Agall Water Supply Scheme

Groundwater Source Protection Zones

(April 2001)

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1 Introduction

The groundwater sources at Agall, Hollimshill and Tully are used to supply the Rahan Water Scheme. This report deals specifically with Agall Spring. Groundwater Source Protection Zones for the Hollimshill and Tully sources have been prepared in previous reports (Cronin *et al*, 1998 and 1999).

The objectives of the report are as follows:

- To delineate source protection zones for the spring.
- To outline the principle hydrogeological characteristics of the Agall area.
- To assist Offaly County Council in protecting the water supply from contamination.

2 Location, Site Description and Well Head Protection

Agall Spring is located 6.5 km west of Tullamore, 2.5 km from Rahan village. The spring source is located next to the pumphouse in a cylindrical concrete sump. A v-notch weir is constructed in the overflow outlet that flows to a small stream. The site is fenced off and protection of the spring was recently upgraded by covering the site with crushed rock. There is no cover on the sump.

3 Summary of Spring Details

G.S.I. No:	:	2021NEWOO4
Grid ref. (1:25,000)	:	N 22678 22346
Townland	:	Agall
Well type	:	Spring
Owner	:	Offaly County Council
Elevation (ground level)	:	~59 m OD.
Depth to rock	:	1-5m
Static water level	:	Ground level
Normal Abstraction	:	1000 $m^3 d^{-1}$
Estimated Average Discharge	:	1500 $m^3 d^{-1}$

4 Methodology

4.1 Desk Study

Details about the spring such as elevation, and abstraction figures were obtained from GSI records and County Council personnel; geological and hydrogeological information was provided by the GSI.

4.2 Site visits and fieldwork

This included carrying out depth to rock drilling, subsoil sampling, and spring flow measurements. Field walkovers were also carried out to investigate the subsoil geology, the hydrogeology and vulnerability to contamination.

4.3 Assessment

Analysis of the data utilised field studies and previously collected data to delineate protection zones around the source.

5 Topography, Surface Hydrology and Land Use

The source occurs at a break in slope on the margin of a gravel hill. The land rises to the south as far as Hollimshill to an elevation of about 120 m OD. The land to the north is low-lying and boggy.

Several streams start at the margins of the gravel hills to the east and west of the spring, all of which flow northeast, north and northwest towards the Clodiagh and Brosna Rivers. There are frequent surface drains on the bog, again draining northwards. The land to the north of the spring is free draining with no surface water features. Pallas Lough occurs to the north of Hollimshill, that has no surface outlet.

A sand and gravel quarry is in operation 300 m south of the spring. A forestry with an area of about 2 km^2 occurs 1 km south of the spring. The rest of the area is used as pasture land.

6 Geology

6.1 Introduction

This section briefly describes the relevant characteristics of the geological materials that underlie the spring. It provides a framework for the assessment of groundwater flow and source protection zones that will follow in later sections.

Bedrock information was taken from a desk-based survey of available data, which comprised the following:

- County Offaly Groundwater Protection Scheme (Daly *et al*, 1998)
- Information from geological mapping in the nineteenth century (on record at the GSI).

Subsoils information was taken from the Offaly Groundwater Protection Scheme (Daly *et al*, 1998). One auger hole was drilled by GSI personnel near the spring to investigate the subsoils.

6.2 Bedrock Geology

The Borrisokane Limestone rock unit occupies the whole area around the source. It is a thick-bedded, coarse grained, pale limestone with some darker fine-grained beds with occasional thin clay rich bands.

Movements in the earth's crust have caused the rocks to be folded, faulted and jointed. The rock units have a NE-SW orientation, dipping southeastwards at a low angle. Two major fault sets occur that trend NE-SW and SE-NW. The joint pattern is likely to have similar orientations.

6.3 Subsoil (Quaternary) Geology

The subsoils comprise a mixture of coarse and fine-grained materials, namely: alluvium, sand & gravel. The characteristics of each category are described briefly below:

6.3.1 Peat and Alluvium

These materials occupy the low-lying area to the north of the spring. The alluvium is a fine grained, grey blue deposit (BS5930: CLAY). It can be seen in sections along the stream that the spring overflows into and is up to 1 m thick.

6.3.2 Sand & Gravels

Extensive fluvioglacial sand and gravels are present in County Offaly, which are particularly widespread in the area around Agall. Sand & Gravel is the dominant subsoil type throughout the area. They are described using the British Standards (BS5930) as being sandy GRAVELS. The boulders and cobbles are limestone in composition. Sands & gravel in Offaly are often associated with eskers. There is an esker about 2 km to the south of the spring that has a northwest-southeast trend. Eskers deposits are generally composed of coarse boulder gravels that are highly permeable.

6.3.3 Depth to Bedrock

The depth to rock is known in certain localities from information gathered for the Offaly Groundwater Protection Scheme and from one auger hole drilled close to the spring. The depth to bedrock varies from about 4->25 m.

7 Hydrogeology

7.1 Introduction

This section presents our current understanding of groundwater flow in the area of the springs. The spring is shown in Figure 1.

Hydrogeological and hydrochemical information for this study was obtained from the following sources:

- Offaly Groundwater Protection Scheme (Daly *et al* 1998).
- An Assessment of the Quality of Public and Group Scheme Groundwater Supplies in County Offaly, (Cronin *et al*, 1999).
- GSI files. Archival Offaly County Council data for the years 1977, 1989, 1991. C1–C2 type parameters.
- Offaly County Council annual drinking water returns 1992–1999 inclusive (C1, and C4 type parameters).
- Hollimshill Public Supply. Groundwater Source Protection Zones. Cronin *et al*, 1999.
- Tully Public Supply. Groundwater Source Protection Zones. Cronin *et al,* 1998.
- Spring flow measurements.

7.2 Rainfall, Evaporation and Recharge

The term 'recharge' refers to the amount of water replenishing the groundwater flow system. The recharge rate is generally estimated on an annual basis, and is assumed to consist of an input (i.e. annual rainfall) less water losses prior to entry into the groundwater system (i.e. annual evapotranspiration and runoff). The estimation of a realistic recharge rate is critical in source protection delineation, as it will dictate the size of the zone of contribution to the source.

In areas where point recharge from sinking streams, etc., is discounted, the main parameters involved in recharge rate estimation are annual rainfall, annual evapotranspiration, and annual runoff and for the Agall area, they are estimated as follows:

- Annual rainfall: 837 mm. (Met Éireann)
- Annual evapotranspiration losses: 448 mm. Potential evapotranspiration (P.E.) is estimated to be 482 mm $yr.^{-1}$ (based on data from Met Éireann). Actual evapotranspiration (A.E.) is then estimated as 93 % of P.E.
- Potential recharge: 389 mm $yr.^{-1}$. This figure is based on subtracting estimated evapotranspiration losses from average annual rainfall. It represents an estimation of the excess soil moisture available for vertical downward flow to groundwater or for runoff.
- Annual runoff losses: 20 mm. This estimation assumes that 5% of the potential recharge may be lost to overland flow and shallow soil quickflow without reaching the main groundwater system.

These calculations are summarised as follows:

Average annual rainfall (R)	837 mm
Estimated A.E.	448 mm
Potential Recharge (R – A.E.)	389 mm
Runoff losses	20 mm
Estimated Actual Recharge	369 mm

7.3 Groundwater levels, Flow Directions and Gradients

Water levels in Pallas Lough, Agall Spring and the Clodiagh River are assumed to represent groundwater levels in the area. The water level at the spring is estimated to be about 59 m OD. The water level at Pallas Lough is about 76-77 m OD. The static water level at the Hollimshill source is about 73 m OD.

The water table in the area is assumed to be a subdued reflection of topography with water flowing northward and discharging in the vicinity of Agall Spring. It is likely that fractures in the bedrock along with the break in slope intersecting the low-lying area that focuses the groundwater to emerge at this location. At Hollimshill, the top of the water table lies within the bedrock. Information from other wells in the area around Hollimshill indicate that the top of the water table lies below the top of the bedrock. There is very little information close to the spring. The unsaturated zone is assumed to be >10 m over most of the area, except near Pallas Lough, Agall Spring and the Clodiagh River. It is estimated that the water table enters into the gravel about 1 km from the source. The estimated saturated thickness toward the spring is about 5 m. The saturated thickness of the gravel is unproven.

The hydraulic gradient of the Borrisokane Limestone in the Agall area is estimated to be about 0.004.

7.4 Aquifer Characteristics

The groundwater levels indicate that the top of the water table occurs below the top of the bedrock over most of the area, except near the source, the peat land areas around Agall and the Clodiagh River. Whilst there is a significant sand & gravel body overlying the bedrock, the main aquifer is likely to be the limestone bedrock. The sand & gravel body is likely to provide storage for groundwater and probably maintains yields in dry weather. As water approaches the spring the top of the water table is likely to occur within the sand & gravel body.

The Borrisokane Limestone is classed as a **regionally important fissured aquifer (Rf).** Several large supplies draw water from this aquifer in County Offaly (Daly *et al*, 1998).

Data for the transmissivity, permeability and porosity are taken from the work done for the groundwater sources at Hollimshill and Tully as they are located in the same aquifer. Modelled transmissivities at Tully and Hollimshill are 140 and 650 $m^3 d^{-1}$ respectively. Field transmissivities are 52-530 $m^2 d^{-1}$ at Hollimshill and 13 $m^2 d^{-1}$. Modelled permeability at Tully is 4.5 $m d^{-1}$. The permeability at Hollimshill is 13 $m d^{-1}$. At Agall the aquifer parameters are likely to be similar to those at Hollimshill and possibly higher as it is a spring with a high discharge. The permeability and resulting groundwater velocities of the Borrisokane Limestone Formation are likely to be high as water approaches the spring. The permeability is estimated to be about 20 $m d^{-1}$ at the spring. Porosity is taken to be about 2%.

There are a few karst features recorded in the Borrisokane Limestone Formation, but it appears that the degree of karstification is limited (Daly *et al*, 1998).

7.5 Hydrochemistry and Water Quality

The Tully, Agall and Hollimshill sources collectively supply the Rahan Scheme. There are no recent data for the Agall source; analyses from Rahan (mixed water sample) provide a good representation of general water quality in the main limestone aquifer. Current Monitoring (C4) analyses (16 samples; 1996-9) are available for Agall and are presented in Appendix 1.

Nitrate concentrations are generally below the E.U. guide level. The concentrations which are in the range of 19-25 $mg\ l^{-1}$ (average 22.4 $mg\ l^{-1}$) are likely to be representative of present general nitrate contamination by both diffuse (spreading of inorganic fertiliser and slurry) and point sources (septic tank systems and farmyards) in this relatively intensive farming area in mid-Offaly (Daly *et al*, 1997). There is a slight upward trend in the data, as can be seen in the graph in Appendix 1.

Chloride concentrations range from 19-23 mg l^{-1}, with an average of 21 mg l^{-1} (12 samples). Chloride is a constituent of organic wastes and levels higher than 25 mg l^{-1} may indicate significant contamination. Concentrations higher than the 30 mg l^{-1} usually indicates significant contamination. Thus chloride levels give no rise for concern at the source.

Data for the Rahan Water Scheme indicates hard water of bedrock origin. Conductivity readings taken on the 28/7/1999 and 19/5/2000 are both 587 µS cm^{-1}. Overall the water quality in the Rahan area appears to be good - all major cations and anions are within the E.U. limits.

7.6 Spring Discharge

The spring has an V-notch weir installed, however, it is in a state of disrepair and could not be used. Previous records are not available. Two estimates of the overflow were made using flow meter equipment. A discharge meter was installed to measure the abstraction. Continuous or more frequent monitoring is required to establish a better understanding of the total discharge at the spring. On 28/7/1999 the abstraction was estimated to be 873 m^3 d^{-1} and the overflow was estimated to be 250 m^3 d^{-1}. On 19/5/2000 the abstraction was measured at 981 m^3 d^{-1} and the overflow was estimated to be 865 m^3 d^{-1}. The average annual discharge is calculated to be about 1500 m^3 d^{-1}. However, it is likely that the discharge during the winter months is likely to be higher, even though the measurement taken on the 19/5/2000 was taken after heavy rainfall. Therefore, the calculated average discharge may be an underestimate.

7.7 Conceptual Model

- Agall Spring is located in the Borrisokane Limestone which is the highest permeability rock unit in the area.
- The sand & gravel body is likely to provide storage for groundwater and probably maintains yields in dry weather.
- A combination of the slope intersecting the low-lying peatland and fractures in the bedrock is likely to be the reason that the groundwater emerges at Agall Spring.
- The permeability of the aquifer depends on the development of faults, fissures and fractures. The permeability and resulting groundwater velocities are likely to be high as water approaches the spring.
- As the limestone aquifer is overlain by highly permeable sand & gravel the groundwater can be considered as unconfined.
- The water table in the area is assumed to flow northward toward the floodplain of the Tullamore and Clodiagh Rivers, discharging at Agall spring.
- The groundwater gradient is relatively flat within the permeable limestone aquifer, estimated to be 0.0045.

8 Delineation of Source Protection Areas

8.1 Introduction

This section delineates the area around the spring that is believed to contribute groundwater to the spring, and that therefore requires protection. The area is delineated based on the conceptualisation of the groundwater flow pattern, and is presented in Figures 1 and 2.

Two source protection areas are delineated:

- Inner Protection Area (SI), designed to give protection from microbial pollution;
- Outer Protection Area (SO), encompassing the remainder of the zone of contribution (ZOC) of the springs.

8.2 Outer Protection Area

The Outer Protection Area (SO) is bounded by the complete catchment area to the source, i.e. the zone of contribution (ZOC), which is defined as the area required to support an abstraction from long-term recharge. The ZOC is controlled primarily by a) the total discharge, b) the groundwater flow direction and gradient, c) the rock permeability and d) the recharge in the area.

The shape and boundaries of the ZOC were determined using hydrogeological mapping, water balance estimations and the conceptual model. The ZOC boundaries are shown in Figures 1 and 2. Therefore, the boundaries drawn are estimates, based on information on the Borrisokane Limestone in the Offaly area, experience and judgement. More definitive boundaries would require a detailed site investigation in the area, comprising a drilling programme. Topography in this instance is not particularly useful to delineate the boundaries as the aquifers are very permeable and the water table is relatively flat. Therefore the eastern and western boundaries are based on the assumed water table and the water balance required to provide water to the spring. The southern boundary extends as far as the northern boundary for the Hollimshill source. The boundaries are based on our current understanding of groundwater conditions in the area and on the available data. It is assumed that groundwater downgradient of the spring is not pulled back toward the spring. A 30 m buffer is placed on the downgradient side of the spring.

The area delineated using the boundaries described above is about 2 km^2. The water balance shows that to provide the discharge at the source an area of about 1.5 km^2 is required. However, the water balance uses a mean annual flow that may underestimate the true mean flow. To get an accurate mean annual flow, continuous monitoring of the spring discharge over the winter and summer months is recommended. Therefore the delineated ZOC allows for minor errors in estimating the groundwater flow direction and a possible underestimate of the outflow from the spring.

8.3 Inner Protection Area

Delineation of an Inner Protection Area is required to protect the source from microbial and viral contamination and it is based on the 100-day time of travel to the supply. Estimations of the extent of this area cannot be made by hydrogeological mapping and conceptualisation methods alone. Analytical modelling using the aquifer parameters in Section 7.4 assists in estimating the 100-day ToT boundary. The inner protection area is shown in Figure 2.

It is estimated that groundwater velocities range up to approximately 4 m d^{-1} in the Borrisokane Limestone. The 100-day ToT boundary in the Borrisokane Limestone Formation is estimated to be 400 m from the spring. However the water table is believed to extend up into the gravel, with up to 5 m of saturation at the spring. The saturated thickness have not being proven. It is not feasible to draw a definitive 100-day ToT boundary, as specific data on permeabilities and porosities are not available for the area. More definitive boundaries would require a detailed site investigation in the area.

9 Groundwater Vulnerability

Vulnerability is a term used to represent the intrinsic geological and hydrogeological characteristics that determine the ease with which groundwater may be contaminated by human activities and depends on the thickness, type and permeability of the subsoils. A detailed description of the vulnerability categories can be found in the Groundwater Protection Schemes document (DELG/EPA/GSI, 1999).

The subsoils comprise sand & gravel that have a depth greater than 3 m across the entire area. The vulnerability category of these high permeability deposits is ‘High’ (H), except where the water table is estimated to be within 3 m of the ground surface up to 160 m south of the spring; the groundwater vulnerability in this region is classed as ‘Extreme’ (E). A map of vulnerability is given in Figure 1.

10 Groundwater Protection Zones

The groundwater protection zones are obtained by integrating the two elements of land surface zoning (source protection areas and vulnerability categories) – a possible total of 8 source protection zones. In practice, the source protection zones are obtained by superimposing the vulnerability map on the source protection area map. Each zone is represented by a code e.g. **SI/H**, which represents an Inner Protection area where the groundwater is highly vulnerable to contamination. Two groundwater protection zones are present around the spring source as shown in Table 1. The final groundwater protection map is presented in Figure 2.

Table 1 Matrix of Source Protection Zones for Agall Spring

VULNERABILITY RATING	SOURCE PROTECTION	
	Inner	***Outer***
Extreme (E)	SI/E	Absent
High (H)	SI/H	SO/H
Moderate (M)	Absent	Absent
Low (L)	Absent	Absent

11 Potential Pollution Sources

Land use in the area is described in Section 5. The land near the source is largely grassland-dominated and is primarily used for grazing. Agricultural activities and septic tanks are the principal hazards in the area. Machinery in the sand & gravel quarry pose a threat to the groundwater from possible diesel spills, fuel leaks etc. Spillages and runoff from the road also poses a threat. The main potential pollutants are diesel/oil spills, nitrogen, faecal bacteria and viruses.

12 Conclusions and Recommendations

- Agall spring is a large spring that is located in a **regionally fissured (Rf) aquifer.**

- The vulnerability of the groundwater in the ZOC for Agall Spring is classed as high (H) and extreme (E) within 160 m of the spring.

- Septic tanks, farmyards, landspreading, diesel/oil spills and runoff from the roads pose a threat to the water quality at the springs.

- The hydrogeology of the area is complex and the available information is not adequate to allow the delineation of definitive groundwater protection zone boundaries. The protection zones delineated in the report are based on our current understanding of groundwater conditions, on the available data and our judgement. Additional data obtained in the future may indicate that amendments to the boundaries are necessary. A more definitive understanding of the hydrogeology would require an extensive site investigation that would include drilling, geophysics and spring flow measurements.

- It is recommended that:

1) A chemical and bacteriological raw water analysis should be carried out on a regular basis at the source.
2) particular care should be taken when assessing the location of any activities or developments that might cause contamination at the well.
3) the potential hazards in the ZOC should be located and assessed.
4) The discharge of the spring should be monitored regularly.

13 References

Cronin, C. and Daly, D., 1999. *An Assessment of the Quality of Public and Group Scheme Groundwater Supplies in County Offaly*. Geological Survey Report, 30 pp.

Cronin C., Daly, D., and R. Flynn, 1999. *Hollimshill Public Supply. Groundwater Source Protection Zones.* Geological Survey Report, 12 pp.

Cronin C., Daly, D., and R. Flynn, 1998. *Tully Public Supply. Groundwater Source Protection Zones*. Geological Survey Report, 18 pp.

Daly, D., Cronin, C., Coxon, C. and S.J. Burns, 1998. *County Offaly Groundwater Protection Scheme*. Geological Survey Report for Offaly County Council, 60 pp.

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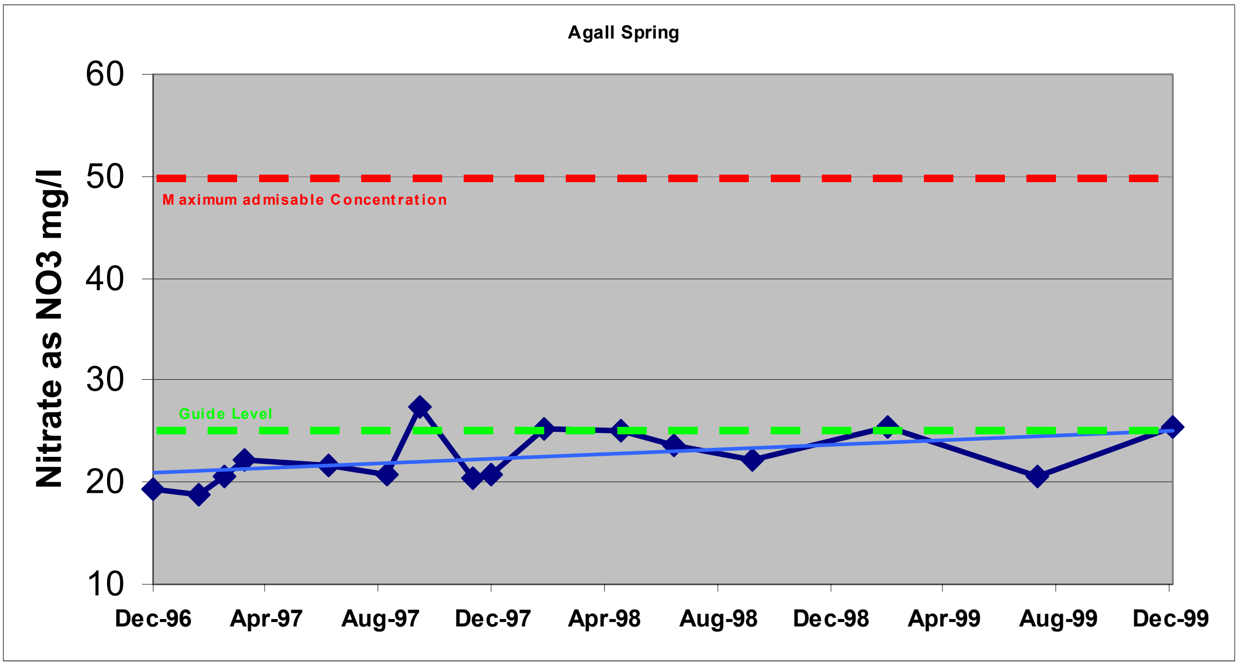
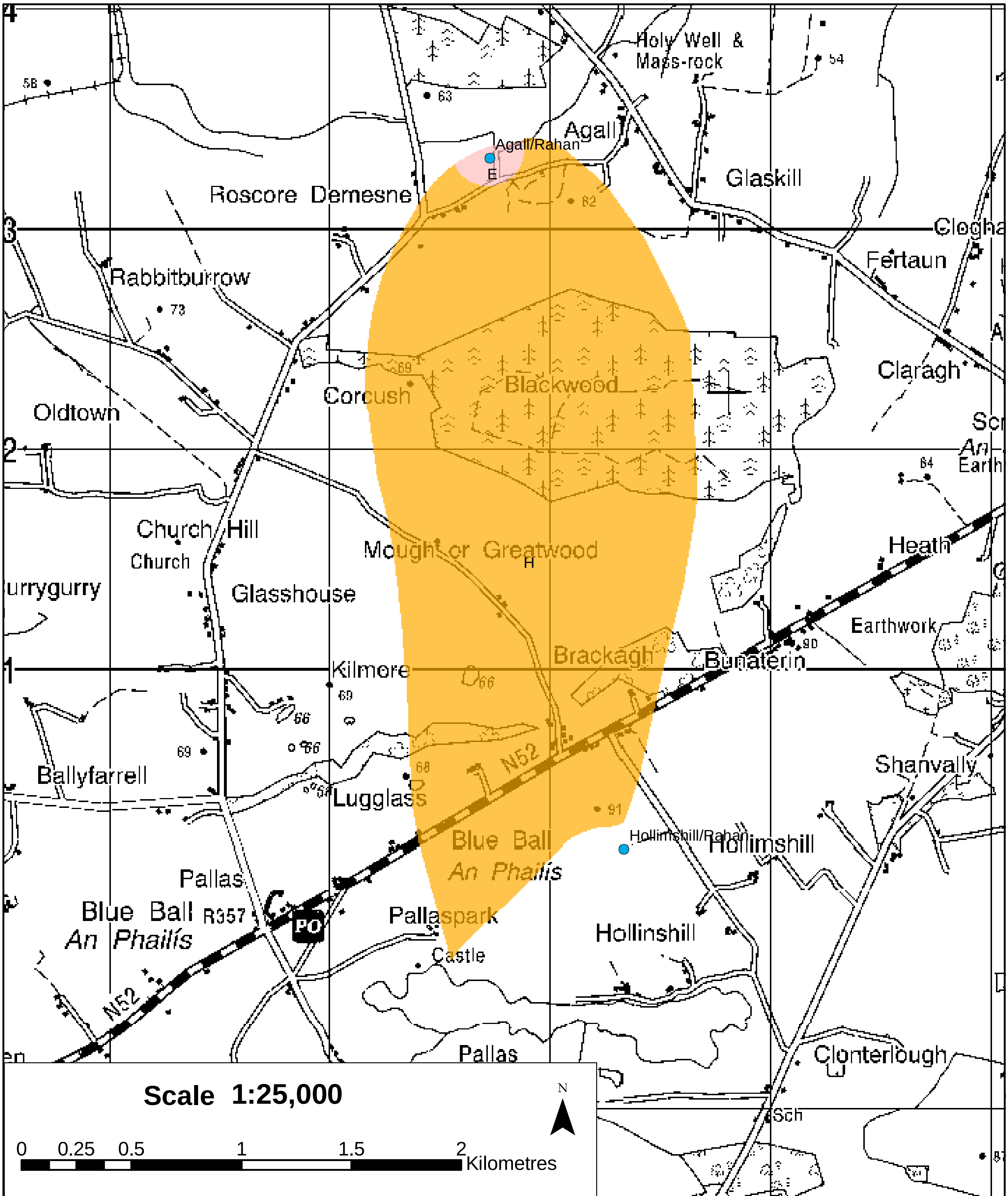
Appendix 1 Hydrochemical Analyses (C4)

Current Monitoring (C4) from Offaly County Council.

Date	Chloride	Na	K	Nitrate
12/02/96				19.3
02/17/97		9.2	1.9	20.5
03/10/97	21.00	8.4	1.5	22.2
06/09/97	22.00	19	2.1	21.6
09/15/97	22.00	8.6	1.4	27.3
11/10/97	22.00	8	1.2	20.4
12/01/97	23.00	8.7	1.1	20.8
01/26/98	19.00	8.9	1.3	25.2
04/06/98	21.00	10.2	1.5	25.0
06/15/98	20.00	10.2	1.5	23.7
09/07/98	22.00	10.4	1.1	22.25
02/01/99	21.00	10.82	1.73	25.36
07/12/99	20.80	10.27	1.19	20.61
12/04/99	21.20	10.42	1.28	25.36

Appendix 2 Graph of Nitrate concentrations at Agall Spring





Vulnerability Categories

E - Extreme

H - High

Spring

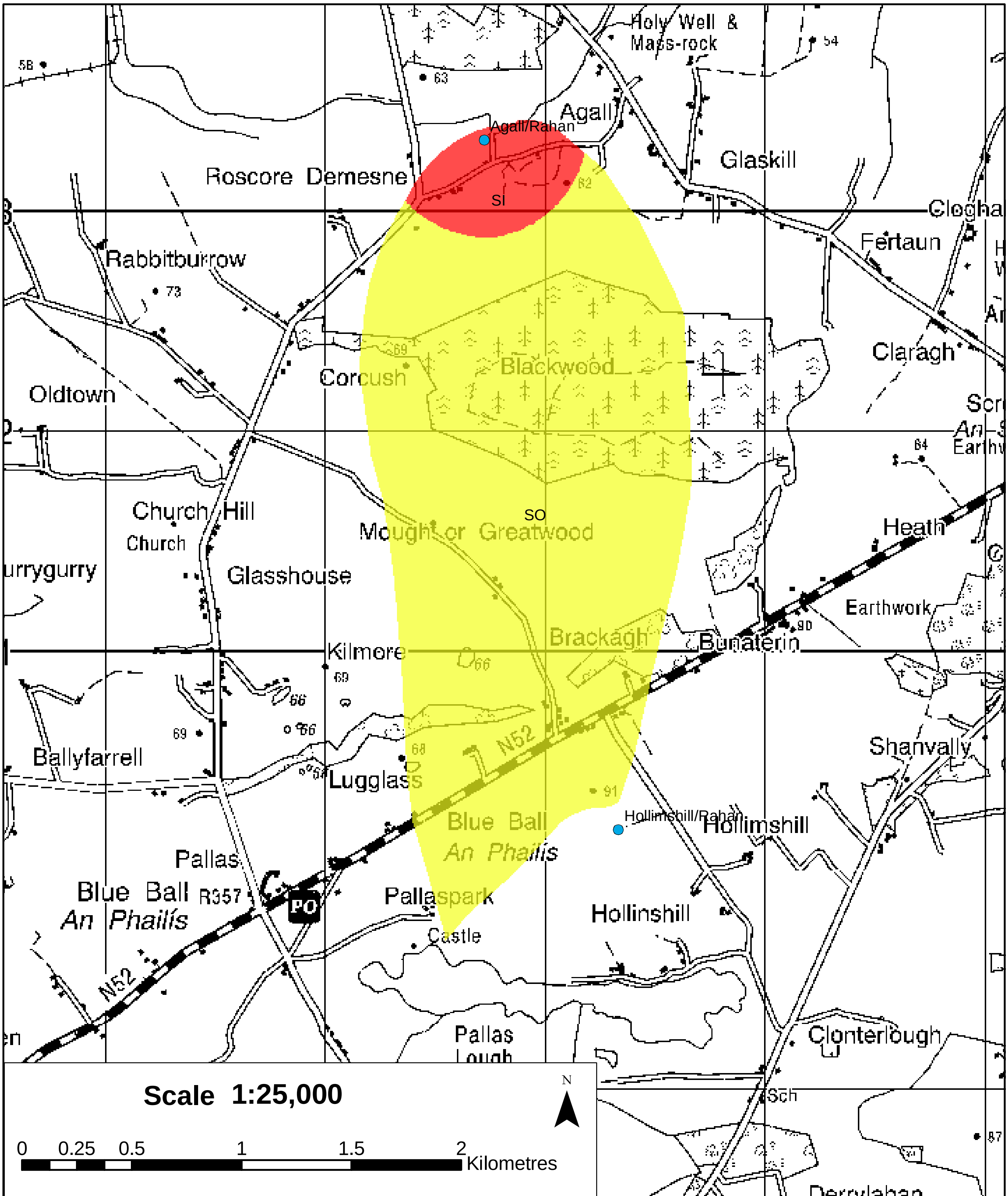
This Source Protection Area map is designed for general information and strategic planning usage. The boundaries are based on the available evidence and local details have been generalised to fit the map scale. Evaluation of specific sites and circumstances will normally require further and more detailed assessements and will frequently require site investigations to determine the risk to groundwater.

The map is intended for use in conjunction with groundwater protection responses for potentially polluting activities, which lists the degree of acceptability of these activities in each zone and describes the control measures necessary to prevent pollution.

Project Hydrogeologist: Coran Kelly
Project Manager: Donal Daly
Digital Map Production: Antonio Manna

ESTO FIDELIS

GSI



LEGEND

- SI Inner Protection Zone
- SO Outer Protection Zone
- Spring

Project Hydrogeologist: Coran Kelly
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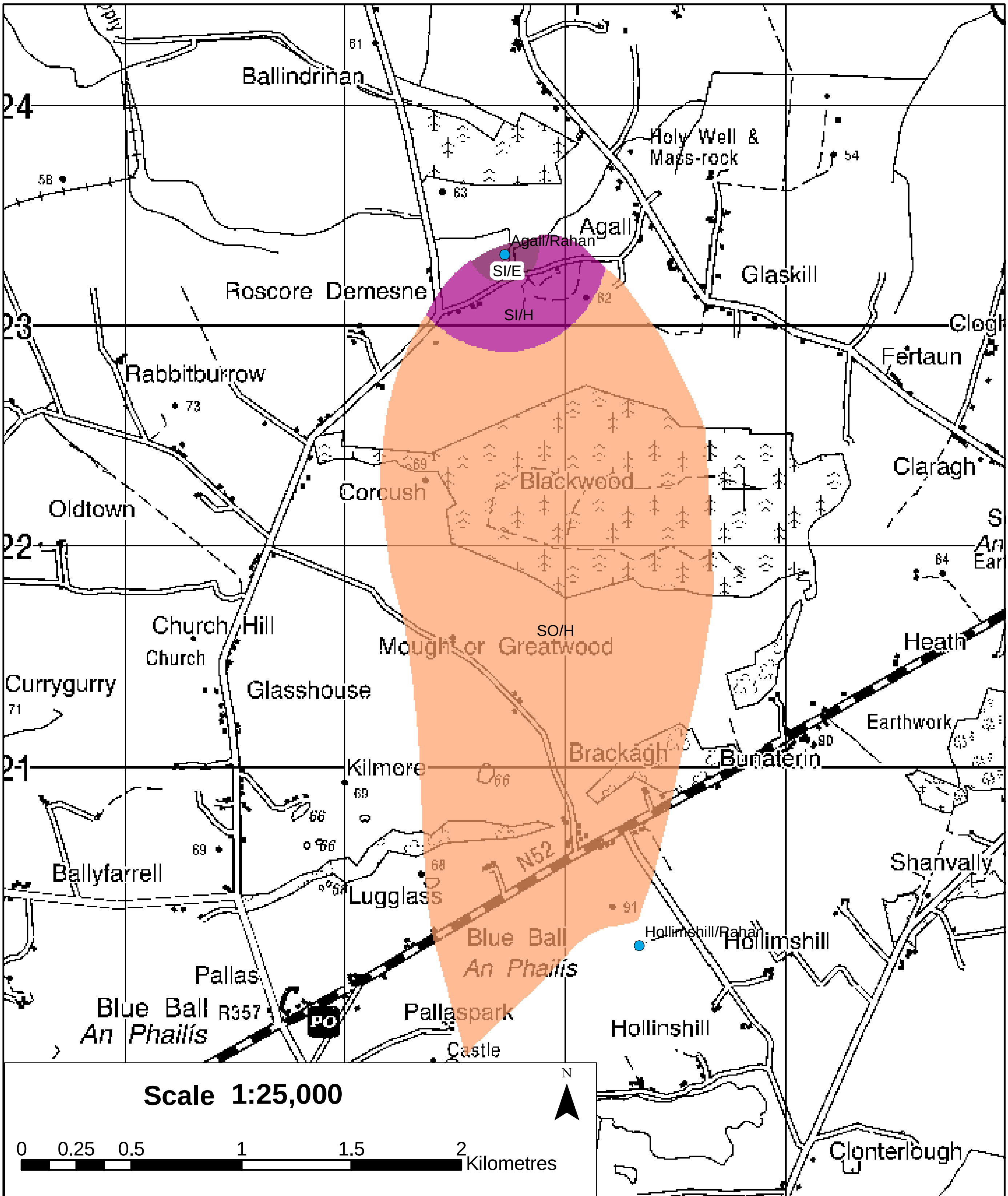
ESTO FIDELIS

GSI



SOURCE PROTECTION ZONES

VULNERABILITY RATING	SOURCE PROTECTION ZONES	
	Inner SI	Outer SI
Extreme (E)	SI/E	Not Present
High (H)	SI/H	SO/H
Moderate (M)	Not Present	Not Present
Low(L)	Not Present	Not Present

● Spring

This Source Protection Area map is designed for general information and strategic planning usage. The boundaries are based on the available evidence and local details have been generalised to fit the map scale. Evaluation of specific sites and circumstances will normally require further and more detailed assessements and will frequently require site investigations to determine the risk to groundwater.

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ESTO FIDELIS