

Dunkerrin Water Supply Scheme

Dunkerrin Village Well

Groundwater Source Protection Zones

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1 Introduction

The objectives of the report are as follows:

- To delineate source protection zones for the source.
- To outline the principal hydrogeological characteristics of the Dunkerrin 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 spring. 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. The maps produced for the scheme are based largely on readily available 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 source is located in Dunkerrin Village, Co. Offaly. Originally, there was a spring, which was dug out, and now comprises a circular concrete sump 1.9 m deep. A pumphouse has been built around the chamber with a galvanised roof and padlocked doors as shown in Figure 1. An overflow channel is located on the northern side of the pumphouse, from which, according to the caretaker there is always a flow present. The chlorination tank and chemicals are stored in the pumphouse. There is a raw water tap available. The Dunkerrin Village well is one of three sources comprising the Dunkerrin Water Supply Scheme which serves a population of 2,200.

3 Summary of Spring Details

GSI No.	2017NWW003
Grid reference	20628 18490
Townland	Dunkerrin
Owner	Offaly County Council
Well Type	Spring/Dug Well
Elevation (ground level)	Approximately 100m OD. (Malin Head)
Static water level	0.5m below top of the sump
Depth to rock	>3 m
Normal abstraction	227 m ³ d ⁻¹ (50,000 gallons per day) (Caretaker 15/1/03)
Maximum Abstraction	682 m ³ d ⁻¹ (150,000 gallons per day) (Caretaker, 15/1/03)
Hours Pumping	15-24 hours per day (caretaker, 15/1/03)
Depth of sump	1.90 m (measured by GSI staff 15/1/03)

Figure 1 Views of Dunkerrin Village Well Pumphouse and Chamber



4 Methodology

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

The data collection process included the following:

- Interview with the caretaker 15/1/2003.
- Estimating the spring overflow by GSI staff 15/1/2003.
- Drilling of 4 auger holes by GSI staff 28/4/2003.
- 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

The spring is located at approximately 100 m OD, at the bottom of a north facing slope of a small esker ridge (111 m OD). Immediately to the south of this hill, there is a low-lying flat area occupying approximately one km². Sloping upwards from this low-lying area, are several ridges (215-236 m OD), that form a horseshoe around the spring, occupying the townland areas of Moatquarter, Honeymount and Ballymoheen. To the north and northwest of the spring, the land is relatively flat and low-lying, apart from occasional hummocky areas, hillocks and eskers. The average topographic slope down to the spring is in the order of 1:25.

Two streams flow past the spring: one approximately 100 m to the northeast, originating in the high ground of Rathnaveoge Lower; and, one approximately 600 m to the southwest, which originates in the low-lying flat area described above. Both streams are flowing northwest. In the low-lying area north of the spring there are several large artificial field drains. The surface water divides for the streams occur in the high ground to the south of the spring, in the townland areas of Moatquarter, Honeymount, Ballymoheen and Rathnaveoge. The regional drainage is to the north and north west and is part of the Little Brosna subcatchment of the Shannon River Basin District. There are three springs mapped at Rathnaveoge Church, which are the source of the main stream to the east of the spring.

Dunkerrin Village occupies the land immediately around the spring. There is a school, church and several houses and farms in the immediate vicinity. The main Dublin - Limerick road passes approximately 130 m south of the spring. The land use around the village is generally grassland, used for pasture and silage. There are several sand/gravel pits (both disused and in use) in the vicinity.

6 Geology

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

6.1 Introduction

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

- Gately, S., Sleeman, A.G., and G. Emo. A geological description of Galway - Offaly, and adjacent parts of Westmeath, Tipperary, Laois, Clare and Roscommon to accompany the Bedrock Geology 1:100,000 Scale Map Series, Sheet 15, Galway - Offaly.
- Archer, J.B. *et al.* 1996. Bedrock Geology 1:100,000 Map Series, Sheet 18, Tipperary, Geological Survey of Ireland.
- Information from geological mapping in the nineteenth century (on record at the GSI).

- Offaly Groundwater Protection Scheme (Daly *et al*, 1998).
- Subsoil mapping by the GSI.
- Auger Drilling of 4 holes carried out by GSI (April 2003).

6.2 Bedrock Geology

The bedrock consists of limestones, shales and sandstones, shown in Figure 2 and they are described briefly below.

The **Dinantian Lower Impure Limestone** (Ballysteen Formation) is the dominant rock type beneath the spring. This is a medium dark grey, well bedded, fossiliferous limestone with mudstone bands and some siltstones. It occupies the area in the immediate vicinity to the spring, and extends approximately one kilometre south.

The **Devonian Old Red Sandstones** (Cadamstown Formation) comprise sandstones and shales. It occurs one kilometre south of the spring, extending southwards, occupying the bedrock cored hills.

There are two major fault sets present in the area: NW-SE and NE-SW. A northeasterly trending fault is mapped approximately 1 km south of the spring, and is the contact between the Old Red Sandstone and the Lower Impure Limestone. There is possibly a northwesterly trending fault extending through the stream valley southeast of the spring toward Rathnaveoge Lower, as suggested by the topographic contours.

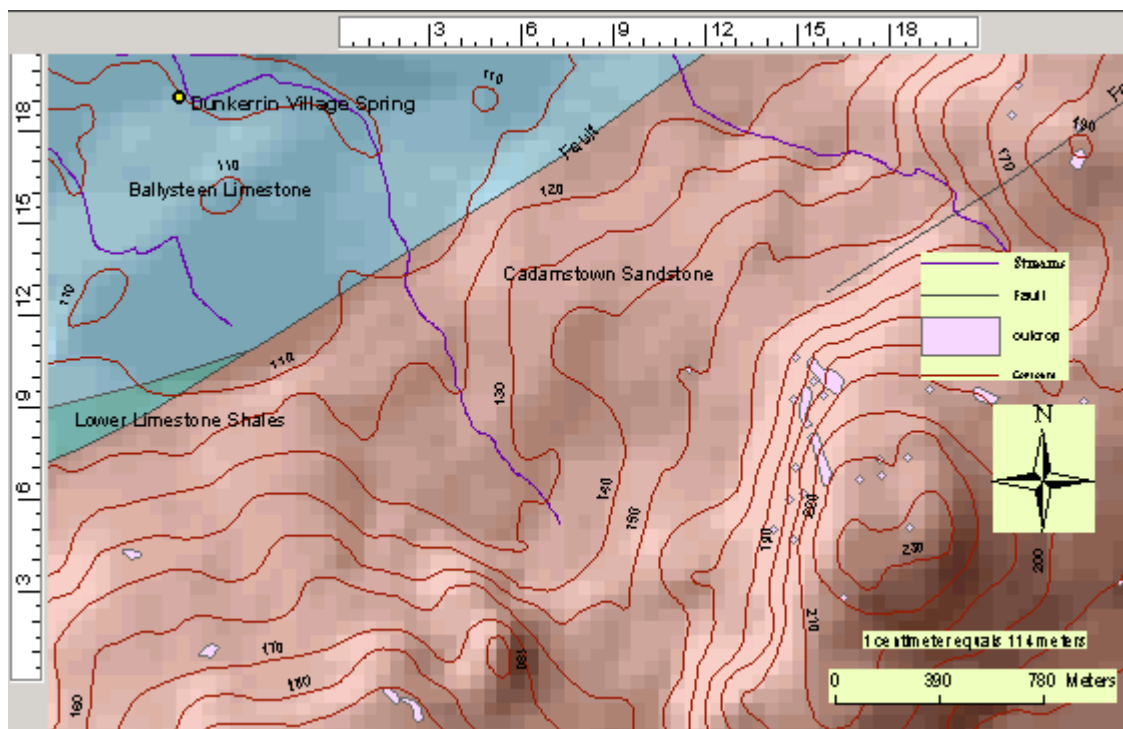


Figure 2 Geology around Dunkerrin Village.

6.3 Subsoil Geology

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

- The spring is located at the northern edge of a mapped sand/gravel deposit, shown in Figure 3, that extends south as far as the county boundary with Tipperary, and in places beyond, for example at Moatquarter and Rathnaveoge Lower. Sand/gravel deposits in County Offaly are thought to be

mainly outwash deposits, that are generally coarse and poorly sorted, often with lenses of better sorted material. They normally contain less than 3% fine grade material (Daly *et al*, 1998). Sand/gravel is present at auger holes 2 and 4 – neither of which met bedrock. The water table was met at approximately 5 m below the surface in auger hole 2.

- ‘Till’ or ‘Boulder clay’ is an unsorted mixture of coarse and fine materials laid down by ice. Till occupies the area to the north, northeast of the spring and also the areas surrounding the sand/gravel deposit in the south and east. Seven metres of till, “**SILT/CLAY**” (BS5930, 1999) is present at auger hole 3.
- Peat occupies a small area to the west of the spring, and is generally less than 1 m thick and overlies gravel.
- Marl is a calcium carbonate deposit, often containing a small proportion of organic matter or clay minerals. It occupies an area of approximately 0.5 km², located 500 m to the east and southeast of the spring. It is usually thin (less than 1 m), cream, white or rusty white in colour. Auger hole 1 was drilled 10 m without meeting bedrock into this area, where 3 m of marl/alluvium is present. The water table was met approximately 4 m below ground level. There were no returns after 4 m below ground, thus the subsoil beneath the marl/alluvium is not known.
- In general, the subsoil thickness increases from south to north. Outcrop is mapped to the south of the spring in the higher ground around Honeymount and depth to rock is generally greater than 10 m in the lower lying areas. Figure 3 shows the auger sites with depth to bedrock.



Figure 3 Sand/gravel, contours, streams, location of auger holes and depth to bedrock.

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 sand/gravel aquifer, and the permeability and thickness of the subsoil in areas where the sand/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 sand/gravel, thus for the purposes of vulnerability mapping the “**water table**” is the target.

- The permeability of the sand/gravel is classed as “**high**”, the permeability of the till “**moderate**”, and the permeability of the peat and marl “**low**”.
- The water table is within 3 m of the surface at the spring and estimated to be within 3 m of the ground surface for up to 100 m south of the spring, therefore the vulnerability to contamination at the spring is classed as “**extreme**”.
- Depth to bedrock varies from being greater than 10 m in the low-lying areas to less than 1 m to the south of the source.
- The vulnerability map is given in Figure 5. The majority of the area to the south of the spring is classed as being “**highly**” vulnerable.

Depth to rock and depth to the water table interpretations are based on the available data cited here. 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.
- A drilling programme carried out by GSI to ascertain depth to bedrock and subsoil permeability.

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 Dunkerrin, 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: 950 mm.

Rainfall data for gauging stations around Dunkerrin (from Fitzgerald, D., Forrestal, F., 1996).

Gauging Stations	Grid reference	Elevation OD (m)	Approximate distance and direction from source	Annual precipitation 1961-1990
Moneygall	S032811	125	4 km south west	1032 mm
Shinrone	S045925	70	7 km north	885 mm
Roscrea	S110905	64	8 km north east	882 mm

The contoured data map for the Offaly Groundwater Protection Scheme (Daly *et al*, 1998) show that the Dunkerrin Village spring is located approximately at the 950 mm average annual rainfall isohyet.

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: 500 mm yr.⁻¹.

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

Recharge coefficient: 70%.

The slopes and the nature of the deposits around the source need to be considered in order to give a representative value for the runoff during rainfall events. The areas of sand/gravel have higher recharge coefficients than the areas covered by till, peat, alluvium and marl, which cover approximately three quarters of the area. In addition, most of the catchment has a relatively steep slope and there are two streams draining the catchment. Thus, a representative value for the recharge coefficient, is estimated to be in the order of 70%.

These calculations are summarised as follows.

average annual rainfall (R)	950 mm
estimated P.E.	475 mm
estimated A.E. (95% of P.E.)	450 mm
effective rainfall	500 mm
recharge coefficient	70%
Recharge	350 mm

8.2 Groundwater Levels, Flow Directions and Gradients

Water level data are sparse. Water levels are close to or at the ground surface in the low-lying area in the vicinity of the spring. The streams suggest surface water divides occur in the vicinity of Moatquarter, Honeymount, Ballymoheen and Rathnaveoge Lower. The water table in the area is generally assumed to be a subdued reflection of topography: as the topography slopes north and northwestwards, the water table slopes north and northwestwards toward the spring. The dominant driving heads are the hills south of the source. The flow directions are expected to be perpendicular to the contour lines. In simple terms, rainfall reaching the water table will be funnelled in a northerly and north-westerly direction toward the spring.

Recharging water on the esker ridge will flow vertically down to the water table, thus the ridge has no significant effect on the general flow directions.

Groundwater gradients in sand/gravel are expected to be quite flat. Gradients in the bedrock aquifers are likely to be steeper, in particular, where the topographic slopes are steep. The hydrogeological data near the spring suggest local gradients are in the order of 0.002; and a value of 0.002 is used in later sections to determine the extent of the source protection zones.

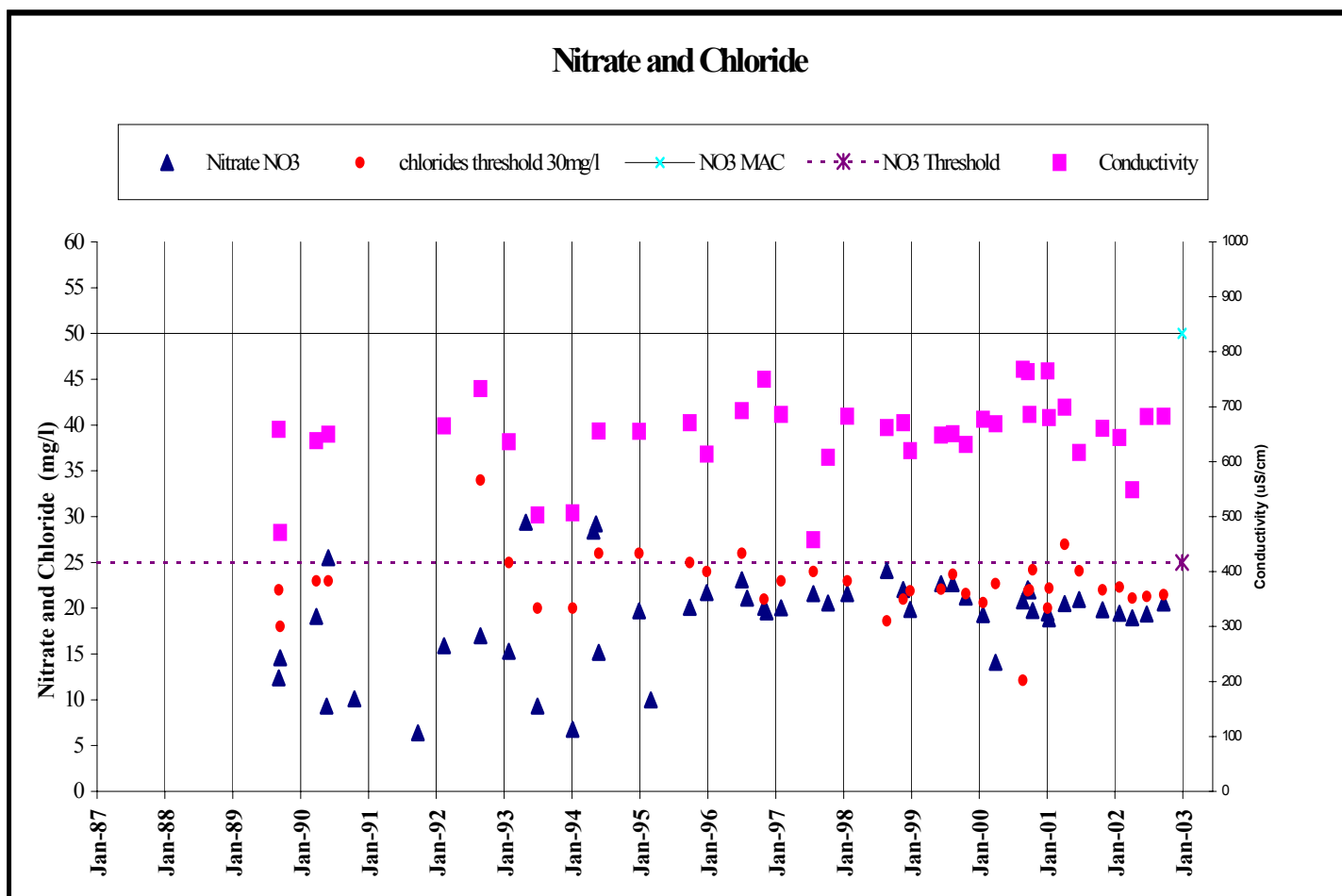
8.3 Hydrochemistry and water quality

Data on trends in water quality are summarised graphically in Figure 4. The following key points are identified from the data.

- The water is very hard with an average total hardness of 364 mg l⁻¹ (equivalent CaCO₃) and electrical conductivity values of 458-764 µS cm⁻¹. These values are typical of groundwater from limestone rocks. As would be expected, the pH of the groundwater is generally neutral (a mean of 7.1).
- Nitrate concentrations in available samples from the last 15 years range 7-29 mg l⁻¹ (average is 20 mg l⁻¹). There are no reported exceedances above the EU maximum admissible concentration of 50 mg l⁻¹. There are occasional peaks above the threshold level of 25 mg l⁻¹, for example, on

30/5/94, the nitrate level is reported to be 29 mg l⁻¹. The peaks and slightly elevated levels may indicate contamination from inorganic fertiliser and/or organic waste source. The data suggests that over the last fifteen years there is a slight increase in levels.

- Chloride is a constituent of organic wastes and levels higher than 25 mg l⁻¹ may indicate significant contamination, and levels higher than the 30 mg l⁻¹ usually indicates significant contamination. Chloride data range from 20 to 34 mg l⁻¹ (average (24 mg l⁻¹), suggesting that contamination from organic wastes has possibly occurred on one occasion (15/9/1992: 34 mg l⁻¹) and there may be regular contamination.
- There are no detections of *E.coli* in the available one **raw** water analysis, nor in 140 available treated water analyses.
- The available data shows that potassium levels are regularly elevated above the GSI threshold level of 4 mg l⁻¹. On 1/11/2000 and 22/1/2001 the reported concentrations were 8.25 and 18.8 mg l⁻¹ respectively. The potassium:sodium (K/Na) ratio is regularly above the GSI threshold level of 0.35, suggesting contamination from an organic waste source, possibly farmyard wastes, as elevated potassium: sodium ratios are linked with farmyard wastes.
- In summary, elevated potassium levels and high potassium:sodium (K/Na) ratio, occasionally elevated chloride and nitrate levels suggest contamination from farmyard wastes.



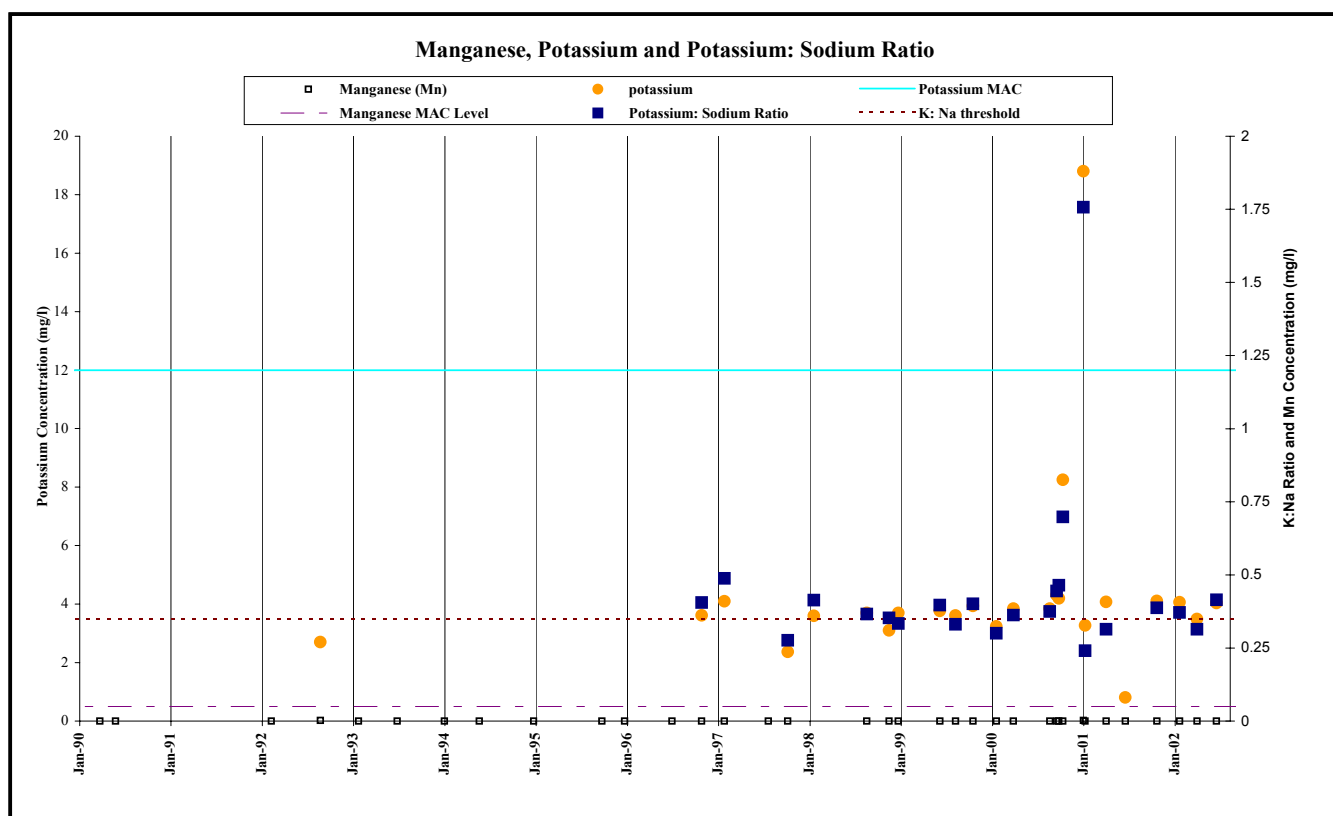
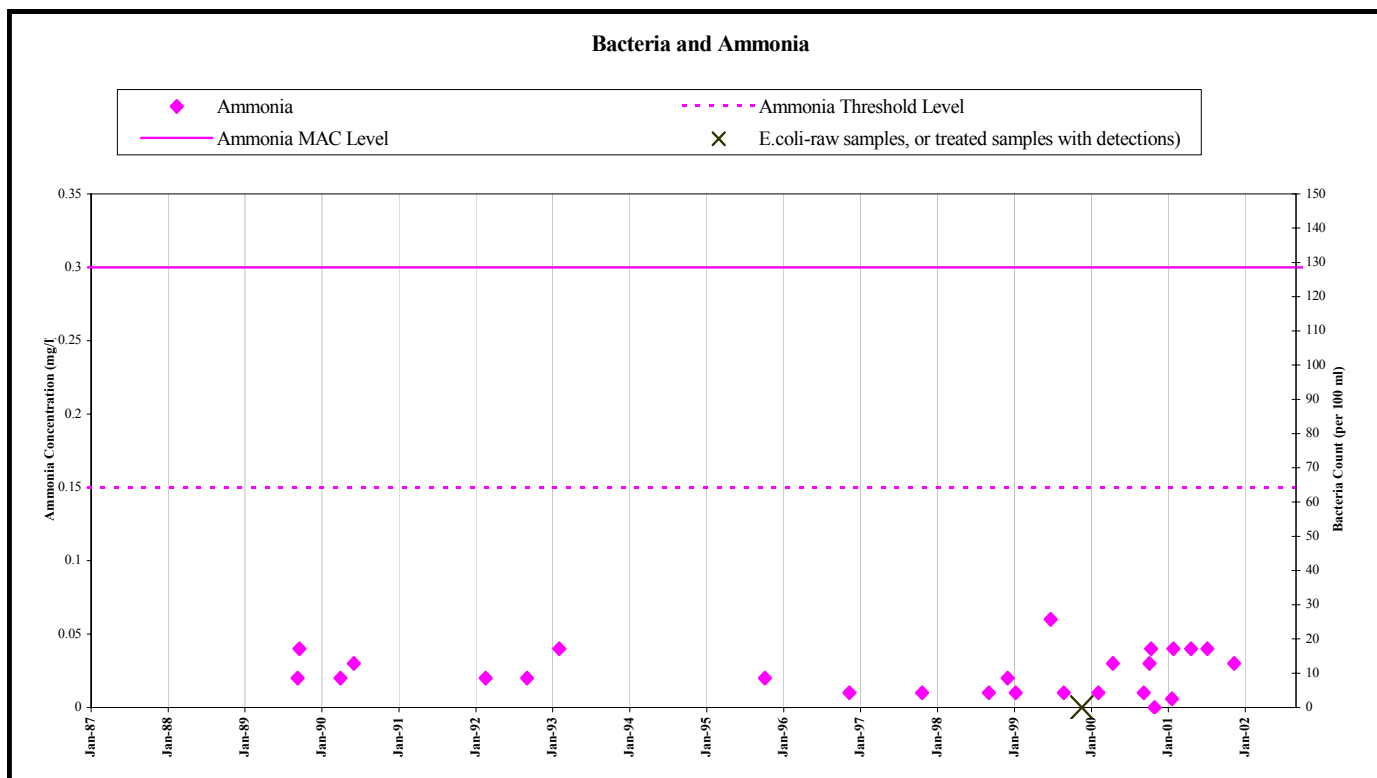


Figure 4 Key Indicators of agricultural and domestic groundwater contamination at Dunkerrin Village Spring.

8.4 Spring Discharge

Currently, average daily abstraction is $227 \text{ m}^3 \text{d}^{-1}$ (50,000 gallons per day). The maximum abstraction recorded is $682 \text{ m}^3 \text{d}^{-1}$ (150,000 gallons: 2002). It is not known if there was an overflow on this date, however, the caretaker indicated that, generally there is always an overflow. As such, the source is treated as a spring rather than a well. Since 1990, the data (given below) show that abstraction is generally increasing.

Year	Average Daily Abstraction ($\text{m}^3 \text{d}^{-1}$)
2003	227
2000	206
1999	192
1998	205
1997	192
1996	150
1995	92
1994	32
1993	65
1992	97
1991	164
1990	177

The total spring discharge (abstraction and overflow volumes) is not well characterised, as there are no records of the overflow. GSI staff estimated the overflow in January 2003, and the total discharge is given below.

Date	Total discharge	Data source	Method
15/1/2003	$420 \text{ m}^3 \text{d}^{-1}$ ($193 \text{ m}^3 \text{d}^{-1}$ = overflow; $227 \text{ m}^3 \text{d}^{-1}$ = abstraction)	GSI Personnel	Flow metre

Frequent overflow monitoring is required to provide a more reliable dataset. The spring is an “**intermediate**” sized spring according to the GSI classification of spring discharge.

8.5 Aquifer Characteristics

The spring is located on the northern edge of a sand/gravel deposit, and together with the bedrock it feeds groundwater to the spring. In 1984, a five day constant rate test was carried out at the sump. After pumping for five days, at $218 \text{ m}^3 \text{d}^{-1}$, the maximum drawdown was 0.5 m, giving a specific capacity of $436 \text{ m}^3 \text{d}^{-1} \text{m}^{-1}$.

The groundwater gradient in the gravel deposit is estimated to be 0.002, porosity is assumed to be in the region of 10%, and permeability is estimated to be 50 m d^{-1} . In the vicinity of the spring, groundwater velocities are likely to be high; estimated from permeability, porosity and gradient to be approximately 1 m d^{-1} .

The sand/gravel in the area is classed as a **locally important sand/gravel aquifer (Lg)**. Two other “**intermediate**” springs, in the same sand/gravel body are located 3 km south west of Dunkerrin at Busherstown, which are used as part of the Moneygall Public Water Supply (Kelly, 2004). The auger holes indicate that the sand/gravel is greater than 10 m. On the slopes further south, the sand/gravel thickness is interpreted to be shallow, probably less than five metres. Groundwater is generally unconfined.

The Lower Impure Limestone is classed a **locally important aquifer** that is **moderately productive in local zones (LI)**. It is generally thought to have poor aquifer properties: low permeability and transmissivity; poor storage capabilities; and low porosity. However, in the vicinity of faults, aquifer properties may be higher. Several large faults are mapped in the vicinity, and it is possible that there may be large fault running through the valley toward the spring, along the central line of the horseshoe formed by the ridges.

The Devonian Old Red sandstone is classed as a **locally important aquifer that is moderately productive in local zones (LI)**. It is generally assumed that groundwater is discharged quickly to the surface water streams in the area.

The sand/gravel is considered to be the main aquifer providing water to the spring. However the bedrock is expected to contribute groundwater to the spring. A combination the boundary of the sand/gravel with peat, the break in slope, the possible fault, and the funnelling effect of the topography driving the groundwater to focus at a central location, are probably responsible for the spring at this location.

8.6 Conceptual Model

- The scheme currently abstracts about $227 \text{ m}^3 \text{ d}^{-1}$ from an “**intermediate**” sized spring, located in a sand/gravel aquifer.
- The sand/gravel is a **locally important sand/gravel aquifer (Lg)**. The Lower Impure Limestone is a **locally important aquifer that is moderately productive in local zones (LI)** and the Old Red Sandstone is a **locally important aquifer that is moderately productive in local zones (LI)**.
- The gradient in the sand/gravel is approximately 0.002, porosity 10% and permeability 50 m d^{-1} .
- A combination of the break in slope, the sand/gravel bounding the low-lying peatland and a possible fault in the bedrock are likely to be the main reasons that the groundwater emerges at the spring.
- Groundwater flow is expected to be from the south.
- The groundwater is generally assumed to be unconfined.
- Groundwater vulnerability is classed as “high” to “extreme”.
- Elevated potassium levels and high potassium:sodium (K/Na) ratio, occasionally elevated chloride and nitrate levels suggest contamination from farmyard wastes.
- Diffuse recharge occurs over the catchment and the annual average recharge is estimated to be 350 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 6 and 7.

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 spring.

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), and is defined as the area required to support an abstraction from long-term recharge.

The ZOC is controlled primarily by (a) the groundwater flow direction and gradient, (b) the subsoil and rock permeability, and (c) 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 the groundwater flow in the area. They are described below.

The Northern boundary is constrained by the spring, as it is assumed that groundwater downgradient cannot flow back up to the spring. An arbitrary buffer of 30 m is placed on the downgradient side of the spring.

The Southern boundary is constrained by topography. The ridges of Moatquarter and Honeymount are assumed to act as groundwater divides. It is assumed that water on the northern side of this ridge will flow toward Dunkerrin Spring.

The Western boundary is constrained by topography. The western boundary cuts through the small stream that flows out of the low-lying alluvium area because it is assumed that groundwater in the gravels flows beneath the alluvium toward to the spring. It is assumed that the stream is draining the low-lying flat area.

The Eastern boundary is constrained by topography. The eastern boundary is difficult to delineate, in particular in the area between Castleroan and Cobb's Wood. This is because of the main stream flowing north passed Dunkerrin spring and it is difficult to ascertain the divide between water discharging to the stream and water discharging to the spring.

It is assumed that groundwater high up in the catchment in Rathnaveoge Lower and Ballymoheen discharges to the springs by Rathnaveoge Church and groundwater on the eastern side of the main stream discharges to the stream.

The area defined by the boundaries described above is approximately 2 km². A water balance was used to estimate recharge area required to supply groundwater to the source. The area needed is approximately 0.7km². The area outlined above is greater than the area required. The discharge and recharge figures quoted in these calculations are both estimates, they have both been selected to be conservative in the context of requiring a large area to balance recharge with discharge. However, the area over which the alluvium sits is approximately 0.5 km² and this area is assumed to provide little or no recharge to the spring. In addition, recharge to the higher slopes over the Old Red Sandstone, is expected to discharge to the streams. The difference between the water balance and physical constraints is therefore taken to allow for the uncertainties associated with them.

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 estimated values for permeability, gradient and porosity (50 m d⁻¹, 0.002, 10%, respectively), given in Section 8.5, the calculated velocity is 1 m d⁻¹. Accordingly, the boundary of the inner protection area (SI) is 100 m from the spring on the upgradient side.

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.

Three groundwater protection zones are present around the source as illustrated in Table 1. The final groundwater protection zones are shown in Figure 7.

Table 1 Matrix of Source Protection Zones at Dunkerrin

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

11 Potential Pollution Sources

Land use in the area is described in Section 5. Agricultural activities and septic tanks are the principal hazards to the water quality in the area. The main potential sources of pollution within the ZOC are farmyards, septic tank systems, landspreading of organic and inorganic fertilisers and road spillages. The main road crosses the outer protection area (SO). The eastern-most parts of the village are inside the inner protection area (SI).

12 Conclusions and Recommendations

- The Dunkerrin Spring is an intermediate spring located in a sand/gravel body which is considered with the bedrock aquifers to provide water to the spring. The gravels are mapped as a **local important sand/gravel aquifer (Lg)**.
- The groundwater feeding the source is “extremely” to “highly” vulnerable to contamination.
- Available data suggests that there is contamination from an organic source, possibly from farmyard wastes, thus requiring investigation and careful management to ensure that they don’t rise to significant levels.
- 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.
- It is recommended that:
 1. The potential hazards in the ZOC should be located and assessed, in particular those within 500 m of the spring.
 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, particularly in relation to nitrates.
 4. A flow metre on the pump and a permanent v-notch weir installed in the overflow in order to allow further characterisation of the spring.

13 References

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APPENDIX 1 LOGS OF AUGER HOLES.

Site 1 Auger Hole in low-lying area

Grid reference: 206500 184400

Summary: 0-1m Fill

1-4m Alluvium, fine grained blue grey subsoil
water table 4-5m below ground level.

EOH at 10 m without meeting bedrock, no returns after 4-5 m.

Site 2 Auger Hole in Tierneys transport

Grid reference: 206552 185026

Summary: 0-2m Light brown till

2-7m Dark grey Till (SILT/CLAY)

EOH at 7 m, assumed to have met bedrock.

Site 3 Auger Hole on edge of esker

Grid reference: 206300 184500

Summary: 0-10m Sand Gravel

EOH at 10m without meeting rock.

Water table not met.

Site 4 Auger Hole on disused cottage site

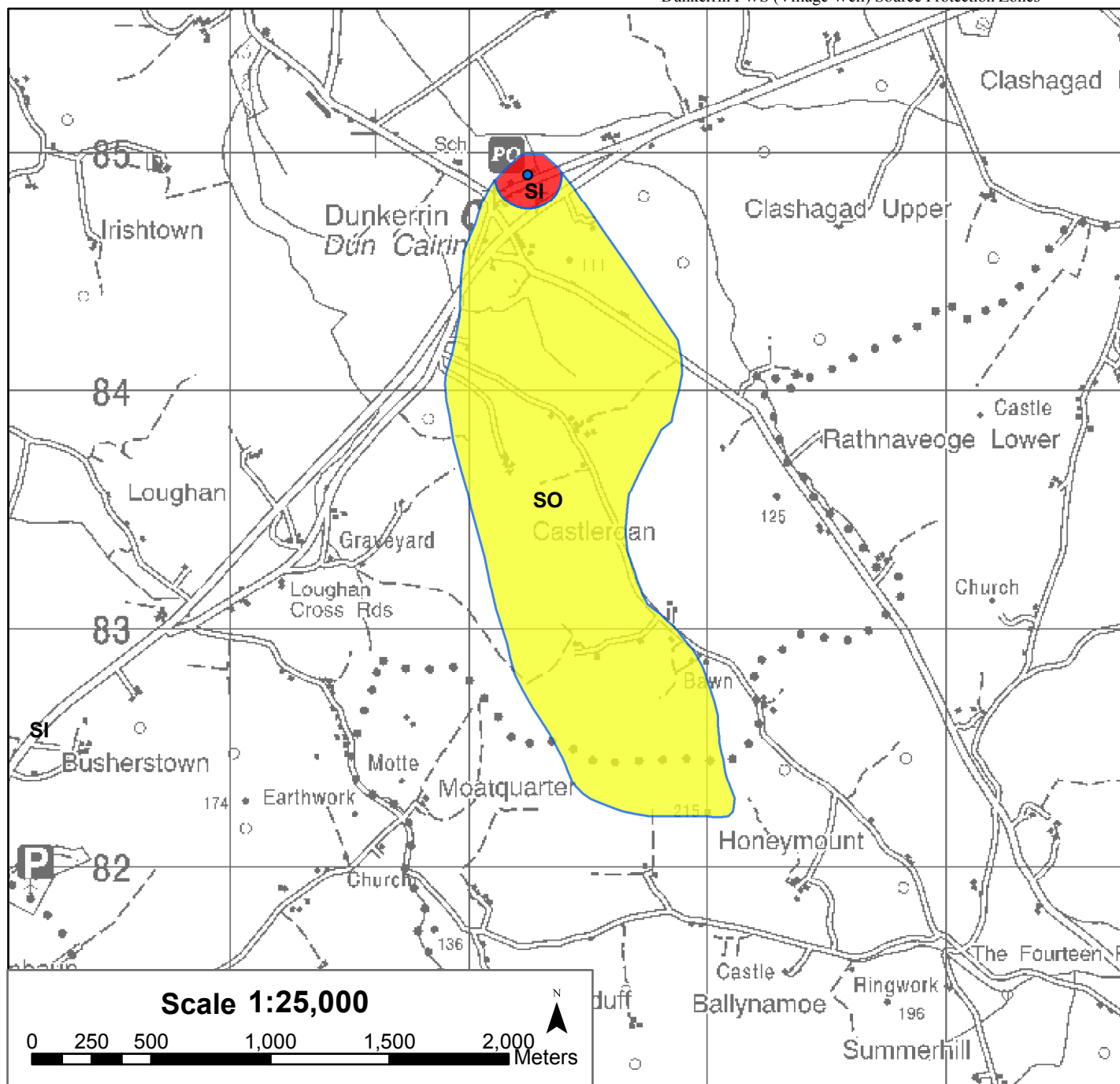
Grid reference: 207200 183980

Summary: 0-10m Sand Gravel

EOH at 10 m without meeting bedrock.

Water table: 5m below ground level.

16



LEGEND



Inner Protection Zone SI



Outer Protection Zone SO



Spring

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Digital Map Production: Silvia Caloca

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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 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 6 Source Protection Areas for Dunkerrin Village Well

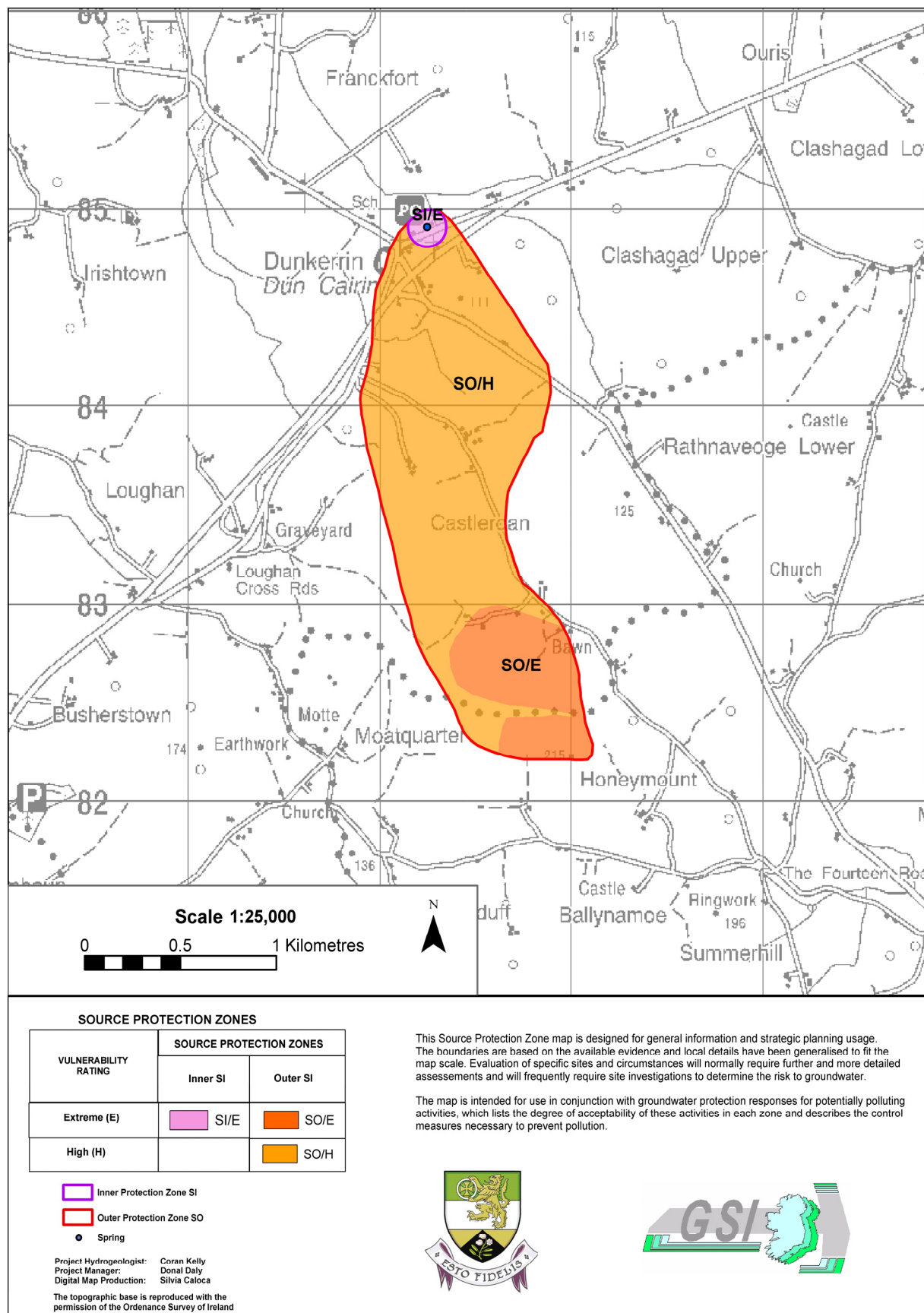


Figure 7 Groundwater Source Protection Zones for Dunkerrin Village Well