

Edenderry Water Supply Scheme

Kishawanny Bridge Borehole

Groundwater Source Protection Zones

February 2004

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1 Introduction

The objectives of the report are as follows:

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

The protection zones are delineated to help prioritise certain areas around the source in terms of pollution risk to the borehole. This prioritisation is intended to provide a guide in the planning and regulation of development and human activities. The implications of these protection zones are further outlined in 'Groundwater Protection Schemes' (DELG/EPA/GSI, 1999).

The report forms part of the groundwater protection scheme for the county (Daly, *et al*, 1998). The maps produced for the scheme are based largely on the readily information in the area and mapping techniques which use inferences and judgements based on experience at other sites. As such, the maps cannot claim to be definitively accurate across the whole area covered, and should not be used as the sole basis for site-specific decisions, which will usually require the collection of additional site-specific data.

2 Location and Site Description

The current borehole (GSI well number: 2623SWW004) is located on the eastern outskirts of Edenderry, beside the Edenderry – Dublin road (R402), as shown in Figure 1. The border (River Boyne) with County Kildare is 40 m east of the borehole.

Water was originally abstracted from the River Boyne, then in the 1970s, a groundwater source was sought. In 1979, Flood Water Well Drillers were contracted to drill two deep boreholes (GSI well numbers: 2623SWW002, 2623SWW003). Neither were successful, and it was 1986 before the current pumping well (GSI well number: 2623SWW004) was drilled. According to the caretaker, all the previous wells have been backfilled; largely due to “sand” in the boreholes, a problem that was encountered during drilling of the wells.

A trial borehole was drilled at the site of the water tower in Edenderry in 2003, with the view of possibly augmenting the supply.

3 Summary of Borehole Details

GSI No.	2623SWW002	2623SWW003	2623SWW004 (pumping well)
Grid reference	264450 233320	264500 233250	264567 233393
Townland	Edenderry	Edenderry	Edenderry
Owner	Offaly County Council	Offaly County Council	Offaly County Council
Well Type	Borehole	Borehole	Borehole
Well Name	BH1 (Floods')	BH2 (Floods')	Dunnes
Depth	55m	99m	60.5m
Elevation (ground level)	Approximately 70 m		
Static water level	Ground level 5/4/1979	-	5.8 m below ground level 18/2/1986
Pumping water level	-	-	Estimated 20-30 m
Depth to rock	Greater than 10m	Greater than 10m	29 m
Diameter	-	0.364	0.2m PVC: slotted 52-60.5m
Normal abstraction	Out of commission	Never operated	300-400 m ³ d ⁻¹ (see note)
Maximum abstracted	-	-	550 m ³ d ⁻¹ (Entec UK)
Yield	654 m ³ d ⁻¹	872 m ³ d ⁻¹	1083 m ³ d ⁻¹
Maximum Drawdown	19.4	-	37 m
Specific Capacity	33 m ³ d ⁻¹ m ⁻¹	-	29 m ³ d ⁻¹ m ⁻¹
Hours Pumping	-	-	20-24 hours a day
Date Drilled	1979	1979	18/2/1986

Note: recent abstraction increased to 550 m³d⁻¹, due to a drop in yield at Toberdaly.

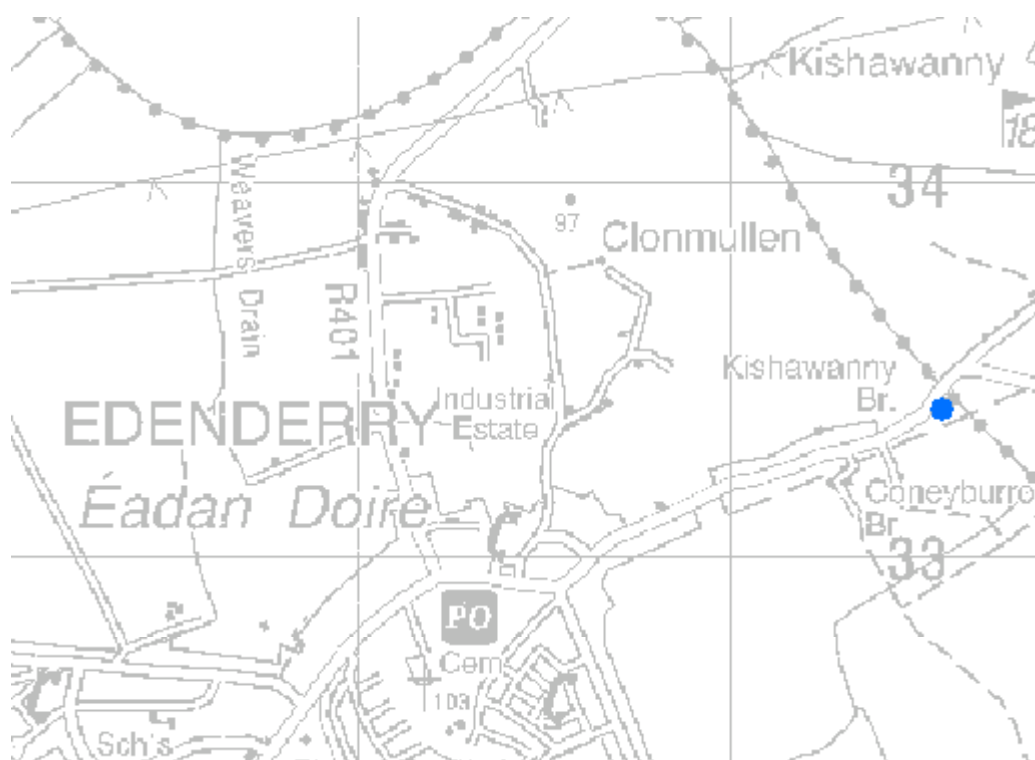


Figure 1 Location of Kishawanny Borehole

4 Methodology

Details about the boreholes such as depth, date commissioned and abstraction figures were obtained from County Council personnel; geological and hydrogeological information was provided by the GSI.

The data collection process included the following:

- Interview with the caretaker 29/1/03.
- Field mapping walkovers to further investigate the subsoil geology, the hydrogeology and vulnerability to contamination.
- 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

In the vicinity of the borehole, the topography is flat, approximately 70 m OD. To the west and northwest of Kishawanny Bridge, the land rises to 100 m OD at Edenderry and Clonmullen, forming two hills. To the east of Kishawanny Bridge, the topography is relatively flat and undulating, gently rising to 80 m OD at Kishawanny Lower.

The River Boyne is the main surface water feature in the area, occurring 40 m east of the borehole and flowing to the northwest, flowing around the hill at Clonmullen. To either side of the hills at Edenderry and Clonmullen, there are small streams flowing off the hillsides, which discharge to the Boyne. On the lower slopes of the hills and the low lying area around the borehole, there is a high density of artificial drainage. The Boyne river catchment is a subcatchment of the Eastern River Basin District.

The borehole is located approximately 25 m from the Edenderry – Dublin road (R402). Edenderry town occupies the area to the west of the borehole. There are industrial estates, petrol stations, farms

and houses located within one kilometre of the borehole. There is a small disused sand/gravel quarry approximately 300 m from the borehole beside the road to Edenderry. Immediately to the north, south and east of the source, the land is mainly agricultural, dominated by grassland.

6 Geology

6.1 Introduction

This section briefly describes the relevant characteristics of the geological materials that underlie the Edenderry source. It provides a framework for the assessment of groundwater flow and source protection zones that will follow in later sections. An extract of the geology map is given in Figure 2.

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

- Bedrock Geology 1:100,000 Map Series, Sheet 16, Kildare-Wicklow, Geological Survey of Ireland (Mc Connell, B. *et al*, 1995).
- Offaly Groundwater Protection Scheme (Daly *et al*, 1998).
- Information from geological mapping in the nineteenth century (on record at the GSI).
- Subsoil mapping by the GSI.

6.2 Bedrock Geology

- The pumping well is located in an area comprising limestone and volcanic rock.
- The available geological log for the pumping well indicates the bedrock comprises: 5 m of shale; 5 m of limestone; 23 m of volcanics. A geological log for a borehole located in Clonmullen, used as an industrial water supply, indicates that there are at least 30 m of volcanic rock present. No volcanic rock is present in the trial well drilled at the water tower site in Edenderry.
- The **Upper Impure Bedded Limestone** (“Calp Limestone”) consists of dark grey, fine grained limestones.
- The **Pure Bedded Limestone** (“Edenderry Limestone”) is a pale grey, poorly-bedded limestone, that is frequently dolomitised, making them often difficult to distinguish in cores (McConnell, 1995). The **Pure Unbedded Limestone** (“Waulsortian Limestone”) is a pale grey limestone.
- The volcanics are generally fine to coarse grained units, generally 30 m or greater in thickness, interbedded with limestones in sequences over 80 m in thickness. It is considered that the volcanic unit present at Kishawanny and Clonmullen is continuous between the two boreholes. The available geology map (see extract in Figure 2) does not indicate that the volcanics occur at Clonmullen, however, the available log indicates that it does.

6.3 Subsoil Geology

Sand/gravel, peat and till are the dominant subsoils in the area. The characteristics of each category are described briefly below:

- Peat occupies the low-lying areas. Three to four metres of peat are present at Kishawanny, as recorded in the available logs. The thickness and extent of the peat decreases east and west of the borehole, as indicated by subsoil exposures, which show the thickness to be generally less than one metre.
- Six to seven metres of sand/gravel is present at the site, beneath the peat. Sand/gravel is present at all exposures beneath the peat along the road to Edenderry. In the area of Coneyburrow, half way between Edenderry and the borehole there is a small disused sand/gravel quarry.
- Till is not exposed at the surface in the vicinity of the source. The log of the pumping well shows that seven metres of till underlies the sand/gravel, which is in turn underlain by ten metres of clayey gravel. It is exposed at the surface across the River Boyne in County Kildare. Auger holes drilled as part of the Kildare GWPS (Kelly, 2002) indicate that the till is variable in texture, but is generally classed as “**SILT**” (BS: 5930, 1999).

- The subsoil thickness varies from 0 m (outcrop) to greater than 20 m at the pumping well. Shallow rock and outcrop occur in the higher areas at Edenderry and Clonmullen. The deeper areas coincide with the low lying areas covered by peat. The subsoil thins toward the high ground at Edenderry and Clonmullen.

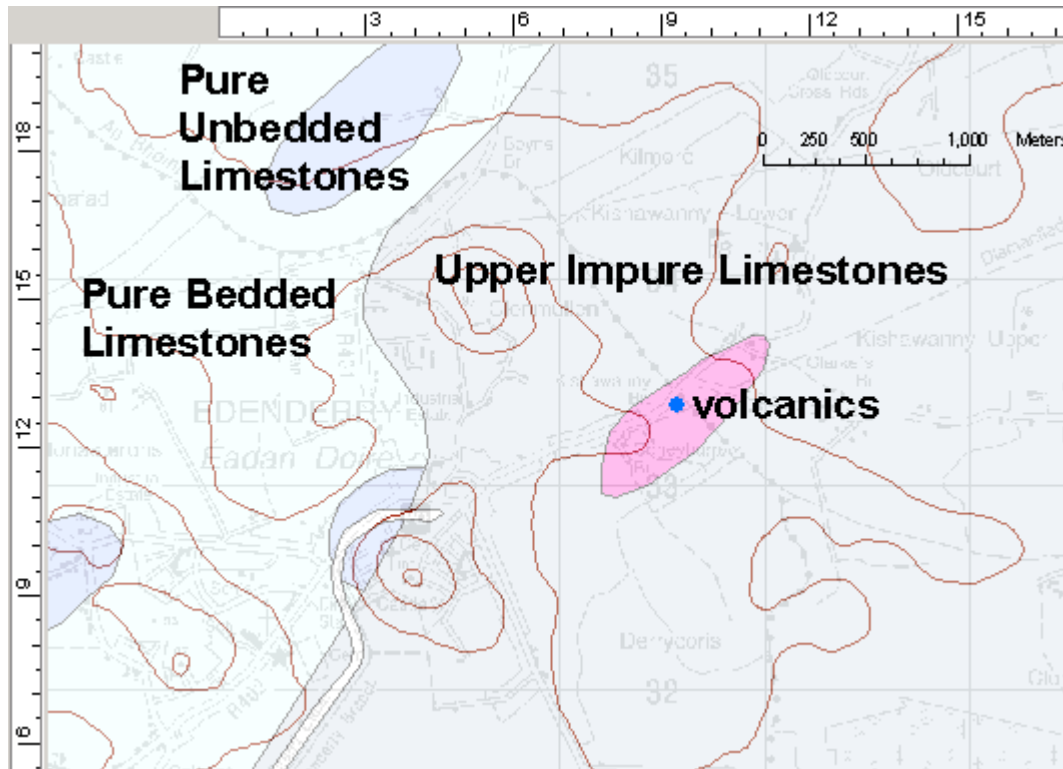


Figure 2 Geology around the Kishawanny Borehole

7 Groundwater Vulnerability

Groundwater vulnerability is dictated by the nature and thickness of the material overlying the uppermost groundwater ‘target’. Consequently, vulnerability relates to the thickness of the unsaturated zone in the gravel aquifer, and the permeability and thickness of the subsoil in areas where the gravel aquifer is absent. A detailed description of the vulnerability categories can be found in the Groundwater Protection Schemes document (DELG/EPA/GSI, 1999) and in the draft GSI Guidelines for Assessment and Mapping of Groundwater Vulnerability to Contamination. (Fitzsimons, 2003).

- The source of the groundwater is the bedrock, thus for the purposes of vulnerability mapping, the “**top of the rock**” is the target.
- The permeability of the sand/gravel is “**high**”, the permeability of the peat “**low**”, and the permeability of the till is “**moderate**”.
- Depth to bedrock varies from 29 m at the source to 0 m to the west and northwest of the source.
- The vulnerability to contamination varies from “**extreme**” to “**moderate**”, becoming increasingly more vulnerable away from the source. The vulnerability is shown in Figure 3.

Depth to rock is based on the available data cited here. However, it can vary over short distances. As such, the vulnerability mapping provided will not be able to anticipate all the natural variation that occurs in an area. The mapping is intended as a guide to land use planning and hazard surveys, and is not a substitute for site investigation for specific developments. Classifications may change as a result of investigations such as trial hole assessments for on-site domestic wastewater treatment systems. The

potential for discrepancies between large scale vulnerability mapping and site-specific data has been anticipated and addressed in the development of groundwater protection responses (site suitability guidelines) for specific hazards. More detail can be found in 'Groundwater Protection Schemes' (DELG/EPA/GSI, 1999).

8 Hydrogeology

This section presents our current understanding of groundwater flow in the area of the source.

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

- Offaly Groundwater Protection Scheme (Daly *et al*, 1998).
- GSI files and archival Offaly County Council data.
- Offaly County Council drinking water returns.
- County Council personnel.
- Hydrogeological mapping carried out by GSI.

8.1 Meteorology and Recharge

The term 'recharge' refers to the amount of water replenishing the groundwater flow system. 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 Edenderry, the main parameters involved in recharge rate estimation are: annual rainfall; annual evapotranspiration; and a recharge coefficient. The recharge is estimated as follows.

Annual rainfall: 850 mm

Rainfall data for gauging stations around Edenderry is given in the table below (from Fitzgerald, D., Forrester, F., 1996).

Gauging Stations	Grid reference	Elevation OD (m)	Approximate distance & direction from source	Annual precipitation 1961-1990
Edenderry (the tunnel)	N644313	81	2 km south	853 mm
Edenderry G.S.	N627325	85	2 km west	838 mm

The contoured data map for the Offaly Groundwater Protection Scheme (Daly *et al*, 1998) show that the borehole is located between the 850 mm and the 825 mm average annual rainfall isohyets.

Annual evapotranspiration losses: 450 mm

Potential evapotranspiration (P.E.) is estimated to be 475 mm yr.⁻¹ (based on data from Met Éireann). Actual evapotranspiration (A.E.) is then estimated as 95 % of P.E., to allow for seasonal soil moisture deficits.

Effective Rainfall: 400 mm

The effective rainfall is calculated by subtracting actual evapotranspiration from rainfall.

Recharge coefficient: 80%

Recharge is variable across the area: low in the peat covered, low-lying area in the vicinity of the borehole; whilst, to the northwest and west around the hill at Clonmullen, where there is outcrop and shallow bedrock, recharge is higher. Thus, a representative value for the recharge coefficient is estimated to be in the order of 80%.

These calculations are summarised as follows:

average annual rainfall (R)	850 mm
estimated P.E.	475 mm
estimated A.E. (95% of P.E.)	450 mm
effective rainfall	400 mm
recharge coefficient	80%
Recharge	320 mm

8.2 Groundwater Levels, Flow Directions and Gradients

The static water level for the current pumping well was 5.8 m below ground on 18/2/1986. The pumping wells' slotted screen interval is 52-60.5 m below ground, corresponding to where the volcanics are present, thus, the static water level represents the piezometric head of the groundwater in the volcanics. Attempts to measure the pumping water level were unsuccessful during the site visit by GSI staff (29/1/2003), but is estimated to be between 20 and 30 m below ground level.

There are approximately 30 m of subsoils overlying the bedrock, and there is a five metre thick shale bed overlying the volcanic rock unit, therefore, groundwater is confined in the immediate vicinity of the borehole and the well does not draw water from the river.

It is assumed that the hills at Edenderry and Clonmullen provide the driving force to groundwater on the western side of the River Boyne, and that groundwater is expected to mirror topography, therefore, groundwater flows radially outward from the high ground, ultimately discharging to the stream and river network. Similarly, on the eastern side of the River Boyne, groundwater is expected to flow from the east and discharge to the river.

The gradient along the river Boyne is estimated to be approximately 0.002, and the topographic gradient from Clonmullen to the Kishawanny borehole is approximately 0.03. The groundwater gradient is assumed to be less than the topographic gradient, and is likely to be steeper than the gradient in the river, and is estimated to be approximately 0.01. During pumping, the drawdown in the well creates a large gradient in the immediate vicinity, therefore groundwater will be drawn toward the well from all directions around the well, including beneath and east of the River Boyne.

8.3 Hydrochemistry and water quality

The following key points are identified from the data.

- The water is generally "hard" with an average total hardness of 296 mg l⁻¹ (equivalent CaCO₃) and electrical conductivity values of 328-593 µS cm⁻¹. The water is slightly softer than what would be normal for groundwater in Offaly, which reflects the influence of the volcanics on the hydrochemical signature. In addition, the pH is slightly higher, which may also reflect the influence of the volcanics.
- Nitrate levels are low (average 4 mg l⁻¹): however, in this instance, nitrate levels may not be good indicators of contamination, as there are probably reducing conditions, which chemically alter the nitrate levels, known as "denitrification", due to the confined nature of the groundwater feeding the borehole. Thus, the nitrate concentrations are not used as a contaminant indicator. They do however, provide further evidence of the confined setting at the borehole.
- Ammonia levels have never exceeded the EU MAC according to the available analyses.
- Chloride is a constituent of organic wastes and levels higher than 25 mg l⁻¹ may indicate significant contamination, with levels higher than the 30 mg l⁻¹ usually indicating significant contamination. Chloride data range from 12 to 22 mg l⁻¹ (average is 15 mg l⁻¹), suggesting that there is little or no contamination.
- There were no detections of *E. Coli* in 102 treated water samples. There does not appear to be any raw water samples available.

- Elevated potassium:sodium (K/Na) ratios indicate contamination from organic waste. The K/Na ratio (17 samples) exceeded the GSI threshold on one occasion (23/1/2001) with a reported value of 0.48, due to an elevated potassium level of 9.8 mg l^{-1} .
- Copper exceeded the EU MAC, on 2/7/2001. The reported level is 1.5 mg l^{-1} , though it may be an anomalous level as normal levels are approximately 0.04 mg l^{-1} , for the available samples (27).
- Manganese exceeded the EU MAC (0.05 mg l^{-1}) on eight occasions (18 samples). The average value is 0.06 mg l^{-1} . Manganese can occur from natural sources or may indicate contamination. In this instance, as the manganese regularly exceeds the EU MAC and the other contaminant indicators do not indicate significant contamination, the manganese is naturally occurring, due to the confined conditions at the source.
- In summary, there appears to be little impact from human activities on the water quality. This may be due to the confined nature of the groundwater at the borehole and the moderate vulnerability rating for the area around the source.

8.4 Aquifer Characteristics

The main aquifer providing groundwater to the pumping well is assumed to be the volcanics. The log for the well indicates that the volcanics are brown and weathered. The well has a reported yield of $1083 \text{ m}^3 \text{ d}^{-1}$ and a specific capacity of $27 \text{ m}^3 \text{ d}^{-1} \text{ m}^{-1}$. Estimated transmissivity for the pumping well from the specific capacity is approximately $30 \text{ m}^2 \text{ d}^{-1}$.

One of the original boreholes (2623SWW002 / BH1) was located beside the pumping well. The screened interval for this well corresponded with the volcanics. The yield was recorded at $654 \text{ m}^3 \text{ d}^{-1}$, specific capacity $33 \text{ m}^3 \text{ d}^{-1} \text{ m}^{-1}$. Transmissivity is calculated to be approximately $60 \text{ m}^2 \text{ d}^{-1}$ from available drawdown data.

The second of the original boreholes (2623SWW002 / BH2) has a reported yield of $872 \text{ m}^3 \text{ d}^{-1}$, but there are no other data available.

The borehole drilled into the volcanics at Clonmullen is used as an industrial water supply, and, is a relatively high yielding well, that is reported to abstract at least $500 \text{ m}^3 \text{ d}^{-1}$.

Permeability is estimated to be in the range of $0.6\text{--}1.2 \text{ m}^2 \text{ d}^{-1}$, based on an assumed aquifer thickness of 50 m, and a transmissivity in the range of $30\text{--}60 \text{ m}^2 \text{ d}^{-1}$.

Porosity is estimated to be approximately 0.02, based on modelled porosity values for volcanics at Herbertstown, Co. Limerick.

Groundwater flow within the volcanic rock is likely to be via the joints and fractures. Weathering may have improved the permeability of the rock. The volcanic rock is classified in this region, as a **locally important aquifer** that is generally **moderately productive (Lm)**. The groundwater is assumed to be confined in the vicinity of the borehole, but becomes unconfined toward Clonmullen, where the shales and limestones are absent, according to the log of the borehole drilled into the volcanics toward the top of the hill at Clonmullen.

The Upper Impure Bedded Limestone are classified in this region as a **locally important aquifer** that is generally **moderately productive (Lm)**. Therefore, it is assumed that these limestones have similar properties as the volcanics in this area.

8.5 Conceptual Model

- The borehole is located in a sequence of rocks comprising: shale; limestone; and volcanics, which are overlain by peat, sand/gravel and till. The screened interval is located in the volcanic rock unit.
- The volcanics and limestones are classified as **locally important aquifers** that are generally **moderately productive (Lm)**. It is likely that the limestones surrounding the volcanics provide groundwater to the source as they have similar aquifer properties in this region.
- The current abstraction is $550 \text{ m}^3 \text{ d}^{-1}$, increased from an average of $350 \text{ m}^3 \text{ d}^{-1}$, due to a shortfall in the supply at Toberdaly.

- The reported yield is $1082 \text{ m}^3 \text{ d}^{-1}$.
- Transmissivity is estimated to be in the order of $30\text{-}60 \text{ m}^2 \text{ d}^{-1}$.
- Permeability is estimated to be in the order of $0.6\text{-}1.2 \text{ m}^2 \text{ d}^{-1}$.
- Groundwater flow directions are expected to be primarily from the northwest and the west.
- It is assumed that the river water is not drawn into the well during pumping and that the groundwater is confined in the vicinity of the well, and during pumping, the well draws water from the bedrock on the other side of the river.
- The hydrochemistry indicates that the groundwater is softer than typical groundwater in Offaly and suggests that the manganese is naturally occurring. Low nitrates indicate that there is denitrification occurring. There appears to be little impact from human activities to the water quality at the borehole.
- Diffuse recharge occurs over the higher relief areas of the catchment and the annual average recharge is estimated to be 320 mm per year.

9 Delineation of Source Protection Areas

This section delineates the areas around the source that are believed to contribute groundwater to it, and that therefore require protection. The areas are delineated based on the conceptualisation of the groundwater flow pattern, and are presented in Figures 4 and 5.

Two source protection areas are delineated:

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

9.1 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 subsoil and 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 understanding of groundwater flow in the area. They are described as follows.

The Western boundary is delineated using topography. The high ground between Clonmullen and Edenderry is assumed to act as a surface water divide, as surface water flows to the east and west on either side. It is assumed that a groundwater divide coincides with the surface water divide. The industrial water supply borehole is located approximately 200 m on the western side of this divide. Given, that this borehole abstracts significant quantities of water, it is probable that the groundwater divide is shifted eastward. In addition, pumping of the new well at the water tower, is also likely to influence the ZOC of the Kishawanny borehole, by also shifting the groundwater divide east. However, as it is uncertain as to how far this divide would extend under these conditions, the topographic divide is used.

The Northern and Southern boundaries are constrained by topography and geology. It is assumed that there is a groundwater divide between the high ground in Clonmullen and the river north of the borehole. Similarly, a groundwater divide occurs between the high ground in Edenderry and the river south of the borehole. There is uncertainty with the boundaries, as the full extent of the volcanic aquifer is unknown. Therefore, the current volcanic boundary is used as the northern and southern boundary in the low-lying area around the borehole.

The Eastern boundary is delineated using outer limit of the volcanics. The volcanics extend approximately 500 m east of the borehole into County Kildare. It is assumed that during pumping the gradient is suffice to draw water through the full extent of the volcanics.

The area delineated is approximately 1.4 km². As a cross check, a water balance was used to estimate recharge area required to supply groundwater to the source. The recharge is estimated to be 320 mm, therefore, an area of 0.6 km² is required to provide 550 m³d⁻¹. Thus, the area delineated is greater than the area required, however, it accounts for the areas of low recharge, for the abstraction quantities at the industrial estate and the future abstraction quantities at the water tower site.

9.2 Inner Protection Area

According to “Groundwater Protection Schemes” (DELG/EPA/GSI, 1999), delineation of an Inner Protection Area is required to protect the source from microbial contamination and it is based on the 100-day time of travel (ToT) to the supply.

Using the “Well Head Protection Area” modelling programme (Blandford, T.N., 1991, 1993), the 100 day time of travel is estimated around the borehole. The estimated values for the gradient, porosity, transmissivity, permeability for the volcanics (0.01, 0.02, 60 m² d⁻¹, 1.2 m d⁻¹, respectively), given in Section 8.4, are used in the calculation of the inner protection area. In addition, the estimated yield (550 m³d⁻¹) is taken into account.

Accordingly, the boundary of the inner protection area (SI) is 250 m on the upgradient side and 110 m on the downgradient side from the well.

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.

Four groundwater protection zones are present around the source as illustrated in and the final source protection zones are given in Figure 5.

Table 1 Matrix of source protection zones for Kishawanny borehole.

VULNERABILITY RATING	SOURCE PROTECTION	
	<i>Inner</i>	<i>Outer</i>
<i>Extreme (E)</i>	Not present	SO/E
<i>High (H)</i>	Not present	SO/H
<i>Moderate (M)</i>	SI/M	SO/M
<i>Low (L)</i>	Not present	Not present

11 Potential Pollution Sources

Land use in the area is described in Section 5. Industrial estates, petrol stations, farms, houses, leakage from sewer systems and roads are the principal hazards to the water quality in the area.

12 Conclusions and Recommendations

- The Kishawanny source at Edenderry comprises a borehole located in a **locally important aquifer** that is generally **moderately productive (Lm)**.
- The groundwater feeding the source is extremely to moderately vulnerable to contamination.
- Available data suggests that there is little contamination at the source.
- The protection zones delineated in the report are based on our current understanding of groundwater conditions and on the available data. There is a level of uncertainty with some of the

boundaries. Reducing the level of uncertainty would require drilling and a geophysical programme to be undertaken. In view of the possible decommissioning of this borehole in the future, this is probably not needed at present.

- It is recommended that:
 1. The potential hazards in the ZOC should be located and assessed.
 2. A full chemical and bacteriological analysis of the **raw** water is carried out on a regular basis.
 3. Particular care should be taken when assessing the location of any activities or developments which might cause contamination at the well.

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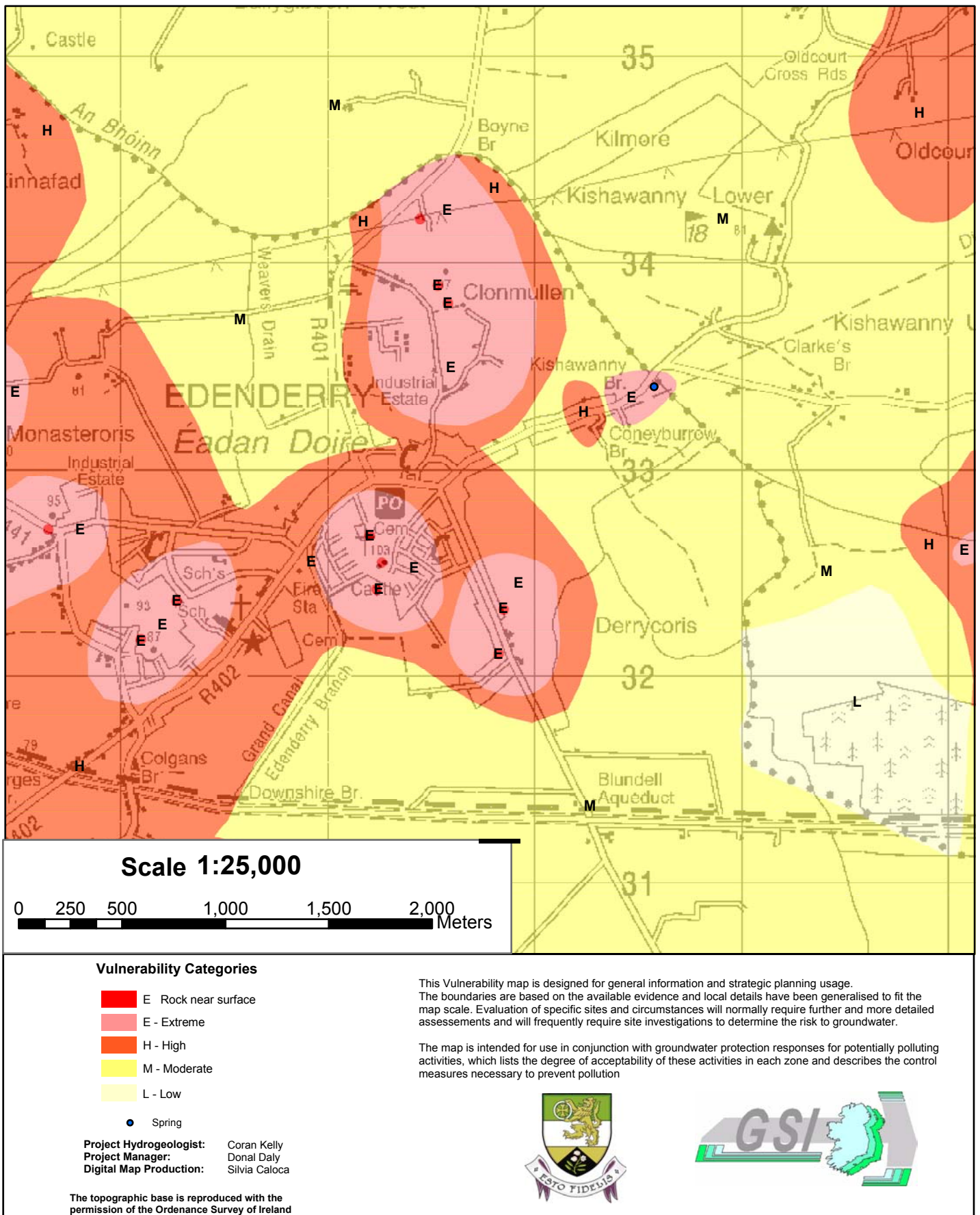


Figure 3 Vulnerability around Edenderry

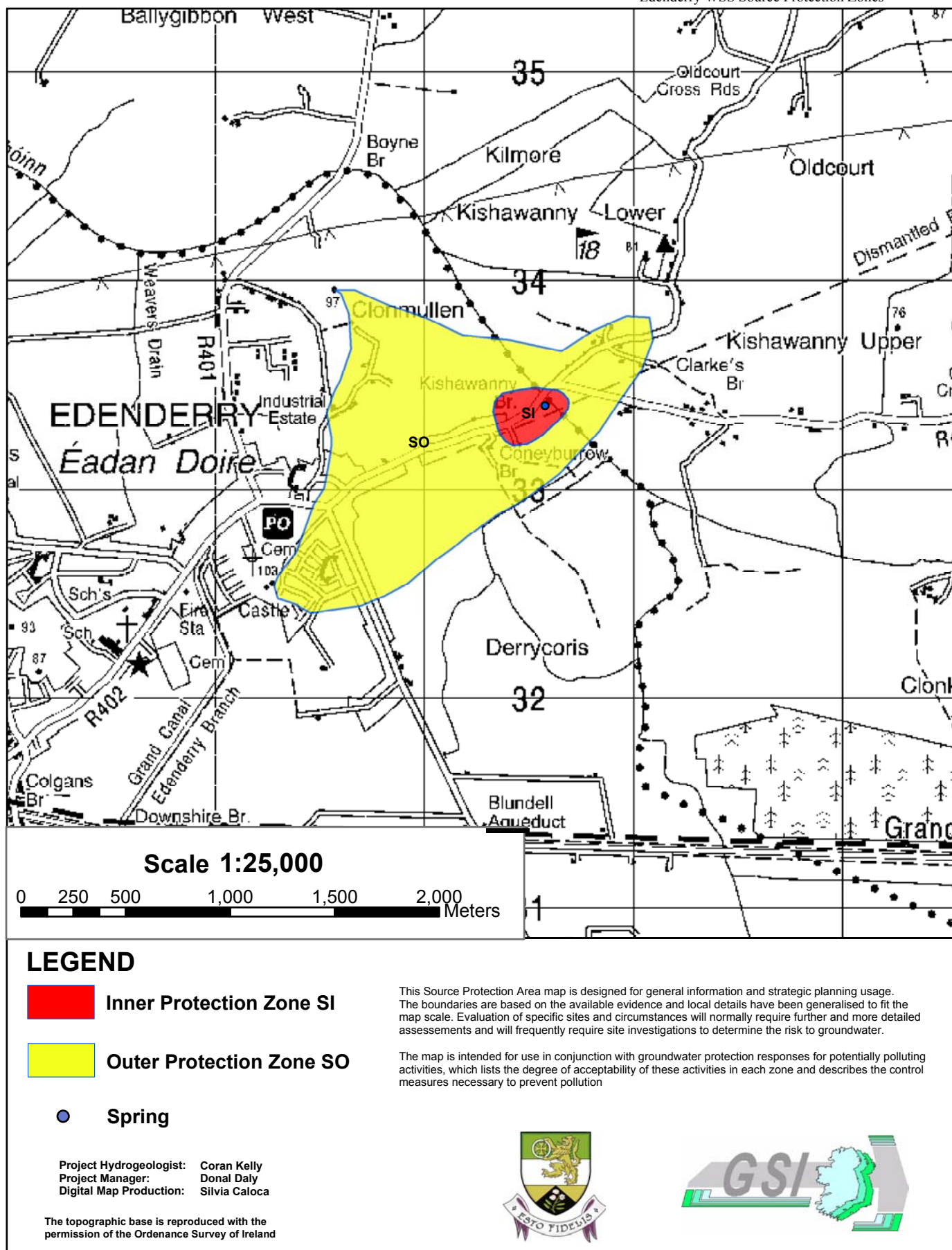
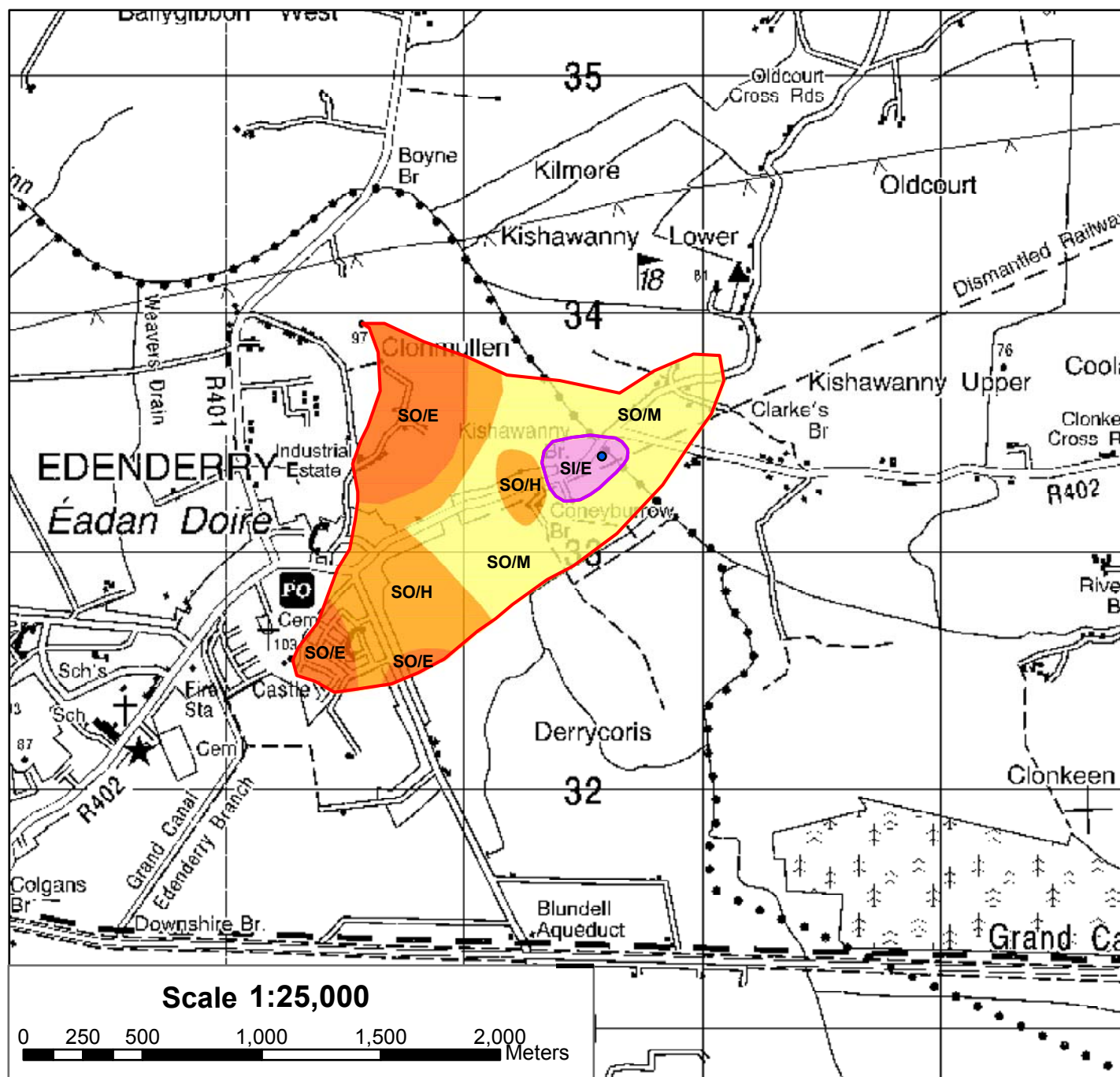


Figure 4 Source Protection Areas



SOURCE PROTECTION ZONES

VULNERABILITY RATING	SOURCE PROTECTION ZONES	
	Inner SI	Outer SI
Extreme (E)	SI/E	SO/E
High (H)		SO/H
Moderate (M)		SO/M

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

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This Source Protection Zone 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 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



Figure 5 Source Protection Zones