Kyle & Orchard Springs

(Stradbally, Ballylynan & Timahoe Public Water Supplies)

Groundwater Source Protection Zones

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In collaboration with:

Laois County Council

November 2000

‘Note:

Since this report was published, the Orchard abstraction point is not longer in use. The Source Protection Area and, possibly, other component maps have been updated based on improved geoscientific evidence and hydrogeological knowledge. The most up-to-date version of the Source Protection Areas (SPAs) and other maps can be found on the Geological Survey Ireland website (https://www.gsi.ie/en-ie/data-and-maps/Pages/default.aspx).'

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1 Introduction

The objectives of this report are:

- To delineate source protection zones for the Kyle and Orchard Water Supplies.
- To outline the principal hydrogeological characteristics of the area.
- To assist Laois County Council in protecting the water supplies from contamination.

2 Location and Site Description

Kyle Spring (marked as “Toberading” on the O.S. 6” sheet) lies approximately 4 km south-southwest of the town of Stradbally, and 2.5 km northeast of Timahoe village. Orchard Spring lies about 2 km south-southeast of Kyle Spring. Kyle Spring supplies Stradbally and Ballylynan, while Orchard Spring supplies Timahoe, and the two sources are not linked. However, the catchments for the two springs appear to overlap, and therefore this report considers the two jointly.

The Kyle WS is treated by chlorination. The water is pumped to the Gallows Hill Reservoir (Ballycoolan), from where it is piped to Stradbally Reservoir (Carricksallagh, for Stradbally Town); to Ballyadams Reservoir (thence to Ballylynan, Ballyadams, Mill Cross and Pedigree Corner); to Luggacurren and to Rathaneska GWS.

Orchard Spring WS is also treated by chlorination. It is pumped to Timahoe Reservoir, thence to Timahoe, Cremorgan, and Garryglass.

3 Source details

3.1 Kyle

GSI number	23/19SE W146
Grid ref. (1:25,000)	25545 19223
Townland	Kyle
Owner	Laois County Council
Well type	Spring
Elevation (top of casing)	96 m (315 ft) approx.
Depth-to-rock	unknown
Static water level	Surface
Drawdown (wet weather)	1” on v-notch
Current Abstraction	1,591 m^3/d (?1337) pumping rate 91 m^3/h = 2182 m^3/d

3.2 Orchard

GSI number	2319SE W
Grid ref. (1:25,000)	
Townland	Orchard Lower
Owner	Laois County Council
Well type	Spring
Elevation (top of casing)	110 m (370 ft) approx.
Depth-to-rock	unknown
Static water level	Surface
Current Abstraction	214 m^3/d (47,000 gpd) (?44,700) at 91 m^3/h (20,000 gph)

4 Methodology

Desk study

Bedrock geology information was compiled from the GSI report and 1:100,000 scale map of Sheet 16 (Kildare-Wicklow, McConnell 1994). Lithological boundaries were defined using both this map and the 6 inches to the mile scale (1:10,560) bedrock maps. Details of the springs, such as current abstraction rate, were obtained from Laois County Council.

Site visits and fieldwork

Site visits and fieldwork in the area included a walkover survey in order to further investigate the subsoil and bedrock geology, hydrogeology, vulnerability to contamination and any obvious hazards in the following townlands: Kyle, Orchard Lower, Orchard Upper, Clashboy and Fossy Upper. Aoibheann Kilfeather mapped the subsoil types and assessed depth to bedrock throughout the area. Water samples for analysis by the State Laboratory and Health Board were taken in November 1997 and June 1999.

Data analysis

Analytical equations and hydrogeological mapping were utilised to delineate protection zones around the source.

5 Topography and Surface Hydrology

The northern part of the topographic catchment lies between 90 and 120 metres (300-400 ft) above sea level on very level or gently undulating land. Towards the south the topography slopes steeply upwards to Fossy Mountain which reaches over 300 m (1,000 ft). and forms part of the northern scarp of the Castlecomer Plateau.

Low esker ridges (sand & gravel) form the higher ground. One such runs north-south along the Timahoe-Stradbally road, just west of Kyle Spring. Another runs east-west just to the north of Orchard Spring, pursuing a sinuous course until it reaches the Timahoe River, where it turns northwards.

Kyle Spring lies in an extensive alluvial flat, which is drained by two main canalised streams: the Crooked River drains the eastern side of the flat, and the Timahoe/Bauteogue River drains the western side (west of the Timahoe-Stradbally road). The spring itself discharges into an unnamed stream which runs parallel to the Crooked River and then joins it about 1km north of the spring. North of Timogue Bridge, Crooked River becomes the Timogue River. Just south of Stradbally, the Bauteogue and Timogue join to become the Stradbally River.

The area lies at the headwaters of the Barrow River. The catchment boundary of the Timahoe/ Bauteogue river is also the catchment divide between the Barrow and Nore rivers.

The area is underlain by a variety of soils (Conry, 1987). The alluvial flat is underlain by alluvial soil, much of which is characterised by a high water table. The land above and alongside the Timahoe Esker has very well-drained soils of the Baggotstown-Carlow Complex. The glacial tills at the foot of the Castlecomer Plateau have given rise to well-drained soils of the Stradbally and Knockbeg series. Some fairly small areas of poorly-drained Mylerstown Series gley soils are found at the bottom of the esker. The slopes of the Castlecomer Plateau are covered with till-derived soils of the Raheenduff and Abbeyfeale series, which are poorly drained and thus should produce high runoff.

6 Geology

6.1 Bedrock geology

The bedrock geology of the catchment area (Map 1) comprises both Upper and Lower Carboniferous strata. These are summarised below (from McConnell, 1994).

Age	Formation
Upper Carboniferous	Bregaun Flagstone Formation Killeshin Siltstone Formation Luggacurren Shale Formation
Lower Carboniferous	Clogrenan Limestone Formation Ballyadams Limestone Formation

6.1.1 Ballyadams Formation

This formation consists mainly of pale grey shelf limestones. The upper part of the formation tends to be cyclic, dark, rather argillaceous thin bedded limestones passing up into massive pale grey limestones which are capped by small scale karstic features (McConnell, 1994). The Ballyadams Limestone underlies the most northerly part of the catchment of Kyle Spring.

6.1.2 Clogrenan Formation

This formation consists of shelf limestones with abundant chert in bands and nodules in varying concentrations vertically. Fossils occur, concentrated in horizons where they are locally abundant. The Clogrenan Formation is also karstified and occupies the central part of the catchment i.e. south of the Ballyadams Formation and north of the Upper Carboniferous strata.

6.1.3 Luggacurren Shale Formation

This formation is characterised by black to dark grey shales and mudstones. Thin argillaceous cherts and limestones are found in the lower and middle parts of the formation respectively (McConnell, 1994). The absence of sand and silt grade lithologies is distinctive. Bivalve and goniatite fossils occur at many levels. This formation occurs as a thin band between the limestones and the Killeshin Siltstone Formation, and marks the relatively flat lying area before the topography rises steeply to the Castlecomer Plateau in the south.

6.1.4 Killeshin Siltstone Formation

The formation is composed mainly of grey argillaceous siltstones or silty mudstones, with lesser amounts of sandstone and shale. The siltstones are poorly bedded with an irregular conchoidal fracture. Black shales occur infrequently and may contain marine fossils (goniatites and bivalves). The Killeshin Formation underlies the slopes of Fossy Mountain and the Castlecomer Plateau to the south.

6.1.5 Bregaun Flagstone Formation

This formation, which outcrops around the top of Fossy Mountain, consists of thick grey flaggy bedded sandstones and siltstones with subordinate amounts of silty, grey and often micaceous shales.

6.2 Geological Structure

The area lies at the northern end of the Castlecomer Plateau, an elevated syncline (v-shaped fold). The bedrock succession dips southwards at moderate angles.

6.3 Subsoil geology

The subsoils of the area consist of esker sands and gravels, limestone sands and gravels, tills and alluvium as shown in Map 2. Rock is close to the surface for a large part of the catchment, particularly in the southern half.

6.3.1 Esker Sands and Gravels

The Timahoe esker is a prominent feature in the area, traversing a sinuous course from east to west. Much of the deposit has been removed by gravel working. The deposits consist of clean, well sorted sands and gravels showing layering, channel features and imbrication. Layers of very fine sand were noted at one locality.

6.3.2 Limestone Sands and Gravels

These are clean sediments, with no evidence of sorting or imbrication. Clast size varies from 350 mm to fine sand.

6.3.3 Namurian Subsoils

Towards the southern/higher part of the catchment there are extremely weathered shaly subsoils. Shaly fragments are very friable and black in colour with some iron staining. These are assumed to be derived from the underlying Namurian bedrock.

6.4 Depth-to-rock

The depth-to-bedrock map (Map 3) is based on mapping by Aoibheann Kilfeather. Accurate information on depth to bedrock is based on outcrop information, well records, subsoil sections and drilling. The depth to rock is expressed in Map 3 by the use of 1m, 3m, and 10m contours and all three are present in the catchment area. The boundaries were based upon spot depths, many of which were ‘greater than or equal to’ values and which are very scattered in some areas. Therefore the boundaries should not be taken as precisely located. Over much of the upland mountainous areas depth to bedrock is generally less than 1 m. The depth-to-bedrock in the vicinity of Kyle Spring appears to be between 3 and 10m.

7 Hydrogeology

7.1 Data availability

Data were gained from a number of sources:

- Quaternary mapping carried out by Aoibheann Kilfeather, Quaternary Section, GSI.
- County Council records of spring discharge at Kyle Spring, taken as water levels in inches measured at a V-notch weir, and general information from the caretaker, Mr. Frank Riordan.
- Papers by D. Daly et al, 1980, and Misstear et al, 1980, on the hydrogeology of the Castlecomer Plateau.

7.2 Rainfall, Evaporation and Recharge

The rainfall pattern over the area is complicated by varied topography - part of the catchment lies on the scarp of the Castlecomer Plateau which lies to the south. An estimated 80% of the catchment is relatively low lying i.e below the 150 m (500ft) contour. This part of the catchment is assumed to have similar annual rainfall to the weather station at Stradbally Garda station i.e. 807mm per year. This leaves 20% of the catchment with a higher annual rainfall, taken as that of Coan in County Kilkenny (grid reference S596706), on the Castlecomer Plateau, which has an annual rainfall of 1063mm (Fitzgerald and Forrestal, 1996). Therefore a composite figure is used as follows:

$$(80 \times 807) + (20 \times 1{,}063) / 100 = 858 \text{ mm}$$

Since measured rainfall underestimates actual rainfall, the rainfall figure is increased by 5%:

$$858 \times 1.05 = 900\text{mm per year}$$

Potential evapotranspiration (PE) is estimated at 448 mm/yr from a site in Co. Kilkenny on the Castlecomer Plateau in the Nore River basin (E.P. Daly). Actual evapotranspiration (AE) is then estimated as 95 % of PE, i.e. 425 mm/yr. Recharge is estimated as 60% of potential recharge.

Runoff should be relatively low due to the predominance of sands and gravels in the area, but there is some surface drainage in the area, much of which is artificial drainage, signifying that recharge is impeded, probably by the high water table. Runoff from the slopes of Fossy Mountain will be high, but much of this runoff evidently sinks into the gravels at the foot of the scarp.

These calculations are summarised below:

Average annual rainfall	900 mm
Estimated P.E.	448 mm
Estimated A.E. (95 % P.E.)	425 mm
Potential Recharge	475 mm
Estimated Surface Runoff (30%)	145 mm
Recharge	330 mm

The recharge to Orchard Spring is likely to be slightly higher because of the greater proportion represented by the plateau scarp. An approximate figure of 350 mm/year is taken.

7.3 Spring discharge

7.3.1 Kyle

A report (Wright et al 1982*)* gave a discharge figure of 42 lps or 3,628m^3 per day (low flow) for Kyle Spring. No mean or high flows were given. For springs with sparse flow data, a general 'rule of thumb' can be used that mean flow approximates to three times the low flow. In the case of the Kyle Spring this rule is questionable. The caretaker's opinion is that there is less summer-winter fluctuation at Kyle than at nearby Orchard Spring.

County Council data suggest that 3,628m^3/day is a fairly good estimate of low flow discharge. From the available data set (January 1997 to December 1998, n = 29) the average (mean) discharge is approximately 5,000 m^3/day, minimum discharge is 3,112 m^3/day and the maximum discharge is 6739 m^3/day. The County Council data set was somewhat modified to account for readings which were taken when the spring was being pumped.

The available flow discharge measurements are concentrated in the first six months of the year, which probably skews the data, i.e. the mean flow is likely to be lower than the available data would suggest, say, 4,500 m^3/d.

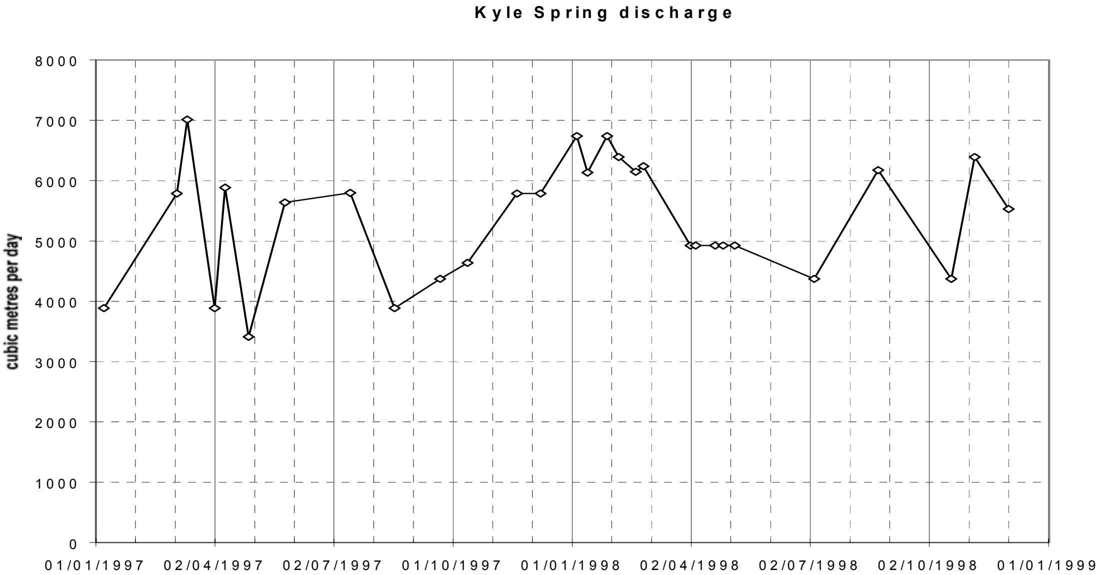

Figure 7.1: Discharge measurements at Kyle Spring (County Council data).

7.3.1 Orchard Spring

No discharge data are available for Orchard Spring. The normal daily abstraction is 200 m^3, equal to 73,000 m^3/yr. The annual mean flow is clearly several times greater than this. In the absence of better data, an annual mean flow of 300,000 m^3/yr is taken, i.e. approximately four times the normal daily abstraction.

7.4 Catchment delineation

An estimation of the catchment area for the mean discharge is given by the water balance equation as follows:

$$\frac{\text{Discharge, in m}^3\text{/year}}{\text{Recharge, in m/year}} = \text{Catchment area, in m}^2$$

The County Council data are used as the best available measure of long term mean discharge from Kyle Spring:

$$1{,}643{,}000 \text{ m}^3\text{/year} / 0.330 \text{ m/year} \quad = \quad 4{,}979{,}000 \text{ m}^2 \text{ i.e. } 4.98 \text{ km}^2$$

This area is significantly greater than the obvious topographic catchment for the spring. It is therefore necessary to assume that the true catchment extends further west, including some part of the catchment of the Timahoe River.

The catchment of Orchard Spring is estimated as follows:

$$300{,}000 \text{ m}^3\text{/year} / 0.350 \text{ m/year} \quad = \quad 857{,}000 \text{ m}^2 \text{ i.e. } 0.86 \text{ km}^2$$

7.5 Hydrochemistry and water quality

7.5.1 Kyle Spring

In December 1997 the hardness of the water was 318.4 mg/l $CaCO_3$. According to the classification used by GSI this would place Kyle spring water into the 'hard' category (251-350 mg/l $CaCO_3$). The conductivity on 19/12/97, 09/07/99 and 27/08/99 was 507, 565 and 595 μS/cm respectively. These values are typical of a limestone aquifer, suggesting relatively long residence times.

Nitrate levels on the first two occasions were 23.8mg/l and 19.6mg/l respectively, compared with the EU MAC of 50mg/l NO_3 and guideline of 25mg/l. These concentrations represent elevated nitrate levels, the potential sources of which are discussed in section 10. The two chloride levels given are 17mg/l and 16mg/l respectively, which are normal.

Concentrations of the major cations - sodium, potassium, calcium and magnesium - do not approach the EU MAC.

Bacteriological analyses of the raw water samples on two occasions (08/06/99 and in 1997) show the presence of both total and faecal coliforms on both sampling occasions.

According to the limited chemical analyses water quality at the Orchard Spring is very similar to that of Kyle. On two out of three available sets of analyses iron levels at Kyle Spring were not detectable whereas they were at a level of .005mg/l at Orchard Spring. The calcium and magnesium concentrations at Kyle tend to be slightly higher at Kyle than at Orchard whereas the nitrate concentration at Kyle tends to be higher than at Orchard.

7.6 Conceptual model

7.6.1 Kyle spring

Kyle spring apparently issues from the Ballyadams Limestone Formation. Since this formation is generally karstified, Kyle spring could be classed as a karst spring. However, the spring has a relatively consistent flow rate and hydrochemistry, which is more characteristic of a gravel spring than of a karst spring. Since the spring emerges from an alluvial gravel area, it is concluded that the groundwater flows out of the limestone, then through the gravel for some distance before emerging at the spring.

The streams which cross the alluvial flat flow in artificial channels of considerable age. Therefore these streams are not in hydraulic connection with the gravel/limestone aquifer in this area. Hence it can be envisaged that groundwater from the south and west may flow beneath the Timahoe/Bauteogue River en route to Kyle Spring.

The Ballyadams and Clogrenan formations are karstified limestones and form an extensive aquifer in the region. Permeability in these rocks is extremely variable and dolomitisation occurs in places. The aquifer properties are likely to be variable and highly anisotropic. The three available electrical conductivity measurements suggest generally diffuse recharge and relatively long residence times in the aquifer. This suggests that the Kyle Spring catchment would fall into the slightly-karstified category of Shuster and White (1971). This is supported by the caretaker's comment that the water level behind the weir, although fluctuating, reacts quite slowly to rainfall events and seasonal variations. It therefore does not exhibit the flashy flow regime expected of a highly karstified limestone spring. The absence of further karst features in the catchment is also supportive. The influence of point recharge may be buffered by the effects of flow through the gravels.

The area of the groundwater catchment calculated from the estimated long term mean discharge is 5.76 km^2 (section 6.4). The topographic catchment is approximately 5.5 km^2. As the source is a spring and is not being pumped excessively (i.e. there is a constant overflow at the weir) it appears that the system is not being stressed. Groundwater will therefore still move in the direction of the regional groundwater flow. If the groundwater catchment closely reflects the surface water catchment then flow would be expected to be largely northwards.

The Namurian formations have a relatively low permeability and are considered to be poor aquifers. Soil and subsoil permeabilities are also low. Groundwater movement is slow and localised, flowing towards the nearest surface water channel, and most potential recharge runs off. The hydrochemical analyses do not show elevated iron concentrations in the spring which often indicate recharge from the Namurian, perhaps through point recharge in karstified limestones. This could reflect the fact that runoff from the Namurian siltstones is not reaching the aquifer rapidly i.e. recharge is largely diffuse. However it is assumed that the entire area of the Killeshin Formation within the catchment could eventually contribute water to the spring.

7.6.2 Orchard Spring

Orchard Spring emerges from the Clogrenan Limestone, or from the gravels overlying the limestone. The Namurian rocks to the south form a hilly region sloping upwards to the Castlecomer Plateau. The top of the Plateau is drained southwards by the River Dinin which later joins the Nore River.

There are two main hydrogeological units in the Kyle/Orchard catchment:

(a) the Namurian rocks in the south of the catchment, i.e. the plateau scarp

(b) the Clogrenan Limestone aquifer overlain by gravels

Orchard Spring is said to react more quickly to rainfall events than Kyle Spring, probably because it is closer to the scarp of the Castlecomer Plateau. Orchard Spring's zone of contribution (ZOC) probably has a greater component of point recharge than Kyle, from surface runoff from the Namurian rocks.

8 Delineation of Source Protection Areas

8.1 Introduction

Two source protection areas are delineated for each spring:

- Inner Protection Area (SI), designed to give protection from microbial pollution;
- Outer Protection Area (SO), encompassing the remainder of the zone of contribution (ZOC) to the springs (see Map 6).

8.2 Outer Protection Area

The Outer Protection Area is delineated such that all groundwater within it may eventually reach the source and it is designed to protect the source from chemical contamination. The Outer Protection Area comprises that part of the ZOC outside the 100 day time of travel (TOT) zone. The Outer Protection Area for both springs extends to the groundwater divide of Fossy Mountain to the south. The eastern and western boundaries of the catchments are based on surface water catchments.

The Zones of Contribution (ZOCs) delineated on the map are as follows:

Kyle:	4.75 km^2
Orchard:	1.2 km^2

These catchment areas correlate reasonably well with the catchment areas calculated in Section 6.4, i.e. 4.98 km^2 and 0.86 km^2 respectively. The less precise correlation for Orchard Spring reflects the fact the absence of reliable data for the spring discharge.

8.3 Inner Protection Area

The Inner Protection Area (SI) is the area defined by a 100 day time of travel (TOT) to the source and it is delineated to protect against the effects of potentially contaminating activities which may have an immediate influence on water quality at the source, in particular microbial contamination. Due to their lithological characteristics (i.e. belonging to a karstified limestone formation) it is assumed that groundwater within all of the limestones of the catchment can reach the source within 100 days. The northern boundary is very well constrained. Being a spring source which has a consistent overflow (at the current pumping rate), pumping will not cause groundwater to move against the regional groundwater flow direction. Therefore the spring marks the most northerly point in the catchment.

Five pumping tests were conducted on different public supply sources occuring in the Ballyadams and Clogrenan Formations in County Laois. These tests demonstrated permeabilities ranging from 12.7 to 25 m/day. Assuming a potential flow path of 2,000 m (2 km) within these limestones, such permeabilities would give rise to travel times of somewhere between 157 and 80 days respectively. Because of the similarities between the lithologies these examples are considered comparable to that of Kyle. Therefore they are considered to be comparable to a 100 day travel time. The Inner Protection Area therefore consists of that part of the ZOC underlain by limestone bedrock.

9 Groundwater Vulnerability

Much of the ZOCs is underlain by limestone sand and gravel deposits. Although the texture of these deposits is variable, field assessment indicates a high permeability.

The permeability of the Namurian subsoils in the southern part of the catchment is inferred from samples taken for grain size analysis in the townlands of Ballintlea Lower and Fallowbeg Upper. They are given a permeability category of ‘probably low’. These subsoils are bisected by the 3m depth-to-bedrock contour. To the northeast of the 3m contour there is a zone of greater than 3m thickness (but probably less than 5 m) and these are assigned a ‘high’ vulnerability value. To the southwest of this line there is an area of less than 3m and this area is assigned a vulnerability category of ‘extreme’.

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 (see the matrix in the table below). 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. Since the bedrock boundary which divides the limestones from the Namurian bedrock also separates the Inner Protection Area (SI) from the Outer Protection Area (SO), there are just four resulting groundwater protection zones around the two sources (Map X).

Matrix of Source Protection Zones

VULNERABILITY RATING	SOURCE PROTECTION AREA	
	Inner	*Outer*
Extreme (E)	SI/E	SO/E
High (H)	SI/H	SO/H
Moderate (M)	*not present*	*not present*
Low (L)	*not present*	*not present*

11 Land Use and Potential Pollution Sources

Agriculture is the principal activity in the area. The land in the vicinity of the sources is largely grassland-dominated and is primarily used for grazing. The hydrochemical analyses have two notable features: elevated nitrate levels and the presence of total and faecal coliform bacteria. However, the low K:Na ratios suggest that contamination from plant organic matter such as slurry is unlikely.

The main potential sources of pollution within the ZOCs are farmyards, septic tank systems and landspreading of organic fertilisers.

Kyle spring is completely open and inadequate spring head protection leaves it very vulnerable to contamination. Protection for Orchard Spring is better.

12 Conclusions and Recommendations

- Kyle spring is a high yielding spring issuing from a regionally important karstified limestone aquifer, overlain by a locally important gravel aquifer.
- Orchard Spring is a medium-yield spring also issuing from a regionally important karstified limestone aquifer overlain by a locally important gravel aquifer.
- The ZOC to both springs is ‘highly’ to ‘extremely’ vulnerable to contamination.
- The Castlecomer Plateau, due to its elevation, influences the rainfall and recharge to the catchment.

It is recommended that:

- Improved spring head protection should become a priority, especially at Kyle Spring.
- Full water quality analyses should be carried out on a regular basis, to give a better picture of seasonal variations in water quality. Flood peak-related sampling would help to gauge the influence of increased recharge and indicate whether or not point recharge occurs at these times.
- Since the western boundary of the ZOC to Kyle Spring is based on topographic evidence and assumed groundwater flow direction, and the local area is very flat lying, additional water level measurements, and possibly a tracing test, should be undertaken at this boundary, or just beyond it, to help to refine the boundary.
- Particular care should be taken when assessing the location of any activities or developments which might cause contamination at the springs.

The protection zones delineated in the report are based on our current understanding of groundwater conditions and on the available data. Additional data obtained in the future may indicate that amendments to the boundaries are necessary.

13 References / Further Reading

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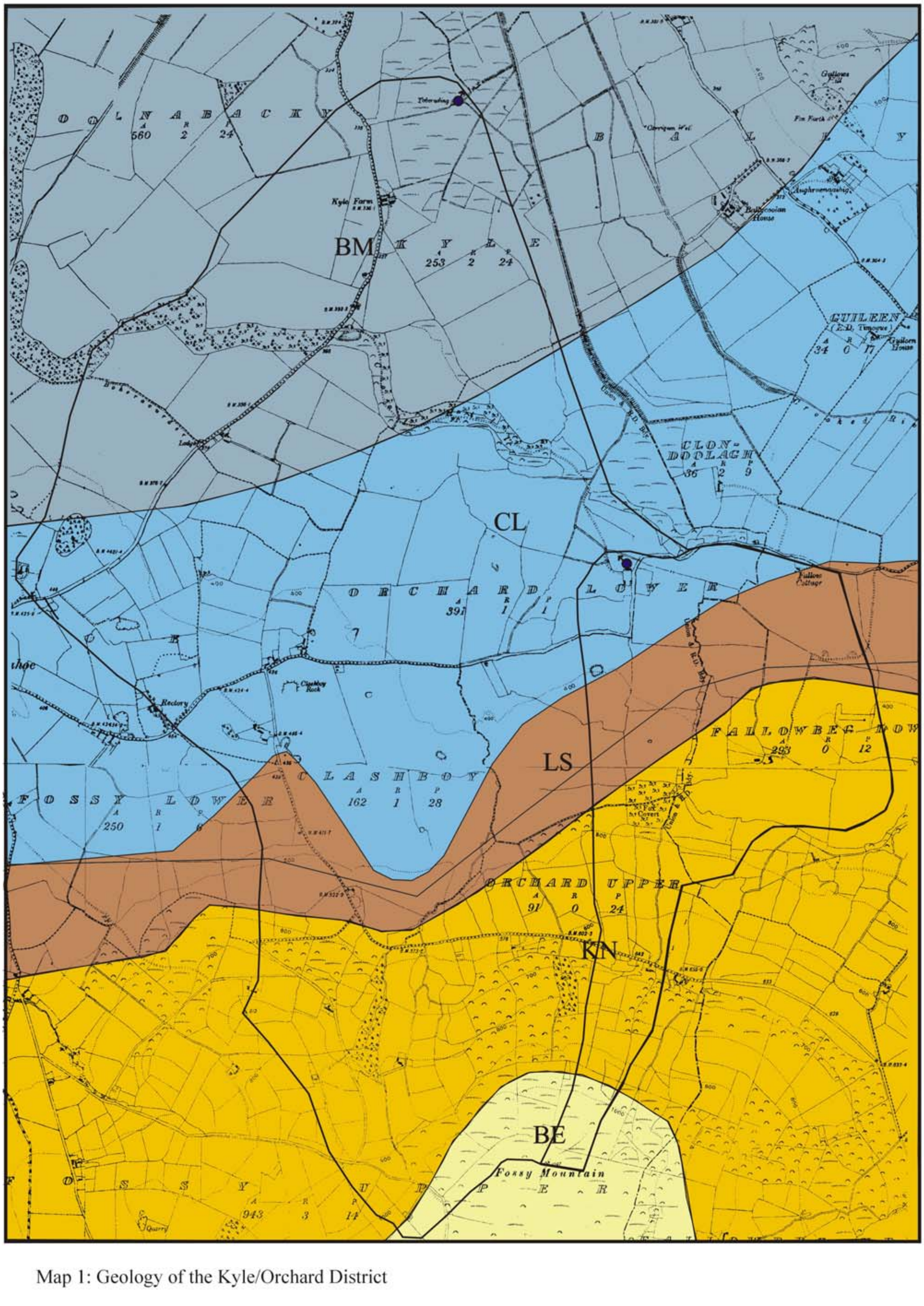


Map 1: Geology of the Kyle/Orchard District

Legend

BE	Bregaun Flagstone Formation
KN	Killeshin Siltstone Formation
LS	Luggacurren Formation
CL	Clogrenan Formation
BM	Ballyadams Formation

Geological Boundary

Unconformity

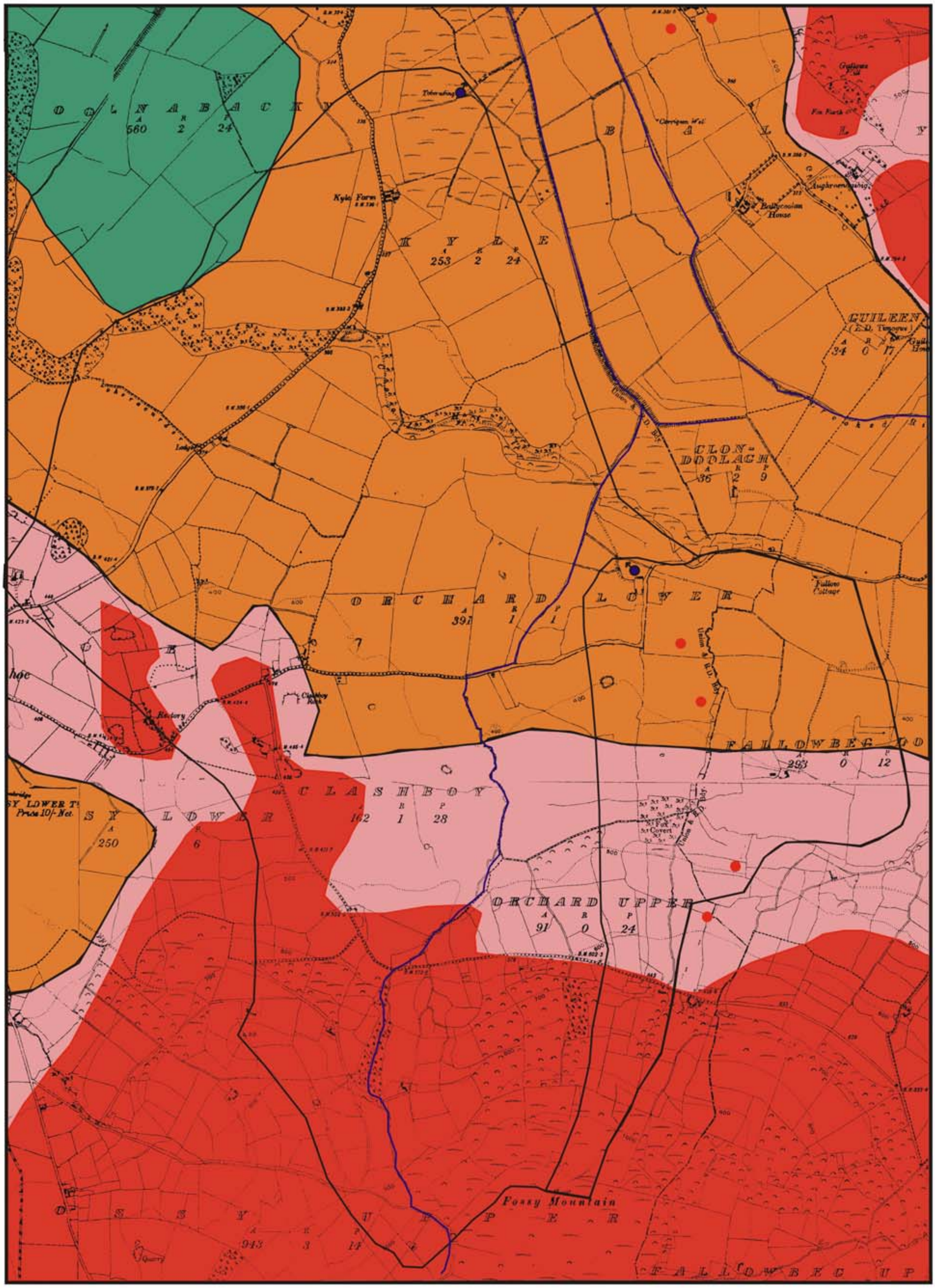
● Spring

Zone of Contribution

N

Scale (metres)

0 500



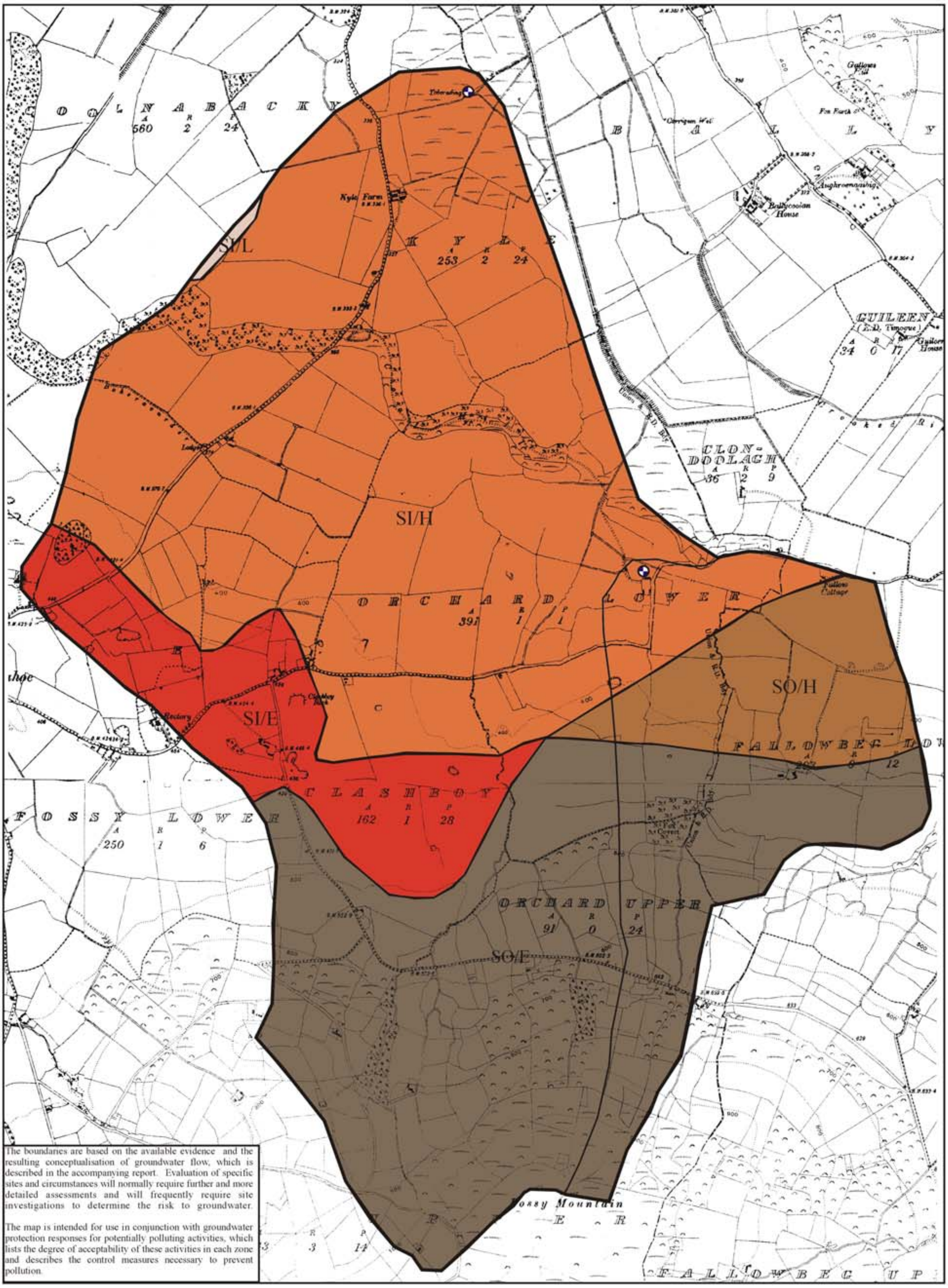
Map 2: Vulnerability classification of the Kyle/Orchard District

Legend

- 🟥 Extreme Vulnerability (E)
- 🟥 Outcrop/Rock Close/Karst (E)
- 🟧 High Vulnerability (H)
- 🟩 Low Vulnerability (L)
- ● Spring
- Zone of Contribution
- Streams and Rivers

N

Scale (metres)
0 500



The boundaries are based on the available evidence and the resulting conceptualisation of groundwater flow, which is described in the accompanying report. Evaluation of specific sites and circumstances will normally require further and more detailed assessments 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.

Map 3: Groundwater Protection Zones for the Kyle/Orchard District

Legend

SI/E	Inner Zone-Extreme	SO/E	Outer Zone- Extreme	╲	Catchment Area
SI/H	Inner Zone-High	SO/H	Outer Zone-High	●	Public Supply Well
SI/L	Inner Zone-Low				

N

Scale (metres)

0 500