

9 CASTLEMITCHELL (CHURCHTOWN) PWS

9.1 Introduction

The objectives of the report are as follows:

- To delineate source protection zones for the Castlemitchell (Churchtown) Public Water Supply borehole.
- To outline the principal hydrogeological characteristics of the surrounding area.
- To assist Kildare 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 well. 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 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 county 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.

9.2 Summary of Borehole Details

GSI No.	2619SWW449
Grid reference	S ² 6384 19572
Townland	Raheenadeeragh/ Churchtown South
Owner	Kildare County Council
Well Type	Borehole
Depth	27m (co. co. records)
Elevation	72.63 m OD (Malin Head)
Pumping water level	8.97 m (measured by GSI personnel 9/5/2002)
Static water level	8.94 m (measured by GSI personnel 9/5/2002)
Normal consumption	~17,600 gals/day (80 m ³ d ⁻¹)
Maximum Abstracted	152 m ³ d ⁻¹ (23/10/1999 Kildare Co. Co. records)
Minimum Abstracted	33 m ³ d ⁻¹ (1/1/2000 Kildare Co. Co. records)
Hours Pumping	16-18 hours per day
Depth of pump	~17 m
Depth-to-rock	>10 m
Diameter	150mm
Treatment	Chlorinated and Raw water tap available
System	Live to mains / No reservoir / submersible pump

Note that two additional borehole supplies occur as part of the Castlemitchell scheme. These are termed the "Housing" and "Quarry" supplies. Locations are presented in Map 8. They are much smaller than the Churchtown supply. They did not form part of the investigations into the Castlemitchell (Churchtown) Source Protection Zones and were not visited by the GSI personnel. However, the potential protection area for each lies within the envelope of the Athy and Castlemitchell protection areas and they have been included within the overall source protection considerations for Athy and Castlemitchell.

9.3 Methodology

9.3.1 Desk Study

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

9.3.2 Site visits and fieldwork

This included the following; an interview with the caretaker 9/5/02, water sampling on July 2002 and drilling of depth to bedrock holes 27th & 28th May 2002. Field mapping walkovers were also carried out to further investigate the subsoil geology, the hydrogeology and vulnerability to contamination.

9.3.3 Assessment

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

9.4 Borehole Location & Site Description

The source is located one kilometre north of the main Athy - Stradbally road (R428) approximately 4 km from Athy. The source comprises a single borehole that pumps water directly into the distribution system, which is approximately 14 km in length. At the time of the GSI site visits the system provided water for approximately 320 people, comprising 76 houses and 11 farms. A manhole cover sits over the borehole which is located next to a small pump house that houses the treatment system and a surge tank. Both the pump house and borehole are located at the roadside. The well head lies within a lined concrete chamber 0.5 m deep.

9.5 Topography, Surface Hydrology and Land Use

The topography in the vicinity of the source is flat or undulating with an altitude lying between 70 and 80 m O.D. The general lie of the landscape is a very gentle dip toward the River Barrow. The highest point in the area stands at 268 m O.D. approximately 5 km south west in the vicinity of Ballintlea. The lowest point in the area is the Barrow river which is about 3.5 km to the east of the supply borehole at an elevation of approximately 54 m OD. Overall topographic gradients are in the order of 0.006.

The River Barrow is the largest surface water feature in the area. The land appears to be free draining with only occasional ditches.

Land use around the source is generally tillage and there are only occasional fields used for pasture. Historically there used to be a brick works in the vicinity of the supply borehole. Within 300 m of the supply borehole there are a church & graveyard, a school and a number of houses. There are also a few sand/gravel pits in the locality (some disused) and there is a large limestone quarry at Ballyadams, approximately 3.5 km south of the supply borehole.

9.6 Geology

9.6.1 Introduction

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

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 *et al*, 1994)

- Information from geological mapping in the nineteenth century (on record at the GSI).
- Glanville (1997) The quaternary geology of Co. Kildare, map descriptions for relevant 1:25,000 sheets. GSI report.

9.6.2 Bedrock Geology

The Ballyadams Limestone Formation occupies the area around the source. It is generally regarded as being a clean, often karstified and dolomitised limestone. The type locality for this rock type is the Ballyadams quarry in County Laois and is approximately 3.5 km south of the supply borehole.

9.6.3 Subsoil (Quaternary) Geology

The main subsoil categories in the vicinity of the source are till ('boulder clay') and sand/gravel. The characteristics of each category are described briefly below:

- 'Till' or 'Boulder clay' is an unsorted mixture of coarse and fine materials laid down by ice. The till is mapped as moderately permeable subsoil (refer to Section 6 Volume I for further details).
- Sand/gravel is widespread in south Kildare. About 500 m to the south of the supply borehole the subsoils change to sand/gravel. Several quarries (some disused) are mapped in the vicinity of the source. One esker is mapped nearby to the source.
- A depth to bedrock drilling programme was carried out to ascertain the subsoil thicknesses. Two holes in the vicinity of the supply borehole have a depth to bedrock that is greater than 10 m. Further west toward the areas of higher relief in County Laois the depth to bedrock decreases significantly and there are areas of shallow rock and outcrop.

9.7 Groundwater Vulnerability

Groundwater vulnerability is dictated by the nature and thickness of the material overlying the uppermost groundwater 'target'. The uppermost aquifer at the source is the bedrock. The rock is therefore the target and considerations of groundwater vulnerability concern the permeability of the whole subsoil profile and the depth to bedrock.

The vulnerability is discussed in Section 6 of Volume 1. The permeability of the till is thought to be moderate and the permeability of the sand/gravel is thought to be high. Depth to bedrock varies from being greater than 10 m near the source to less than 1 m to the west of the source. Thus the vulnerability to contamination at the supply borehole is moderate but will become more vulnerable moving away from the source with the most vulnerable areas occupying the high ground in County Laois and the least vulnerable areas occupying the area around the supply borehole.

Depth to rock interpretations are based on the available data cited here. However, depth to rock can vary over a small scale. 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 only 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).

9.8 Hydrogeology

9.8.1 Introduction

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:

- GSI files and archival Kildare County Council data.
- Kildare County Council drinking water returns.
- Hydrogeological mapping carried out by GSI on 9th, 10th, 27th & 28th May 2002.
- A drilling programme carried out by GSI to ascertain depth to bedrock and subsoil permeability (4 holes in the vicinity of the source and two particle size analyses).
- A Groundwater Protection Scheme for Co. Laois (Deakin, J. *et al* 2002).

9.8.2 Rainfall, Evaporation and Recharge

The term ‘recharge’ refers to the amount of water replenishing the groundwater flow system. The recharge rate is generally estimated on an annual basis, and generally assumed to consist of an input (i.e. annual rainfall) less water losses prior to entry into the groundwater system (i.e. annual evapotranspiration and runoff). The estimation of a realistic recharge rate is critical in source protection delineation; along with the rate of abstraction at the source it will dictate the size of the zone of contribution to the source. In areas where point recharge from sinking streams, etc., is discounted, the main parameters involved in recharge rate estimation are annual rainfall, annual evapotranspiration, and annual runoff and are listed as follows:

- *Annual rainfall:* 750 mm.
Rainfall data for gauging stations around Kilkea (from Fitzgerald, D., Forrestal., F., 1996) are as follows:

Gauging Stations	Grid reference	Elevation OD (m)	Approximate distance & direction from source	Annual precipitation 1961-1990
Athy (Voc.Sh)	S656933	61	6 km south east	746 mm
Kilberry	S663999	61	4 km north east	745 mm
Stradbally G.S.	S570966	91	7 km west	807 mm

As the borehole is closest (in terms of distance and altitude) to the Kilberry and Athy Gauging stations the precipitation is assumed to be about 750 mm annually. This is supported by the interpreted contour maps of precipitation presented in the “Agroclimatic Atlas of Ireland” (Collins and Cummins, 1996).

- *Annual evapotranspiration losses:* 400 mm. Potential evapotranspiration (P.E.) is estimated to be 425 mm yr.⁻¹. Actual evapotranspiration (A.E.) is estimated as 95 % of P.E., to allow for seasonal soil moisture deficits. More local measurements of evapotranspiration are not available.
- *Potential recharge:* 350 mm yr.⁻¹. This figure is based on subtracting estimated evapotranspiration losses from average annual rainfall. It represents an estimation of the excess soil moisture available for either vertical downward flow to groundwater or runoff and is commonly referred to as "Effective Rainfall".
- *Annual runoff losses:* ~35 mm. 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 subsoils are thought to be free draining and a representative value for the runoff is estimated to be in the order to 10%.

These calculations are summarised as follows:

Average annual rainfall (R)	750 mm
Estimated P.E.	425 mm
Estimated A.E. (95% of P.E.)	400 mm
Potential Recharge (R – A.E.)	350 mm
Runoff losses (10% of recharge)	35 mm
Estimated Actual Recharge	315 mm

9.8.3 Groundwater levels, Flow Directions and Gradients

A GSI well survey was carried out in the 1970's in County Kildare, from which broad estimates of the groundwater levels & directions and gradients can be made. In addition, pumping and static water levels in the supply borehole were measured by GSI staff 9/5/2002 and were 8.97 and 8.94 m below ground level respectively. As can be seen from these two measurements there was virtually no variation between the static and pumping water levels. Note that only 30 minutes was allowed for the water level to recover from the pumping water level before the pump had to be turned on again¹. However, it is generally the case that up to 90% of the expected recovery in a well is within the first 10 minutes.

Water levels measured by the caretaker between April and November 1999 provide data on the seasonal variation of the water levels. Over that period, the variation was about 3 m, where the minimum recorded water level was 8 m below ground in April 1999 and the maximum water level 11.31 m below ground in November 1999. It is assumed that these are pumping water levels because the caretakers records show that the pump is working for about 16-18 hours a day.

Hydrogeological data for other wells in the vicinity of the supply borehole show that the water levels are generally 8 m-11 m below ground level and that the groundwater flow direction is to the east and southeast. This would support the assumption that the regional flow is toward the River Barrow. The higher ground to the west of the borehole in the areas of Binbawn, Ballyduff and Ballintlea are surface watersheds. They are also assumed to be groundwater divides. Groundwater on the eastern side of the divide flows toward the borehole and eventually discharges to the Barrow.

In the vicinity of the source the water table appears to be above the top of the rock; this would suggest that the groundwater is confined at the source.

Groundwater gradients are estimated from these data to be in the region of 0.002-0.004. These gradients are flatter than the topographic gradients.

9.8.4 Hydrochemistry and Water Quality

Data on trends in water quality are summarised graphically in Figure 9-1. The following key points are identified from the data.

- The water is very hard with a total hardness greater than 350 mg l⁻¹ (equivalent CaCO₃) and electrical conductivity values of 593-798 µS cm⁻¹. These values are typical of groundwater from limestone rocks. As would be expected pH of the groundwater is generally neutral (a mean of 7.2).
- Nitrate concentrations in available samples from the last 7 years are typically 40-50 mg l⁻¹ and, until the year 2000, regularly exceeded the EU Drinking Water Directive maximum admissible concentration of 50 mg l⁻¹. However, it appears from the data that there has been a downward trend since 1995, and none of the 19 available results since December 2000 have exceeded 50 mg l⁻¹.
- Chloride is a constituent of organic wastes and levels higher than 25 mg l⁻¹ may indicate significant contamination. Chloride data are generally 30 to 40 mg l⁻¹, suggesting that contamination from organic wastes has occurred. In contrast to nitrates, no decrease in chloride levels is evident.
- Of the six available **raw** water analyses of *E.coli*, a detection of 1 count / 100ml was identified on one occasion in 1997.
- The available nitrates, chloride and bacteriological data suggest that groundwater is being contaminated by organic wastes within the catchment of the source. Given that nitrate levels are dropping while chloride is static, it may be that there are two or more types of hazard contributing to contaminant levels in the source (e.g. domestic wastewater treatment systems, landspreading of organic wastes, landspreading of inorganic fertilisers) and it may be that nitrate loadings from one of these hazards (e.g. inorganic fertilisers) have been decreasing in recent years. There is also a

¹ The water supply system is "live" with no reservoir and a full scale pumping test could not be carried out.

graveyard located within 200 m of the borehole which may be contributing to contaminant levels in the source.

9.8.5 Aquifer Characteristics

The Ballyadams limestone is the main aquifer feeding the supply borehole, consisting of thick-bedded clean limestones. On the basis primarily of lithological, karst, and productivity data, this aquifer has been classed as a **regionally important karst aquifer**, with some development potential (**Rk^d**). Further details can be found in Section 4 of Volume I. The available range of values is given in Table 7. The transmissivity estimate was taken from pump testing data of the Fermoy source in County Laois. In practice, a wide range of transmissivity and permeability values is likely, reflecting the nature of karstified and dolomitised limestones and the unpredictable nature of groundwater flow in these rocks. Faults and fractures are likely to be the focus of groundwater movement and dissolution of the clean limestone is likely to occur preferentially along them.

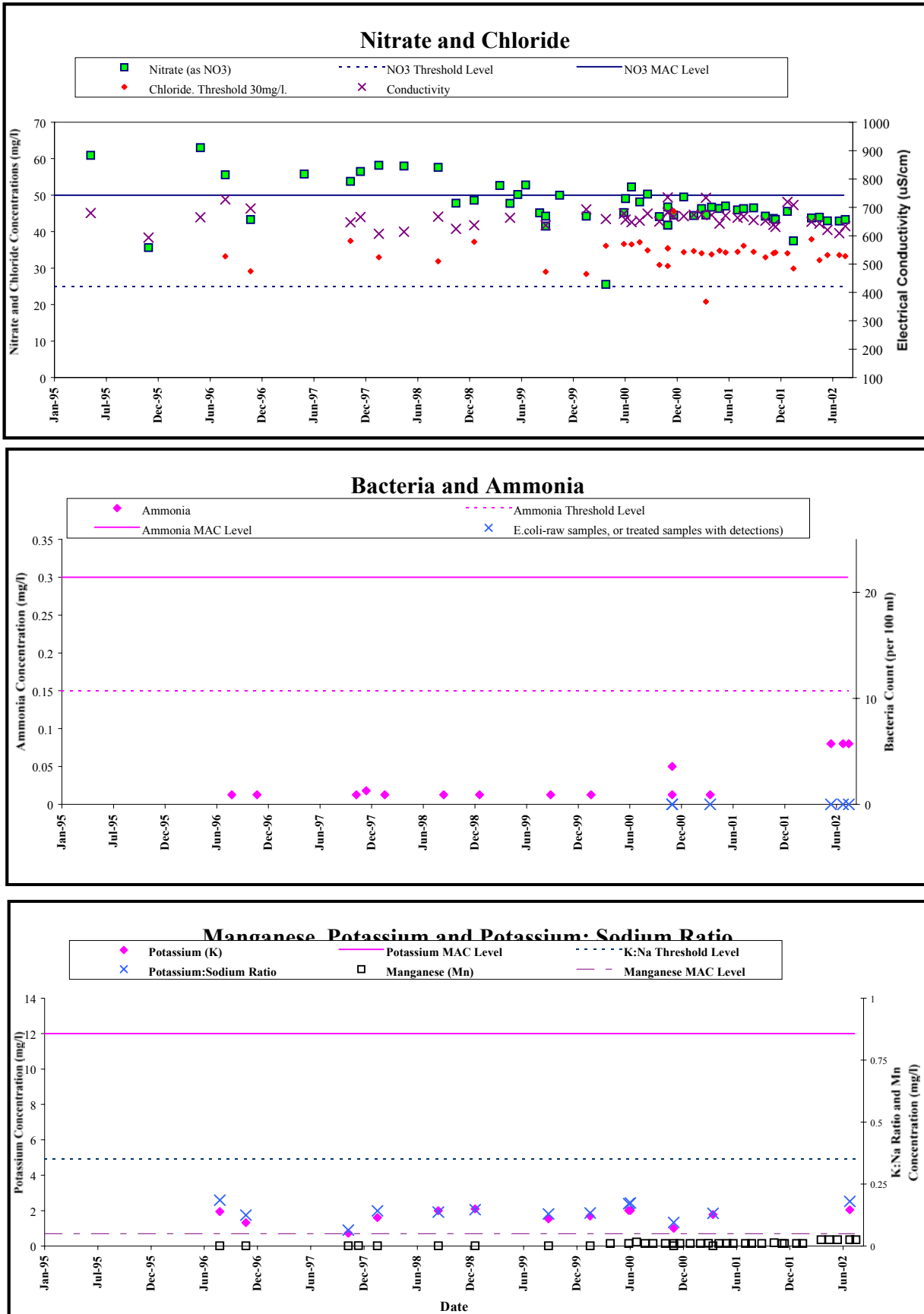
Table 7 Estimated Aquifer parameters for the Ballyadams Limestone at Castlemitchell Supply.

<i>Parameter</i>	<i>Source of data</i>	<i>Ballyadams</i>
Transmissivity (m ² d ⁻¹)	Regional (Laois)	300
Permeability (m d ⁻¹)	Regional (Laois)	15
Porosity	Assumed	0.01

9.9 Conceptual Model

- The Castlemitchell (Churchtown) Public Water Supply borehole is fed by the Ballyadams Limestone Formation which is classed a **regionally important karst aquifer**, with some development potential (**Rk^d**).
- The aquifer parameters in this aquifer are highly variable but are thought to be moderately high in the area of the supply borehole.
- Water levels are generally 8-11 m below ground surface and the bedrock aquifer is confined at the source.
- Groundwater flow is probably confined to fractures, fissures, joints, bedding planes and the uppermost part of the bedrock.
- There are few drains and surface streams and the subsoils are moderately permeable.
- It is thought that the regional groundwater flows to the southeast-east and discharges to the River Barrow.
- Diffuse recharge occurs over most of the land surface through the permeable till. Estimates are in the order of 315 mm yr⁻¹.

Figure 9-1 Castlemitchell - Key indicators of agricultural and domestic groundwater contamination.



9.10 Delineation of Source Protection Areas

9.10.1 Introduction

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.

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) to the borehole.

9.10.2 Outer Protection Area

The Outer Protection Area (SO) is bounded by the complete catchment area to the source, i.e. **the zone of contribution (ZOC)**, which is defined as the area required to support an abstraction from long-term recharge. The ZOC is controlled primarily by (a) the pumping rate, (b) the groundwater flow direction and gradient, (c) the subsoil and rock permeability and (d) the recharge in the area. The ZOC is delineated using both analytical modelling and the results of hydrogeological mapping and conceptualisation. The resulting boundaries are presented in Map 8 and are described as follows:

The **western boundary** is defined using the topographic ridges in Binbawn, Ballyduff, and Ballintlea; all of which are located in County Laois. These ridges are surface watersheds and are assumed to be groundwater divides. As the bedrock is a regionally important karstified aquifer that has high transmissivities it is possible that groundwater flowing from the divide could reach the supply borehole even though the divide is almost five kilometres distant. No significant divides occur closer to the source.

The **eastern boundary** is on the downgradient side of the borehole. Given the flat topography, the generally high bulk permeability in the karst limestone aquifer, and the unpredictable nature of flows in this aquifer, it is considered reasonable to extend the downgradient boundary to 300m, which is the width of the inner source protection area (refer to Section 9.10.3).

The **northern and southern boundaries**: these boundaries are complicated by potential interactions with the ZOC for the Athy sources (refer to Section 8.12.2). They are also difficult to determine given the generally flat topography and the karstified nature of the bedrock. Consequently, the ZOC needs to be big enough to incorporate the catchments of several sources and significant safety margins are required to allow for the variability of groundwater flow within bedrock aquifers. The proposed boundaries have therefore been extended to incorporate the most significant topographic hills in the plains area whilst allowing for a significant safety margin.

Note that the area delineated by these boundaries is significantly greater than the area required to supply sufficient diffuse recharge to meet the abstraction demand at the various supply sources. However, given the uncertainties outlined above, it is difficult to justify boundaries which delineate a smaller area.

9.10.3 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 and viral contamination and it is based on the 100-day time of travel (ToT) to the supply. Estimations of the extent of this area cannot be made by hydrogeological mapping and conceptualisation methods alone. Due to the karstified nature of the limestone aquifer, it is probable that a large proportion of groundwater in the ZOC can travel to the public supply well in less than 100 days. (While this conclusion is arguable, it is advisable to take the precautionary approach in view of the uncertainties concerning flow in karstic limestones.)

Using a permeability value of 15 m d^{-1} , porosity of 0.01 and pumping gradients estimated using the Theim equation, the 100 day ToT is estimated from Darcy's Law to be approximately 300 m for the source.

Given the generally high permeability, gradients should not be significantly influenced by pumping rate and, though they are significantly smaller sources, the inner protection areas for the "Housing" and "Quarry" boreholes are also taken to be 300m.

Inner protection areas for all three supplies are presented in Map 8.

9.11 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. The final groundwater protection zones are shown in Map 8. The matrix of source protection zones is given in Table 8. The vulnerability ratings for County Laois are taken directly from the Laois Groundwater Protection Scheme (Deakin, J. *et al*, 2002). Due to shallow rock and outcrop in the western part of the source protection area these areas are extremely and highly vulnerable to contamination.

Table 8 Matrix of Source Protection Zones at Castlemitchell.

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

9.12 Potential Pollution Sources

Agriculture is the principal activity in the area. Most of the land is used for tillage, although a small proportion is used for pasture. Potential hazards include farmyards, septic tank systems, application of fertilisers (organic and inorganic), pesticides, and possible spillages along the roads. No door to door survey of specific hazards was carried out as part of this study. The available nitrates, chloride and bacteriological data suggest that groundwater is being contaminated by organic wastes within the catchment of the source. Given that nitrate levels are dropping while chloride is static, it may be that there are two or more types of hazard contributing to contaminant levels in the source (e.g. domestic wastewater treatment systems, landspreading of organic wastes, landspreading of inorganic fertilisers) and it may be that nitrate loadings from one of these hazards (e.g. inorganic fertilisers) have been decreasing in recent years.

9.13 Conclusions and Recommendations

- ◆ The source comprises a small production borehole abstracting about $80 \text{ m}^3 \text{ d}^{-1}$ which is located in a **regionally important** karst aquifer, that has some development potential (**Rk^d**).
- ◆ The source varies from being moderately vulnerable to contamination near the borehole to extremely vulnerable at the western part of the outer protection area.
- ◆ Septic tank systems, farmyards, landspreading of organic and inorganic wastes, the graveyard and runoff from the roads are the main potential hazards in the area.

- ◆ 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.
 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 full scale pumping test be carried out to estimate the yield of the well and to improve the hydrogeological understanding of the area.