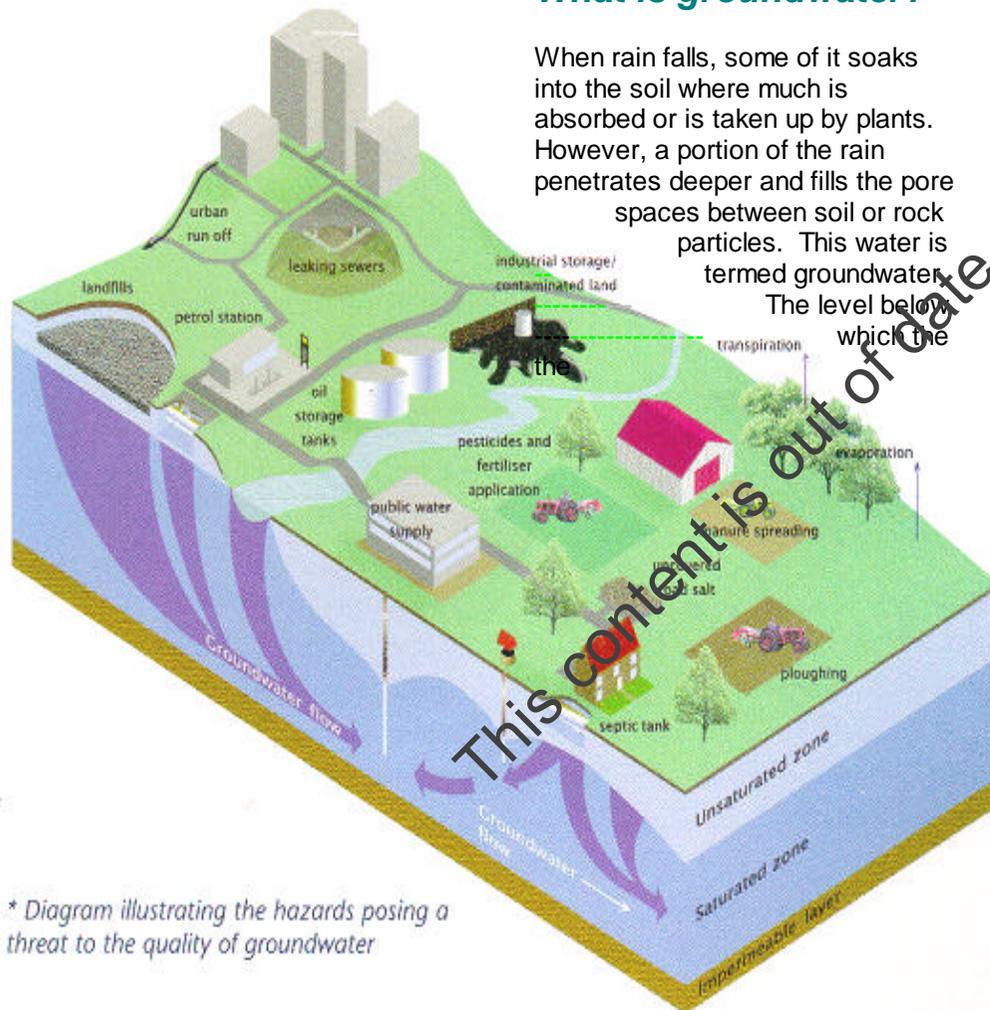
For each source, three zones are defined around a particular water abstraction based on travel times, of the groundwater (Zone 1 = 50 days; Zone 11 = 400 days) and the total catchment area of the abstraction (Zone 111). Agency Regional staff have carried out the work locally, supported by the National Groundwater and Contaminated Land Centre. Conceptual hydrogeological

models have been created and in many cases these are supported by mathematical models such as FLOWPATH and MODFLOW/MODPATH where there are sufficient data. The resulting zones are stored in a digitised format which can be displayed on paper maps or in geographical information systems (GIS).

What is groundwater?

When rain falls, some of it soaks into the soil where much is absorbed or is taken up by plants. However, a portion of the rain penetrates deeper and fills the pore spaces between soil or rock particles. This water is termed groundwater.

The level below which the



A Groundwater Map

ground is fully saturated is called the saturated zone and the zone of partial and variable saturation above this is called the unsaturated zone. The top of the saturated zone is known as the water table. Underground strata (rocks) that can both store and yield significant quantities of groundwater are known as aquifers. Groundwater is a very important source of water in England and Wales. More than 3,000 public water supply and industrial water supply boreholes abstract groundwater and there are many more small, private sources, many of them in rural areas. It is not practicable or efficient to define zones around the smaller sources, other than on a reactive basis where a specific need arises, not least because of the lack of available data. However, the Agency has published guidelines and a methodology for defining sources protection zones around such small sources.

Agency Policy and the legislative background

The Environment Agency is responsible for the protection of “controlled waters” from pollution under the Water Resources Act 1991. These controlled waters include all watercourses and groundwater contained in underground strata. It is an offence to cause pollution of controlled waters either deliberately or accidentally.

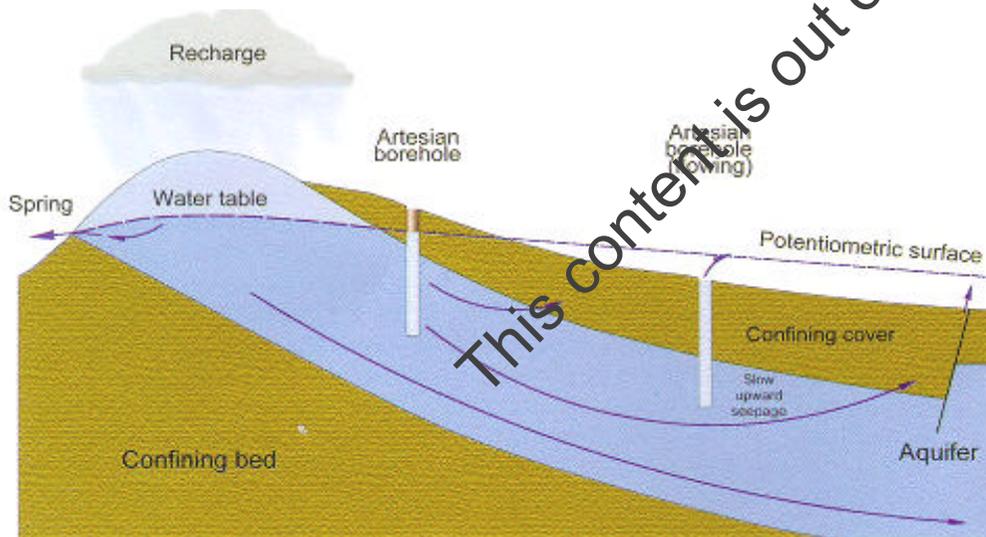
The Agency also has a specific duty to prevent groundwater pollution by certain dangerous substances under the Groundwater Regulations 1998 and the Waste Management Licensing Regulations 1994. Discharge into groundwater of substances in List 1 of the EC Groundwater Directive is prohibited, and discharges of substances in List 11 must be minimised so as to prevent pollution.

* Diagram illustrating the hazards posing a threat to the quality of groundwater

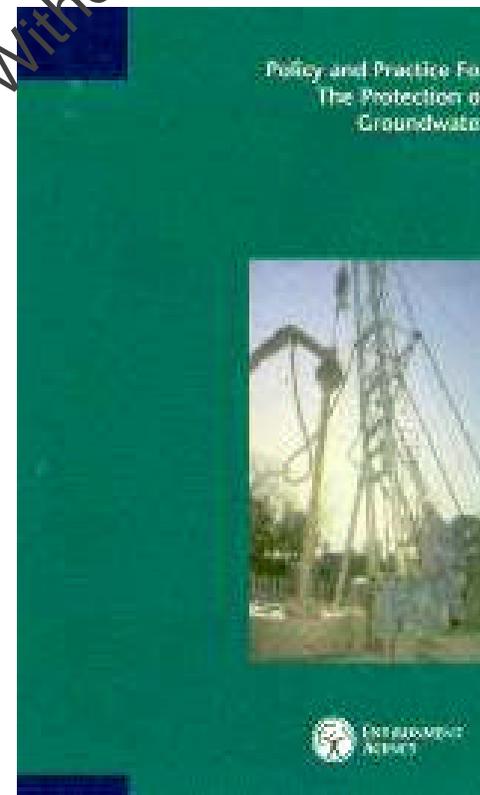
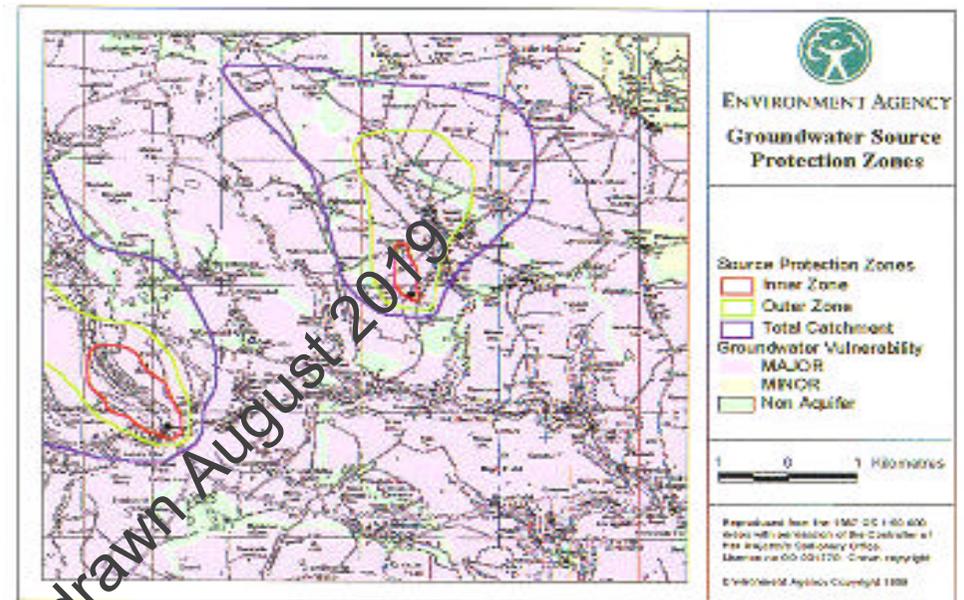
The Agency has published its national policy for groundwater. The "Policy and Practice for the Protection of Groundwater" replaced a range of different approaches used by the former regional water authorities and sets out:

- a series of policy statements on groundwater;
- a classification of groundwater vulnerability resulting in the vulnerability maps;
- a definition of groundwater source protection zones.

These items do not have statutory status, but enable the Agency to respond to various statutory and non-statutory consultations in a consistent and uniform manner. These responses are designed to influence others whose actions can affect groundwater. The PPG is supported by technical tools that allow focused assessment of the risks to groundwater at a particular site.



*Unconfined and confined aquifer, springs and boreholes



*Front cover of the "Policy and Practice for the Protection of Groundwater"

Groundwater vulnerability assessment relates risk to the whole of the groundwater resource. However, a sensible balance also needs to be struck between the protection of groundwater resources as a whole and of specific abstraction sources, not least because both land use and aquifers in England and Wales are already highly developed and heavily utilised. Groundwater source protection zones have therefore been developed to limit the most restrictive policy statements to particular groundwater sources, mainly those used for major potable water supply.

Thus the Agency's approach to groundwater protection through the PPG is a dual strategy which seeks to protect aquifers as a whole and also to safeguard specific sources of water supply.

A history of Protection zones

The definition of areas that aim to protect groundwater sources is not a new idea. Many examples can be found in the UK water supply industry of protected areas within which activities have been restricted or banned. Sometimes by-laws were used. In the Margate Act 1902 a water authority was given the power to control drains, cesspools etc over an area of 1,500 yards from any well. One approach that was widely used in the UK comprised a 3 km radius circular zone around the water source.

The 1970s saw the first use of simple, standard shapes based on hydraulic equations to define protection zones. These were used in planning application assessments and waste disposal site licensing.

In 1992 the National Rivers Authority (a predecessor of the Agency) adopted land zoning based on vulnerability and also on the definition of inner, outer and catchment protection zones. The Agency then conducted a pilot study to develop the identified delineation techniques

for 750 of the most important public supply sources in England and Wales. A second phase was undertaken in 1993-94 to refine over 150 priority sources for the Nitrate Directive and a third phase to define zones around approximately 1,250 public supply, non-public potable and sensitive industrial sources, ran from 1995 to 1997.

The techniques by which groundwater protection zones were defined have been subject to constant technical innovation, and this process of evolution will actively continue. The Agency is

eager to explore new information or methods which may better define and identify the zones.

Defining source protection zones

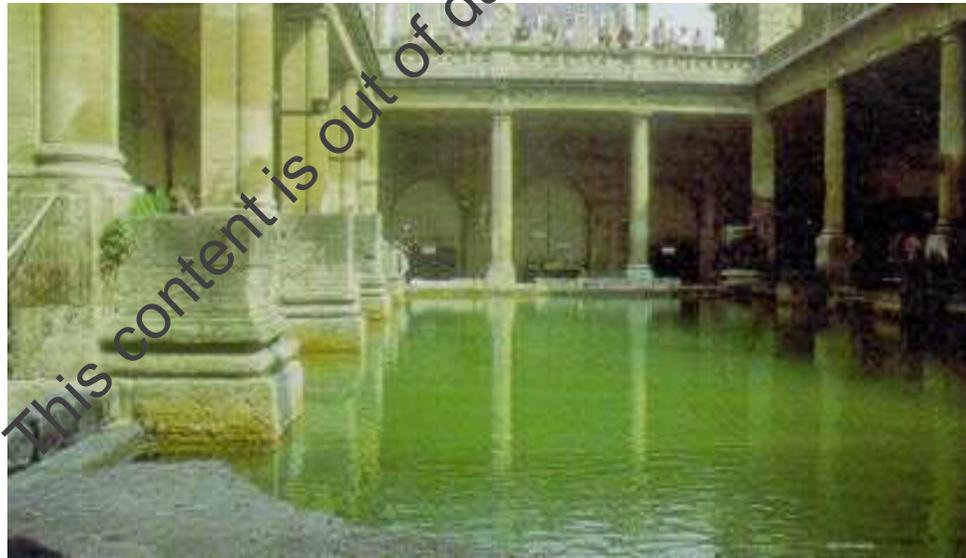
The definition starts with consideration of all significant public water supply and private wells or boreholes that supply water to potable or equivalent standards, for example mineral water, breweries, food processing etc.

As well as the high value use to

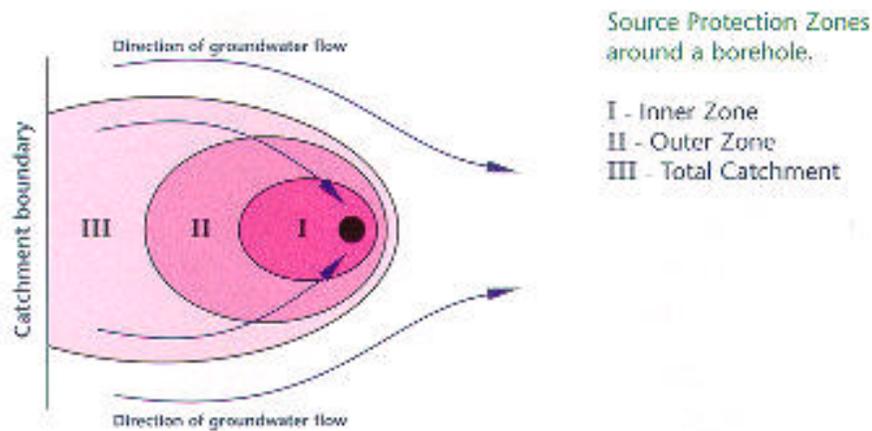
which water abstracted for potable supply is put, there are a number of practical reasons why the principal emphasis for groundwater protection zones has been, and will continue to be, on such sources:

- most available data on aquifer properties are concentrated at, and around, major public supplies;
- the yield from sources may exert a major influence on the flow regime of the aquifer itself;
- where an area is heavily exploited zones may coalesce.

The risk posed by a particular activity to an existing groundwater source (spring, well or borehole) depends on its proximity. More specifically, the pollution threat depends on whether the activity is located within the catchment of that source and on the horizontal flow time (or travel time) to the abstraction point. The Agency has subdivided groundwater source catchments into three zones. Two of these are determined by the travel time of potential pollutants, and the third by the source catchment area itself.



*The Great Roman bath at Bath. Filled by groundwater from the King's Spring, one of three thermal springs in Bath.

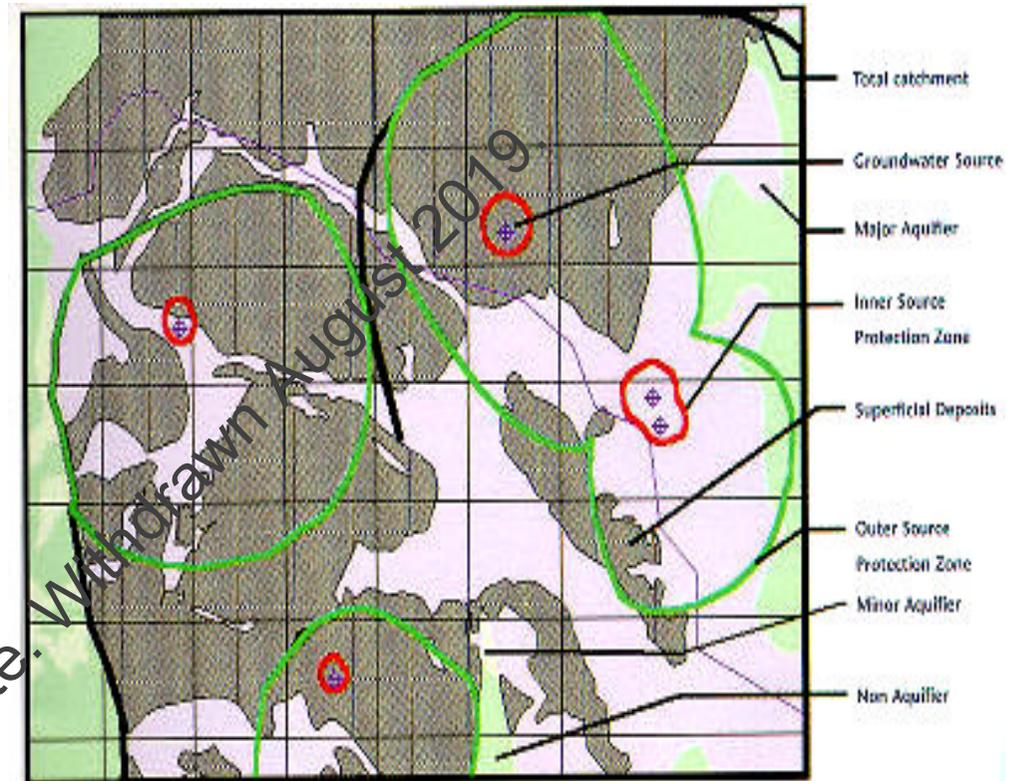


Inner Zone 1 is defined by a 50-day travel time from any point below the water table to the source and, additionally, as a minimum 50m radius from the source. It is based principally on biological decay criteria and is designed to protect against the transmission of toxic chemicals and water-borne disease.

Outer Zone 11 is defined by the 400-day travel time or 25 per cent of the source catchment area, whichever is larger. The travel time is derived from consideration of the minimum time required to provide delay, dilution and attenuation of slowly degrading pollutants.

Source Catchment Zone 111 is defined as the area needed to support the protected yield from long-term groundwater recharge (effective rainfall). In areas where the aquifer is confined beneath impermeable strata, this source catchment may be located some distance from the abstraction.

To define a zone it is necessary to know how the groundwater behaves in that area along with knowledge of well construction, water levels, and groundwater surface water interactions. Once compiled, the information is used to create a conceptual model which is a clear concise statement on the groundwater setting. The choice of zone definition technique is then based on:



- the quality of data available and the degree of understanding of the groundwater setting;
- the operational importance of the source concerned.

Once a model has been applied and calibrated, protection zones are produced based on the best estimate of the parameter values.

Zone shapes

Many factors control the shape and size of zones such as:

- groundwater abstraction rate;
- recharge (direct and indirect);
- aquifer permeability (hydraulic conductivity);
- effective porosity (specific yield);
- aquifer thickness;
- hydraulic gradient and direction of groundwater flow.

Inner protection zones are generally fairly simple in geometry and tend to be circular in form, reflecting the "cone of depression" around an abstraction borehole. The key factors in defining the geometry of source catchment zones are recharge, the form of the groundwater surface and the catchment boundary conditions. Zone shapes can vary from the very simple to the complex. Outer protection zones are generally intermediate in shape between inner and source catchment zones. Zones may be subject to change as additional data become available or when the

hydrogeological regime changes, for example, through changes in the amount of water pumped out of the ground. However, any outside body which seeks to further investigate or define an alternative source protection zone should do so in the knowledge that:

- all investigations will be carried out at the outside body's expense;
- the Agency will require proposed changes to be supported by any new field or scientific evidence;
- the Agency will reserve the right to reject any proposed changes.

What do these zones mean to me?

The primary use of groundwater protection zones is to signal that within specified areas there are likely to be particular risks posed to the quality or quantity of water obtained, should certain activities take place nearby. Used in conjunction with the PPG they are, first and foremost, a screening tool to be used with caution when assessing specific activities. They can help to target pollution prevention measures more effectively to the areas of greatest risk.

Many regulatory bodies, including the Agency, have influence over land use. It is important they are aware of not only the issues of concern that could influence groundwater quality but also of the areas that are at greatest risk. The definition of zones around boreholes provides a readily comprehensible tool for regulators, landowners and developers alike. The zones are an attempt to explain the likely regulatory response in particular areas to make the decision-making process more open and transparent for the wider community. They should aid those industries wishing to take a proactive stance to protect the environment and assist the operator/owner of a groundwater



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abstraction to be aware of the source of his water.

Detailed interpretation of the mapped zones is best left to specialists who can take into account information (or lack of it) which may mitigate the particular risks, and therefore make professional judgements. They will need to consider the information in the source evaluation reports together with any additional data submitted during a site investigation.

The importance of groundwater to our lives cannot be over-emphasised. Placing this resource at risk through neglect or indifference is simply not acceptable. In the US whole cities have lost their water supplies from industrial accidental pollution, with major repercussions for the companies concerned. The zones are a mechanism to help us avoid such a fate in England and Wales.

Availability of source protection zones

The results of modelling and zone definition along with the supporting data are held in Regional and/or Area offices in source evaluation reports. These are available for consultation but, to facilitate ease of use, the Agency has produced a series of maps which display the protection zones (inner, outer and total catchment) for each of the modelled sources. The maps are at a scale of 1:50 000 and 1:100, 000 and, in addition to the zones, display the aquifer type (major, minor or non-aquifer) and an Ordnance Survey topographic base map. These maps will be available for consultation at Agency offices. The digital data will also be available (sometime after January 2000) for download from the Agency's internet web pages for use in geographic information systems (GIS).

Further information

Further information is available including in a number of guidance manuals:

[Guide to groundwater protection zones in England and Wales](#), ISBN 0 11 310104 (available from The Stationery Office)

[Groundwater protection for small sources](#)

[Vol 1: Review of available methodologies and existing practice](#)

[Vol 2: Worked examples](#)

[Vol 3: Compendium of predefined capture zone approximations using WHPA-MWCAP](#)

[Guide to Groundwater vulnerability mapping in England and Wales](#), ISBN 0 11 310103 1 (available from The Stationery Office)

[Policy and practice for the protection of groundwater](#). ISBN 0 11 310145 7 (available from The Stationery Office)

[Manual of standard zone delineation methodologies](#) (available from the National Groundwater and Contaminated Land Centre, Olton Ct, 10 Warwick Rd, Solihull B92 7HX)

[Water Resources Act 1991, Sections 84 and 19](#) (available from The Stationery Office)

[Department of the Environment, PPG12: Development plans and regional planning guidance](#)

[EC Nitrate Directive 91/676 and EC Agri-environmental \(Council\) regulation 2078/92](#)

[Adams B and Foster S, \(1992\), Land surface zoning for groundwater protection. J. IWEM, 6 312-320](#)

[Groundwater Regulations \(1998\)](#) (available from The Stationery Office)



MANAGEMENT AND CONTACTS

The Environment Agency delivers a service to its customers with the emphasis on authority and accountability at the most local level possible. It aims to be cost-effective and efficient and to offer the best service and value for money.

Head Office is responsible for overall policy and relationships with national bodies including Government. Rio House, Waterside Drive, Aztec West/Almondsbury, Bristol BS32 4UD

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The 24-hour emergency hotline number for reporting all environmental incidents relating to air, land and water.

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