Environmental Protection Agency

Establishment of Groundwater Source Protection Zones

Portlaoise Water Supply Scheme

Meelick Borehole

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Suirbhéireacht Gheolaíochta Éireann

PROJECT DESCRIPTION

Since the 1980's, the Geological Survey of Ireland (GSI) has undertaken a considerable amount of work developing Groundwater Protection Schemes throughout the country. Groundwater Source Protection Zones are the surface and subsurface areas surrounding a groundwater source, *i.e.* a well, wellfield or spring, in which water and contaminants may enter groundwater and move towards the source. Knowledge of where the water is coming from is critical when trying to interpret water quality data at the groundwater source. The Source Protection Zone also provides an area in which to focus further investigation and is an area where protective measures can be introduced to maintain or improve the quality of groundwater.

The project "Establishment of Groundwater Source Protection Zones", led by the Environmental Protection Agency (EPA), represents a continuation of the GSI's work. A CDM/TOBIN/OCM project team has been retained by the EPA to establish Groundwater Source Protection Zones at monitoring points in the EPA's National Groundwater Quality Network.

A suite of maps and digital GIS layers accompany this report and the reports and maps are hosted on the EPA and GSI websites (www.epa.ie; www.gsi.ie).

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1 Introduction

Groundwater Source Protection Zones are delineated for the Meelick Borehole which delivers to the Portlaoise and the Ballyroan Water Supply Schemes, according to the principles and methodologies set out in 'Groundwater Protection Schemes' (DELG/EPA/GSI, 1999) and in the GSI/EPA/IGI Training course on Groundwater Source Protection Zone Delineation.

The objectives of the report are as follows:

- To outline the principal hydrogeological characteristics of the area surrounding the source.
- To delineate source protection zones for the borehole.
- To assist the Environmental Protection Agency and Laois County Council in protecting the water supply from contamination.

Groundwater protection zones are delineated to help prioritise the area around the source in terms of pollution risk to groundwater. This prioritisation is intended as a guide in evaluating the likely suitability of an area for a proposed activity prior to site investigations. The delineation and use of groundwater protection zones is further outlined in 'Groundwater Protection Schemes' (DELG/EPA/GSI, 1999).

The maps produced are based largely on the readily available information in the area, a field walkover, test pumping, water levels and 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 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 Methodology

The methodology comprised data collection, desk studies, site visits, field mapping of karst features, sinking streams and exposures, hydrogeological mapping, well audits and water level recording. Analysis of the information collected during the studies was used to delimit the SPZ. Site visits (including interview on 8th July 2010 with caretaker), site walk-overs, field mapping were conducted during July and November 2010.

3 Location, site description and well head protection

The Meelick Borehole (Photograph 1), is located 1.6 km south of Portlaoise town centre along the R426 (Figure 1). The borehole, which is neither grouted nor capped, though is finished above ground level, is contained in metal housing within a fenced and gated Local Authority compound. The photographs show the well head; the large concrete chamber behind the well head chamber is the storage chamber for delivery to the Ballyroan WS. The borehole contributes to both the Portlaoise Water Supply and the Ballyroan Water Supply Schemes.

4 Summary of borehole details

	Meelick (Portlaoise WS)
EU Reporting Code	IE_SE_G_003_11_011
Grid reference	E244898 N197078
Townland	Meelick

Source type	Borehole
Owner	Laois County Council
Ground level at borehole	96.5 m OD
Depth of Borehole	14 m (Laois GWPS)
Construction	8"steel casing
Depth to rock	14 m
Static water level (bgl)	3.03 m 11th August 1998
Pumping water level (bgl)	8 m 8th July 2010
Current abstraction rate (Co Co records)	14.7 l/s @ 24hours/d (1190–1270 m^3/d (2010) of which 400–450 m^3/d to Ballyroan WS)
Specific Capacity (SC)	635 m^3/d/m (763 m^3/day for a drawdown of 1.2 m; 1998 GSI) …………………………………………… 254 m^3/d/m (1270 m^3/day for a drawdown of 5 m; 2010)
Transmissivity	510 m^2/d (GSI, 1998), based on pump test) 310 m^2/d (2010, based on SC)

Photographs of Meelick Borehole showing the well head and the large storage chamber used for augmentation to Ballyroan WS.

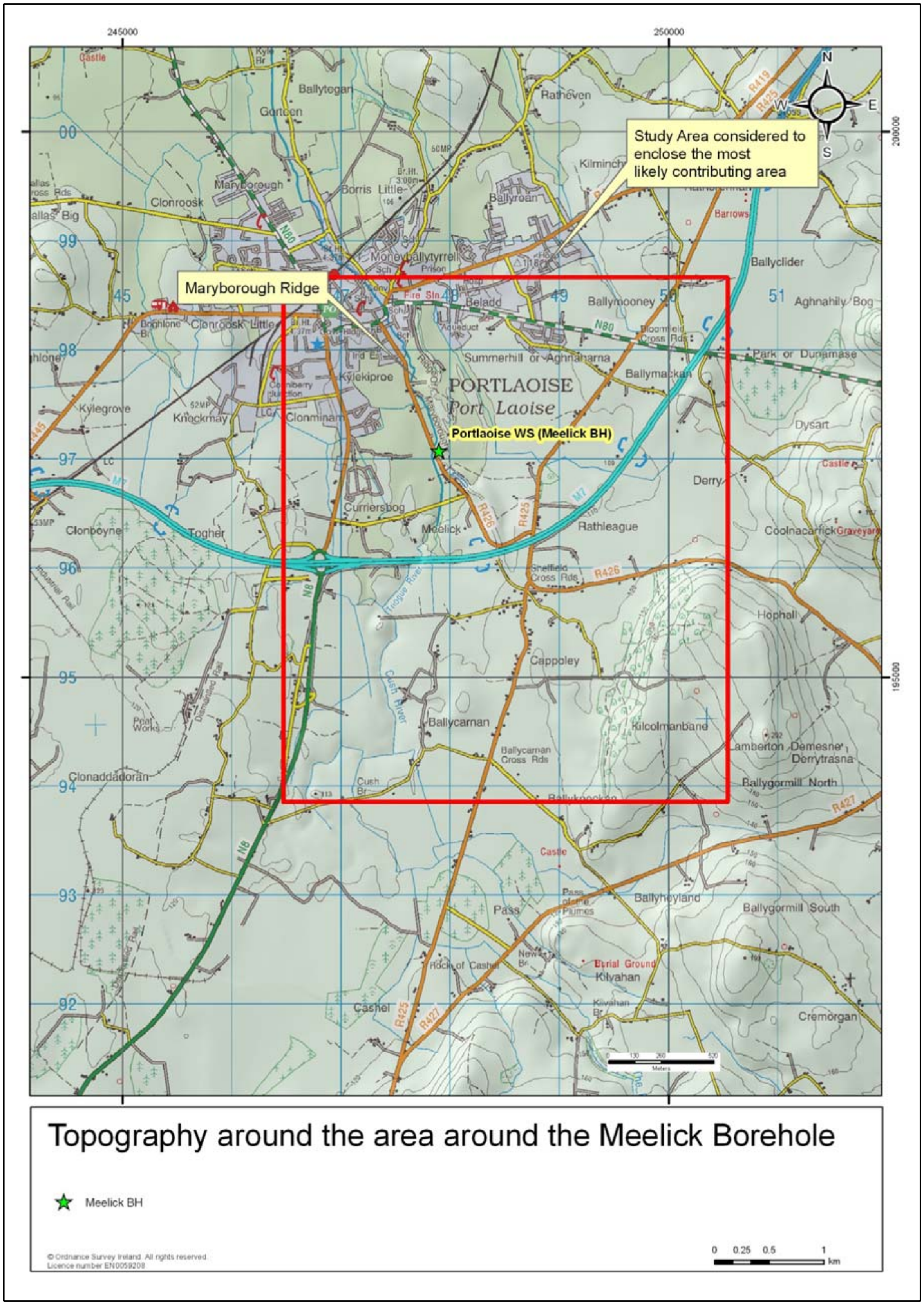

Figure 1 Location and topography surrounding Meelick Borehole

5 Topography, surface hydrology and landuse

5.1 Topography

The regional topography around Portlaoise comprises a relatively flat plain, gently sloping towards the north and set at approximately 90 m OD. Several hills which rise to over 200 m OD occur 2–3 km to the east and southeast of the town. Although at a regional scale the area around Portlaoise and the borehole appears to be relatively flat, there is a small narrow ridge, referred to as 'Maryborough Ridge' that passes through Portlaoise from Mountmellick at the north to Sheffield Crossroads at the south. The ridge forms a discontinuous, sinuous esker, that has an amplitude of approximately 10 m. The borehole is located on the flank of this 'Maryborough Ridge'.

The high hills to the east are approximately 2.5 km southeast of the borehole, and the topography begins to rise gently towards them, with a change to steep gradients just east of Cappoley into Kilcolmanbane (Figure 1 and 3). The topographic slope from the borehole to the lowermost flanks of the hill to its southeast is approximately 0.01 (Figure 1 and Figure 3).

5.2 Surface Hydrology

The Triogue River is the main surface water feature in the area, located approximately 50 m west of the Meelick Borehole, and meanders northwards (Figure 1).

East of the Meelick Borehole, by 250 m, two smaller streams flow northwards passed the source. One originates from small springs on the northern eastern and northwestern flanks of hill southeast of the source, flows toward the borehole but swings to the north approximately 500 m east of the source, just where Maryborough Ridge occurs. It flows to an aqueduct in Portlaoise where it is assumed that it is conveyed to the Triogue underground. Field investigations suggest that this stream is permanent along its course. The second stream, immediately east of the source originates immediately south of the source, and appears to issue from an old gravel pit. According to the caretaker this is not a natural discharge, but was developed during the working of the pit and continues flowing north past the borehole to the aqueduct today.

There are three other smaller streams issuing from the lower western flanks of the hill at Kilcolmanbane, that sink in the townlands of Cappoley and along the townland boundary of Ballycarnan/Ballyknockan respectively, shown in Figure 3. Links to locations of the sinking streams *via* the OSI website is given in Appendix 1.

Directly 1 km south of the borehole, there is a small stream joining the Triogue in the townland of Meelick.

There are springs located at the toe slope of the hill at Kilcolmanbane, at Rathleague, at Derry, west of Sheffield Crossroads, and immediately north of the Meelick Borehole discharging to the Triogue, including the now obliterated Tobergaddy Spring adjacent to the Meelick source along the northern boundary of the compound (Figure 3). The Tobergaddy spring location can be seen on the OSI 6"inch maps, shown in Figure 2 – link given in Appendix 1. The spring dried completely after the construction and subsequent abstraction of the new borehole, according to the caretaker. Rathleague spring is recorded by GSI as a 'Warm' Spring, shown on the inset in Figure 4 and was recorded on the initial geological six inch sheets to have a temperature of 14^{o}C. It is close to a mapped fault.

5.3 Landuse

The borehole occurs on the outskirts of Portlaoise, thus there is both urban and rural activities in the vicinity. The borehole itself is located in a council compound, adjacent to a livestock market and to the north there are garages and workshops and small factory units. Agricultural land use in the vicinity of the borehole is split equally between tillage and pasture. The fields are relatively large and free draining, without notable drainage ditches or rush-dominated areas. There is a dense road network, including the M7 motorway, approximately 1 km south of the borehole.

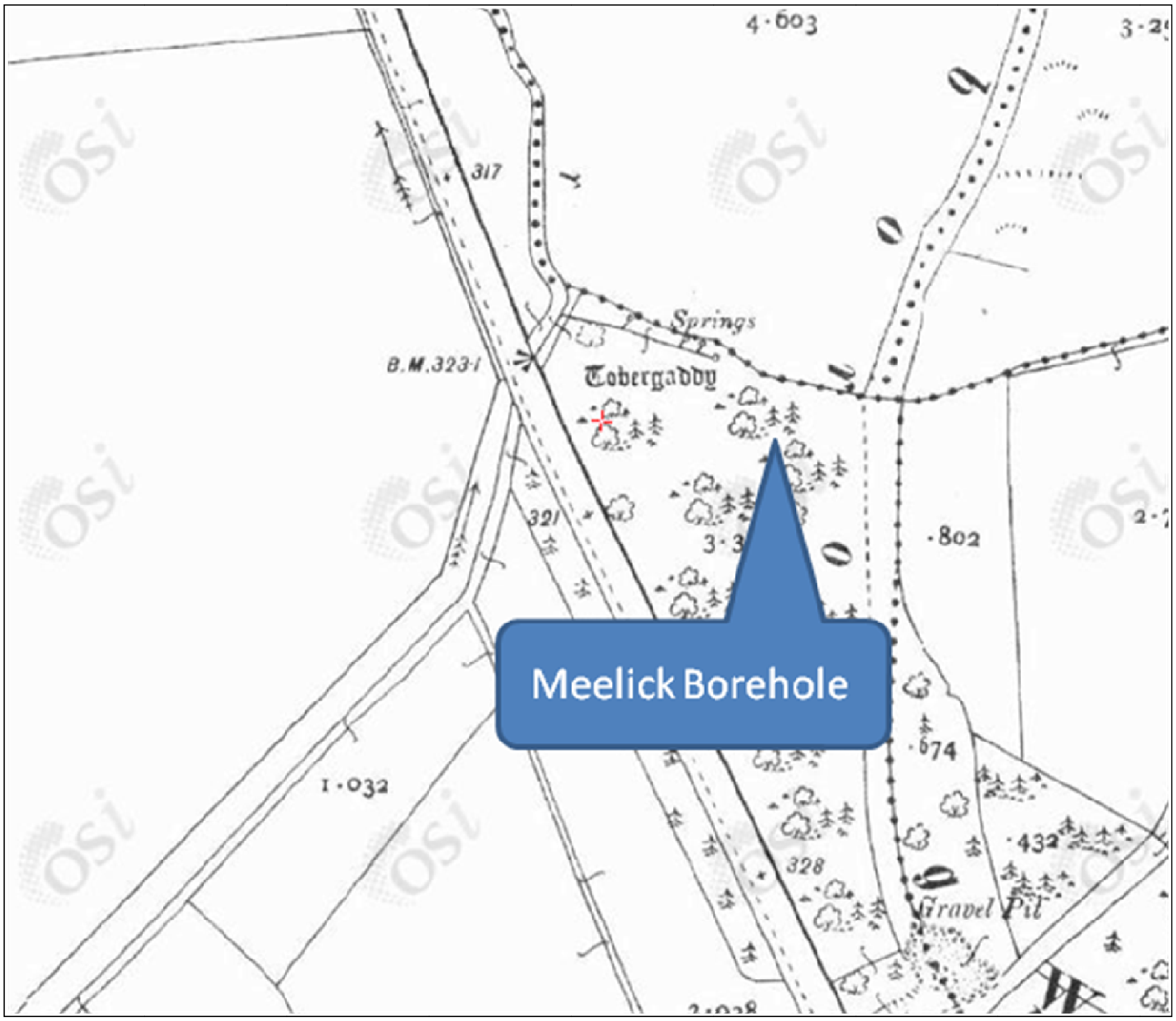

Figure 2 The original spring - Tobergaddy, no longer exists, and location of Meelick Borehole

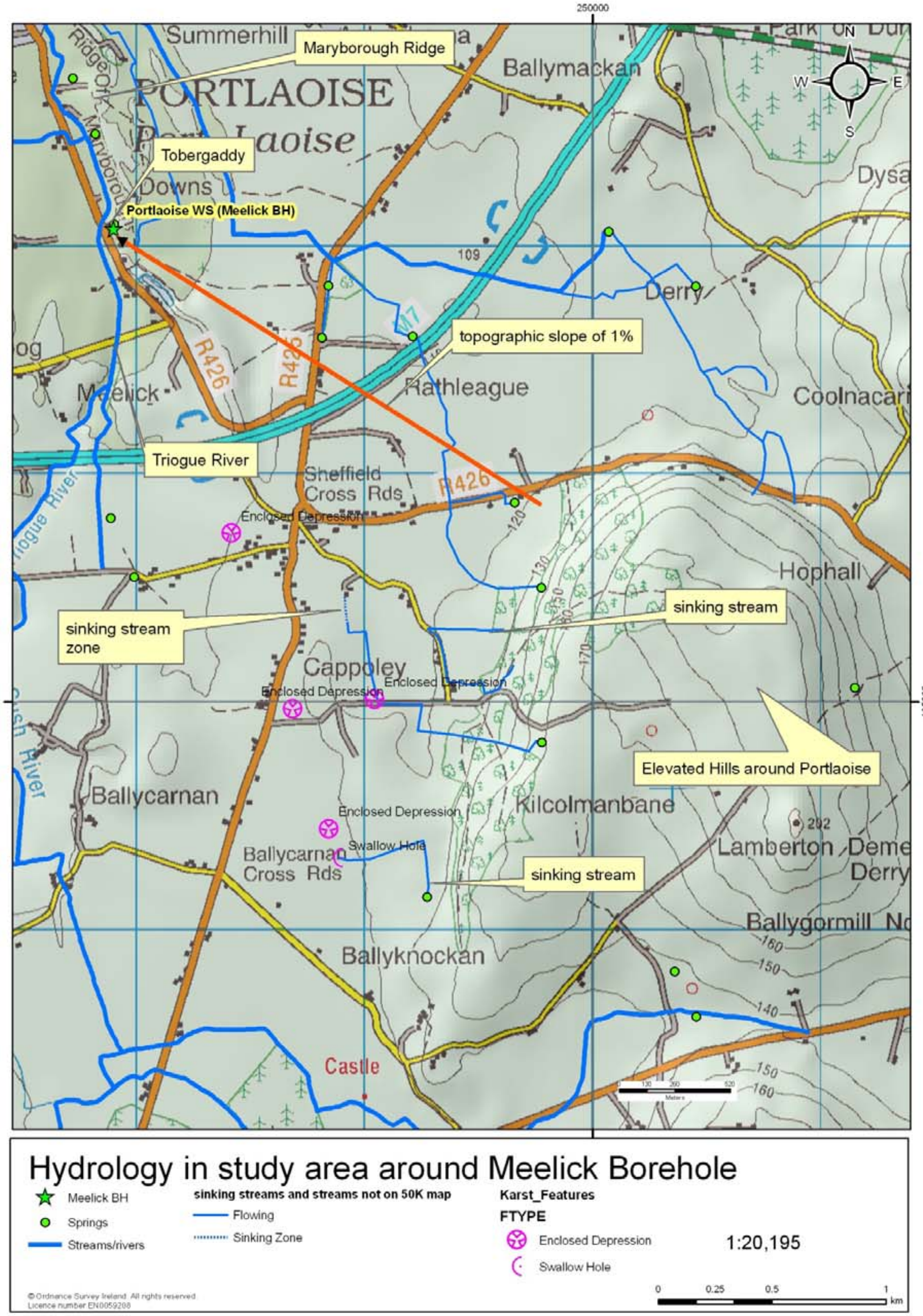

Figure 3 Hydrology in the study area

6 Hydro-meteorology

Establishing groundwater source protection zones requires an understanding of general meteorological patterns across the area of interest. The data source is Met Eiréann.

Annual rainfall: taken to be 900 mm. The contoured data map of rainfall in Ireland (Met Éireann; 1961–1990 dataset) shows that the source is located between the 800–1000 mm annual rainfall isohyets.

Annual evapotranspiration losses: 428 mm. Potential evapotranspiration (P.E.) is estimated to be 450 mm/yr (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 giving an Actual Evapotranspiration of 428 mm.

Annual Effective Rainfall: 472 mm. The annual effective rainfall is calculated by subtracting actual evapotranspiration from rainfall. Potential recharge is therefore, 472 mm/year. See also Section 10 on Recharge which estimates the proportion of effective rainfall that enters the aquifer.

7 Geology

This section briefly describes the relevant characteristics of the geological materials that underlie the area around the Meelick Borehole. It provides a framework for the assessment of groundwater flow and source protection zones. The geological information is based on:

- the bedrock geological map of Galway and Offaly, Sheet 15, 1:100,000 Series (Geological Survey of Ireland (GSI), 2003) and accompanying memoir (Gatley *et al*, 2003),
- the GSI Well, Borehole and Karst Databases,
- the EPA Soil and Subsoil Map of County Laois (Teagasc 2006a and b), and on,
- bedrock outcrop and subsoil exposures encountered and mapped during site visits.

7.1 Bedrock

The region around the borehole is underlain by Dinantian Lower Impure Limestones, Dinantian Pure Bedded Limestones, and Namurian Shales (Figure 4). There are two major northeast-southwest trending faults bounding the Pure Bedded Limestones which underlie the borehole. The Namurian Shales occupy the hills southeast of the borehole.

Prior to the field mapping there were no recorded karst features in the study area apart from Rathleague spring, recorded as a 'Warm' Spring. Field mapping revealed enclosed depressions, sinking streams and a swallow hole, shown in Figure 4. Also shown in Figure 4 is the location of a private well/borehole reported by the owners to be into limestone. This new evidence suggests the mapped faulted bedrock boundary between the limestones and shales is approximately 700–800 m further east than currently mapped, probably close to the base of Kilcolmanbane Hill.

7.2 Soils and subsoils

Alluvium and shallow soils occupy the area immediately around the source, associated with the alluvial and gravel river deposits along the Triogue: shallow, dry soils of basic reaction are located along the esker, whilst shallow wet mineral soils of basic reaction are located in the lowest areas, alongside the river. The hill is covered with an assemblage of acidic, shallow and deep (well drained and poorly drained) soils. Across the intervening area, the soils are predominantly deep, well drained soils of basic reaction, with the exception of some poorly drained soils of basic reaction, and lacustrine clays, associated with small streams, drains and springs (Figure 5).

The subsoils comprise glacial till, glaciofluvial sand and gravel, alluvium and pockets of lacustrine clays (Figure 6). The alluvium and sand and gravel are mapped primarily along the Triogue River. However, in addition, the site investigation data for the M7 indicate that sand and gravel is also present where the motorway runs northeast through Rathleague, and beneath the glacial till where the motorway passes the old R426. These data suggest that the sand and gravel sits directly on top of the bedrock.

The Maryborough Ridge is an esker, which pokes through the sand and gravel deposit. In the immediate vicinity of the borehole, the river meanders toward the west of the sand and gravel, thus the bulk of the deposit is on the east. It is on the lower flanks of the sand and gravel adjacent to the river that the Meelick Borehole is situated. The alluvium is coarse grained where exposed along the river bank west of the source.

The hill of Knockcolmanbane is dominated by shallow rock and till derived from Namurian shales and sandstones (TNSSs). The intervening area is mapped as till derived from limestones (TLs). Small pockets of lacustrine clays are located around Rathleague, approximately 1 km southeast of the borehole. Cuttings into the limestone till suggest moderately permeable deposits, classed as free draining gravelly SILT using BS5930.

7.3 Depth to rock

The depth to rock at the source is reported to be 14 m and on the hill at Kilcolmanbane rock is exposed. Across the gentle incline from the source to the hill, outcrop/rock close to the surface is also mapped north and south of Sheffield crossroads. The site investigation data for the M7 indicate minimum depths of 3–4 m to greater than 11 m, with the majority of the data in the region of 5–10 m.

Further, the site investigation data indicate that where the motorway crosses the mapped alluvium and sand and gravel, the minimum depth is 6 to 7 m, and till is not present. In the vicinity of the sinking streams, a new slatted shed is being built and the depth to rock is reported to be approximately 3 m. Hand augering along one of the sinking stream zones shown in Figure 3 indicates rock is probably less than 0.5 m.

8 Groundwater vulnerability

Groundwater vulnerability is dictated by the nature and thickness of the material overlying the uppermost groundwater 'target'. 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 *et al*, 2003).

A groundwater vulnerability map for the area, shown in Figure 7, has been prepared for County Laois by the GSI (Deakin *et al*, 2000) and in the vicinity of Meelick where the gravels occur, the groundwater vulnerability is mainly mapped as '***High***'. As well as this, across the till dominated area, the vulnerability is also '**High'**, becoming ***'Moderate'*** as the tills deepen from east to west. Across Kilcolmanbane and lower flanks, the vulnerability is mapped as ***'Extreme',*** which includes the area that is designated as rock at / or close to surface, denoted as **'X'**. The remaining portion classified as '***Extreme***' is considered to comprise subsoils and soils with a depth of between 1 m and 3 m.

Following from the current fieldwork for this project, extra data collected showed that revisions to the existing vulnerability map of the Laois groundwater Protection Scheme are required. It is proposed that an '**Extreme'** buffer of 30 m is applied to the karst features and sinking stream. Along the sand and gravel deposit beside the river, the water table is at a depth of 3 m or less, and as this area is in a gravel aquifer (Section 8.5 Aquifer Characteristics), it is proposed that the vulnerability is categorised as **'Extreme'** here.

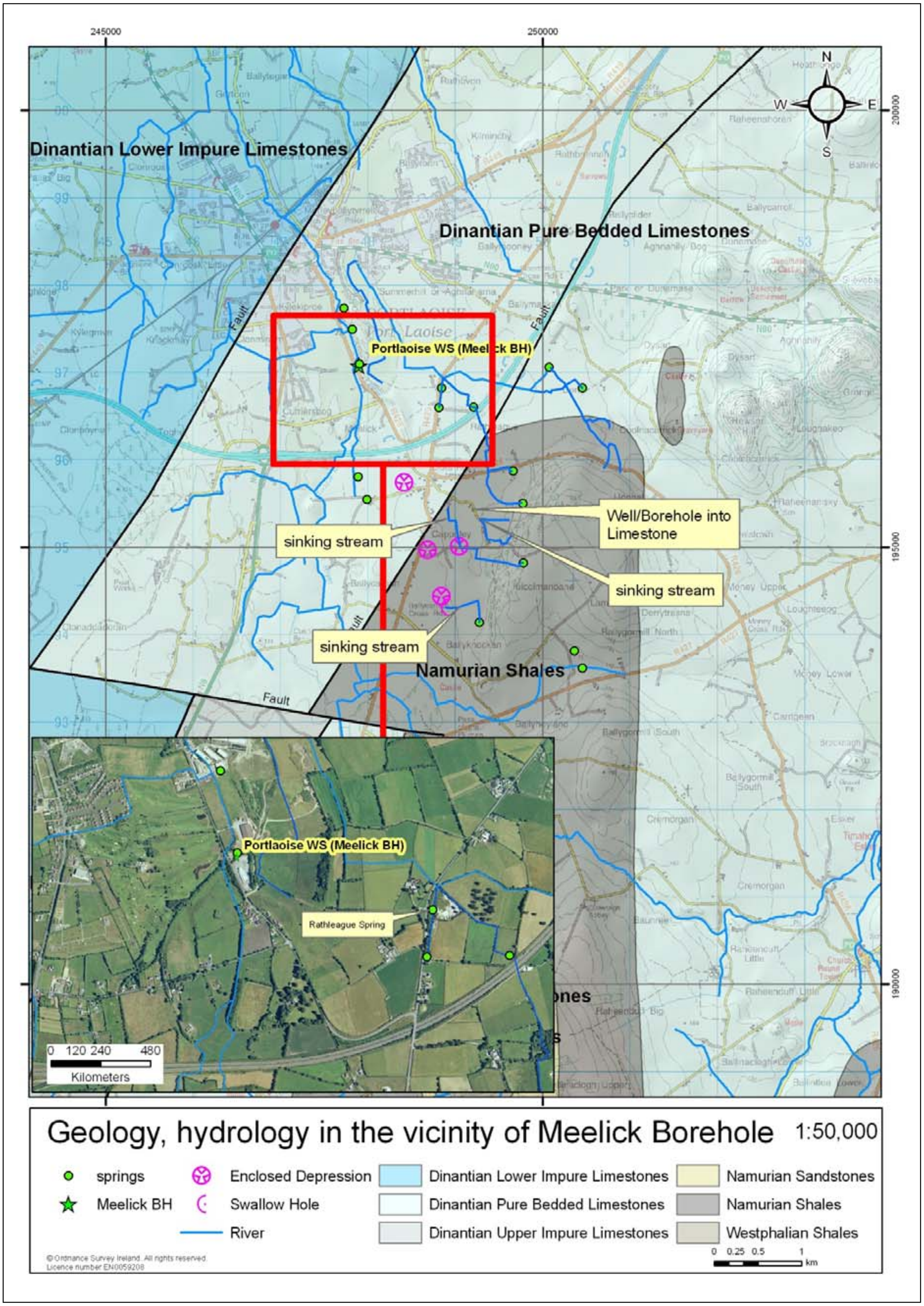

Figure 4 Geology and Hydrology in the vicinity of Meelick

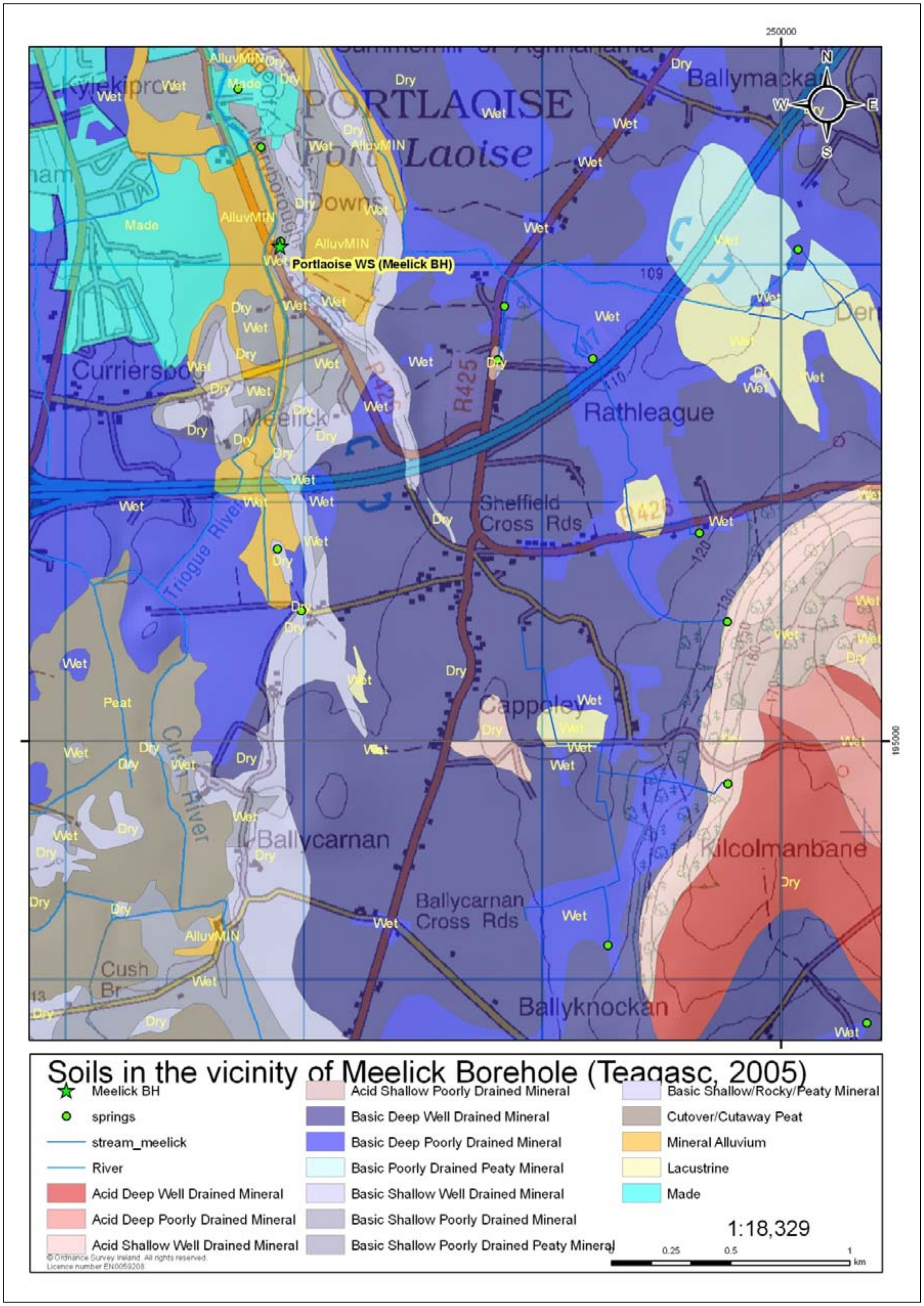

Figure 5 Soils in the vicinity of Meelick (Teagasc, 2006)

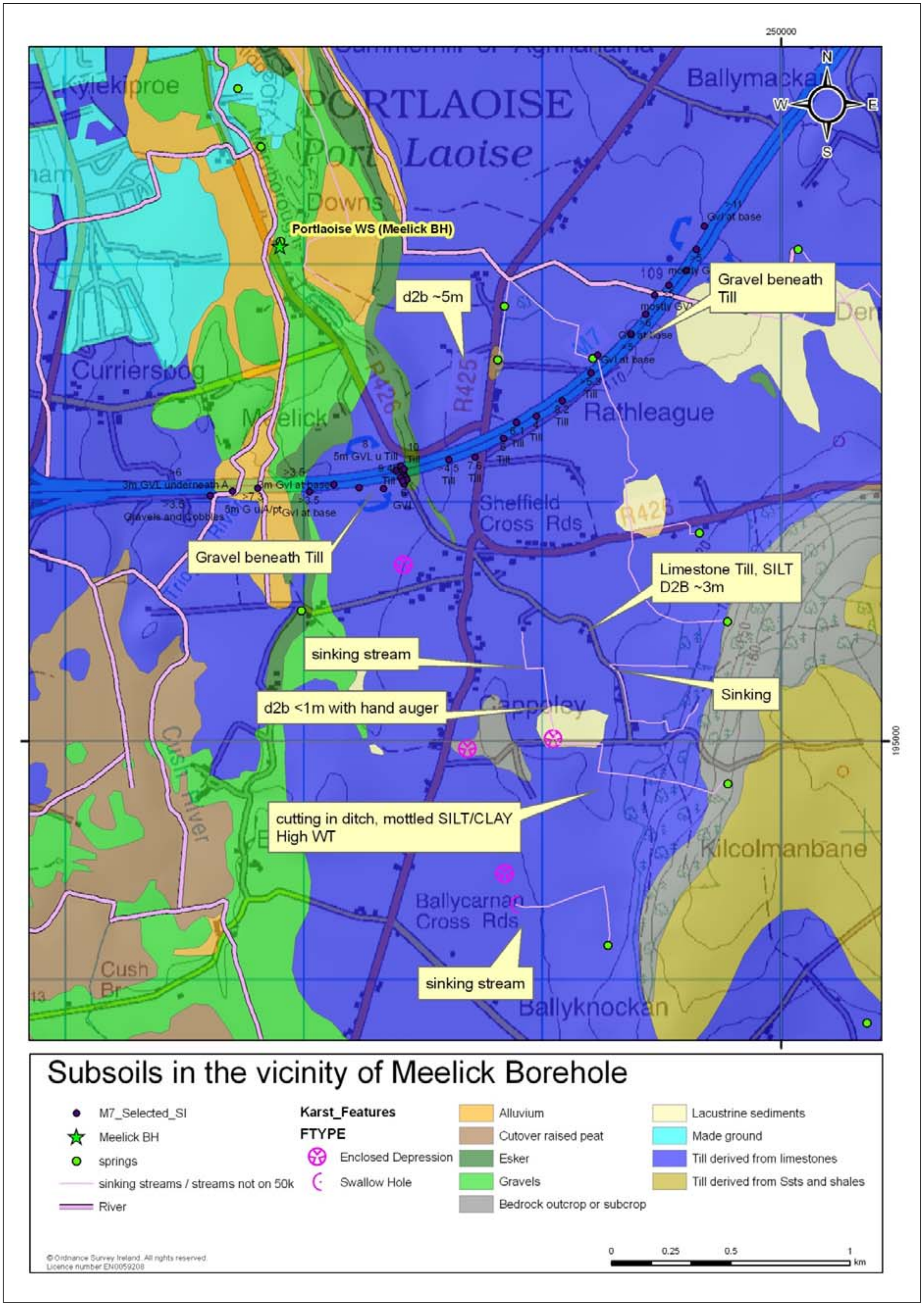

Figure 6 Subsoils in the vicinity of Meelick

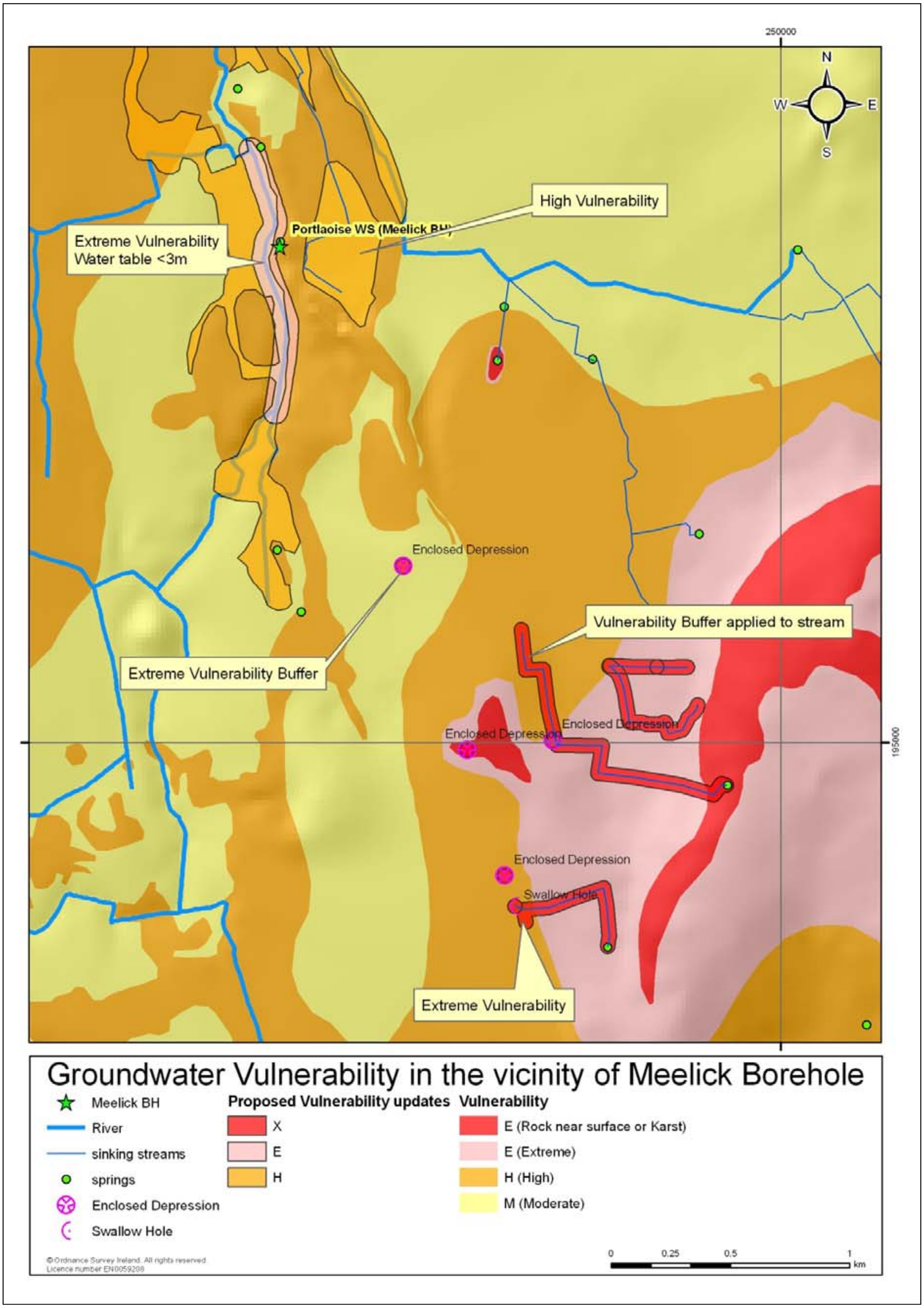

Figure 7 Groundwater Vulnerability with proposed updates indicated around Meelick

9 Hydrogeology

This section describes the current understanding of the hydrogeology in the vicinity of the Meelick borehole. Hydrogeological and hydrochemical information was obtained from the following sources:

- GSI Website and Databases
- County Council Staff
- EPA website and Groundwater Monitoring database
- Local Authority Drinking Water returns
- Test pumping 1998 for Laois Groundwater Protection Scheme (Deakin *et al,* 2000)
- Hydrogeological mapping by TOBIN Consulting Engineers 2010.

9.1 Groundwater body and status

The source is located in the 'intergranular' Mountmellick Groundwater body (GSI, 2004), that is classified as having 'Good Status'. It is a narrow, north-south body corresponding to the sands and gravels paralleling the Triogue River. This groundwater body sits on the 'karstic' Bagnelstown Groundwater Body, also of 'Good Status'. The groundwater body descriptions are available from the GSI website: www.gsi.ie and the 'status' is obtained from the WFD website: www.wfdireland.ie .

9.2 Groundwater levels, flow directions and gradients

The regional surface water flow direction is northwards, and it is assumed that the regional groundwater flow direction is similar. The Triogue is considered to be a groundwater discharge zone and the base level in the area. The static water level in the Meelick borehole is recorded at 3 m bgl at the start of the pumping test conducted in 1998 (Deakin, 2000) and water levels in a number of wells (mostly dug wells) indicate a high water table (0.78–2.5 m bgl). The static water level is similar to the level in the river, whilst the current pumping water level is approximately 7 m below the river level.

The bedrock is karstified and there are sinking streams in the vicinity of Cappoley, and it is not known where they are connected to, although most likely toward the Triogue, perhaps discharging to springs and a small stream tributary of the Triogue. It is considered that the groundwater flow in the gravels in the immediate vicinity of the borehole is sub-parallel to the river. The orientation of the esker is N-S and it is expected to be a zone of preferential flow as it is coarser and it pokes up through the main gravel deposit. Therefore it may act as a conduit for groundwater flow.

It is assumed that in general, the groundwater table mirrors the topography, and that across the area it is relatively shallow. It is likely to be, initially downwards across the Namuarian Shales into the Karstified Limestones, then flat across the limestones towards the Triogue. As groundwater discharges into the river and into the gravels near the river there is expected to be an upwards gradient component. Groundwater gradients are expected to be less than the local topographic gradient of 0.01, in the order of 0.005.

9.3 Hydrochemistry and water quality

The hydrochemical analyses of 35 untreated groundwater samples show that the water is very hard, with total hardness values of 236–733 mg/l (equivalent CaCO3) and electrical conductivity (EC) values of 592 – 816 µS/cm (average 745 µS/cm), indicating that the groundwater has a calcium bicarbonate hydrochemical signature (EPA data). Alkalinity ranges from 300–450 mg/l CaCO3. The pH ranges 7.2–

7.8, with an average of 7.4, which is slightly alkaline. Figure 8 shows the data for the key indicators of contamination and the main points are as follows:

- Nitrate concentrations range from 6.3–19.5 mg/l with a mean of 15.3 mg/l. The mean is less than the groundwater Threshold Value (Groundwater regulations S.I. No. 9 of 2010) value of 37.5 mg/l and there are no peaks above the standard (50 mg/l) set out in the Drinking Water Regulations (S.I. No. 278 of 2007). There is a downward trend in the data, shown in Figure 8, particularly due to recent data – from October 2008 to present.

- Chloride is a constituent of organic wastes, sewage discharge and artificial fertilisers, and concentrations higher than 24 mg/l (Groundwater Threshold Value for Saline Intrusion Test, Groundwater Regulations S.I. No. 9 of 2010) may indicate contamination, with levels higher than 30 mg/l usually indicating significant contamination (Daly, 1996). Chloride concentrations range from 14 to 54 mg/l with a mean of 22 mg/l, however, there has been an increasing trend in concentrations, with 13 of the last 18 samples (February 2005 to November 2009) at or above 24 mg/l; the most recent sample on 18/11/2009 at 54.4 mg/l. It is not clear as to the cause but there is a significant non-agricultural landuse in the vicinity including the council compound itself, the livestock market and the road network – there may be a significant contribution of winter road salt.

- The average concentration of Molybdate Reactive Phosphorous (MRP) is 0.01 mg/L P, which is below the Groundwater Threshold Value (Groundwater Regulations S.I. No 9 of 2010) of 0.035 mg/L P.

- The ratio of potassium to sodium (K:Na) is used to help indicate if water has been contaminated, along with other parameters, and may indicate contamination if the ratio is greater than 0.4 (Cronin *et al*, 1998). The ratio exceeded 0.4 on 29/8/2000, and 23/01/2001 in which case the potassium concentration was elevated – 14 mg/l.

- Faecal coliforms counts have never exceeded Zero. Total coliform counts were exceeded on 12 out of 29 samples.

- Iron concentrations are generally low, but greater than the 0.2 mg/l (the standard set out in the Drinking Water Regulations (S.I. No. 278 of 2007)) on two occasions, 21/11/1996 and 10/11/2004, recorded at 9.126 mg/l and 0.22 mg/l respectively. Manganese and Ammonia concentrations are not elevated.

- Barium concentrations is occasionally elevated, though this is possibly due to undissolved constituent in the sample.

In summary, the water quality is generally good though occasionally contaminated, as evidenced by recently elevated chlorides, iron, potassium:sodium ratio and total coliforms. Fitzsimons (2000) concluded that Meelick was included amongst Laois Groundwater Sources with "*slight anomalies in the analyses which may be naturally induced or indicative of some slight contamination*".

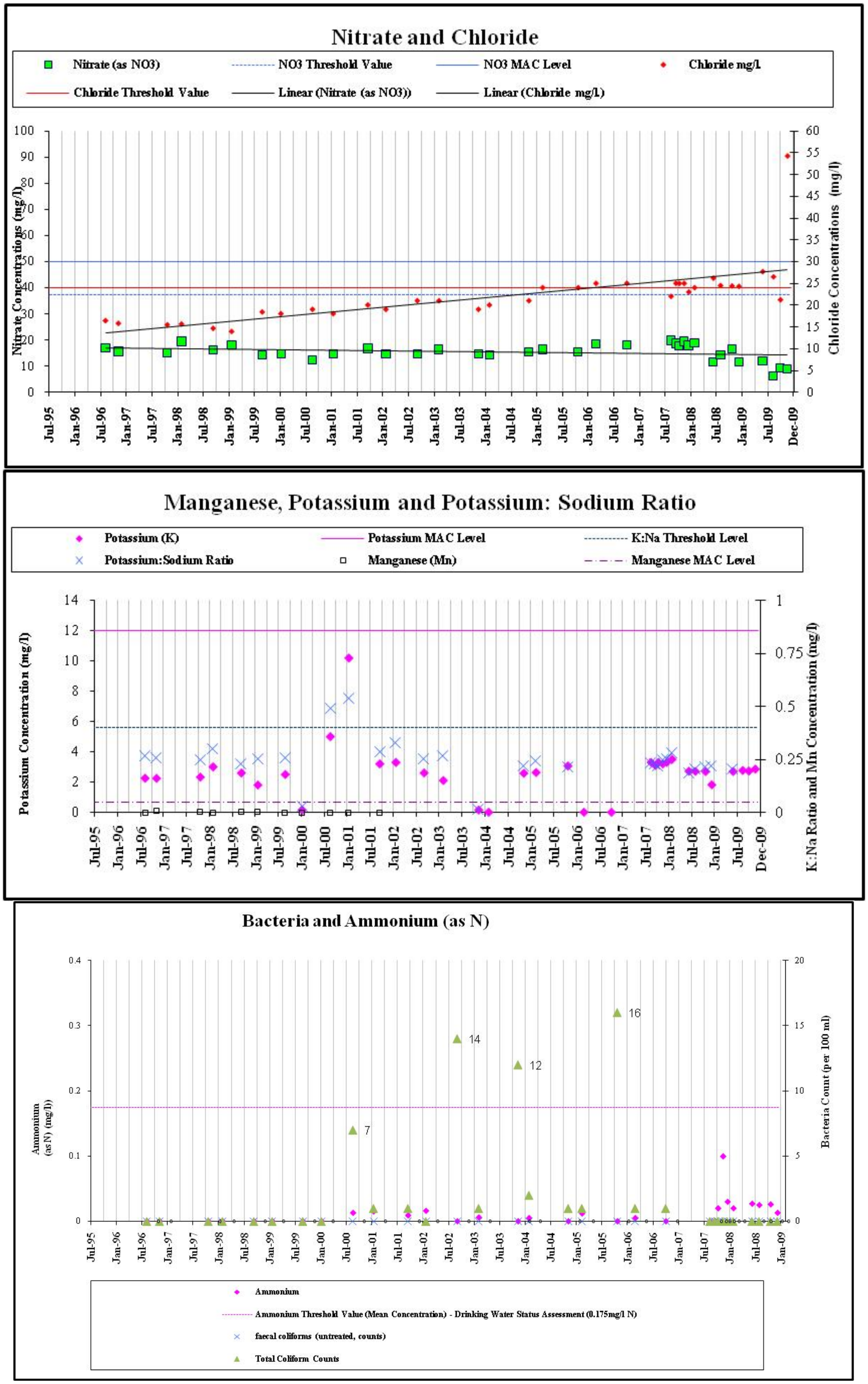

Figure 8 Key Contaminant Indicators at Meelick

9.4 Aquifer characteristics

The Meelick borehole is an ‘Excellent’ yielding borehole; greater than 500 m^3/day, according to the GSI classification, and is located in a Locally Important Sand and Gravel Aquifer (Lg) overlying a Regionally Important Karstified bedrock aquifer (Rk_d).

Test pumping of the borehole was conducted in 1998, and the data are provided in Appendix 3. The abstraction rate was 763 m^3/d, with drawdown recorded at 1.2 m, giving a specific capacity of 636 m^3/d/m, extrapolated to 489 m^3/d/m at the end of a week for that pumping rate. The abstraction rate is currently 1170–1270 m^3/d and the drawdown is approximately 5 m, giving a specific capacity of approximately 254 m^3/d/m. Figure 9 is a plot showing specific capacity against discharge in 1998 and in 2010; it is a measure of ‘Productivity’, developed by GSI (Wright, 1997). It takes account of drawdown, rather than relying on yield alone. The data plots in Class I, indicating a highly productive borehole. Despite the productivity classification, the data show that the increased abstraction rate and corresponding drawdown indicate a significantly lower specific capacity for the current pumping regime.

Figure 10 shows the discharge – drawdown data curve for the test carried out in 1998. The transmissivity was estimated to be 510 m^2/d from the constant rate test and 344 – 583 m^3/day from the recovery data (Deakin and Wright, 2000). The current specific capacity is approximately 254 m^3/d/m, therefore an estimate of the apparent transmissivity based on this data using Logans method of estimating transmissivity would be approximately 310 m^2/d (Misstear, 1998). Transmissivity is related to saturated thickness, thus the difference in apparent transmissivity is due to increased drawdown under the current pumping regime: the borehole draws water from unconfined saturated gravels and lowers the water table around the borehole, thus reducing the thickness of the saturated aquifer The test pumping data show also that equilibrium conditions were not established after 9 hours of pumping.

The aquifer map, shown in Figure 11, illustrates the sand and gravel aquifer overlying the bedrock aquifer. The sand and gravel deposit was named as the Maryborough Esker by Daly (1983) and is currently referred to as the Mountmellick Groundwater Body. The sand and gravel aquifer is a linear elongate deposit occurring along Triogue River, stretching approximately 5 km south of Portlaoise as far north as Mountmellick, some 10 km north of Portlaoise. It is approximately 1 km at its widest and in the immediate vicinity of the Meelick Borehole it is approximately 700 m wide in total, with about 540 m on the Meelick Borehole side of the river. The sand and gravel aquifer, occurring along the river system, naturally has a high water table, and has in general greater than 5 m of saturated thickness. The alluvium shown interspersed with the gravel areas on the subsoils map is coarse grained and is underlain by gravel as evidenced by the site investigation data for the M7. It is assumed that the river and the gravels occur in a discharge zone for the bedrock aquifer. The esker is a feature that sits beneath the main gravel deposit, not on top of the main deposit. It is likely to have high permeability.

Hydrogeological mapping indicates that the limestones extend further east than the GSI bedrock map indicates. The stream flowing across the R426 east of Sheffield Cross roads has a high electrical conductivity (>600 µS/cm) and groundwater temperature (9.1^{o}C) and has a high flow (>5l/s), suggesting, albeit one reading, that it is a gaining stream. There is no evidence that this stream sinks along its course. This also provides evidence for a more easterly position of the Limestone / shale boundary.

How much harder can this borehole be realistically pumped? Currently the pumping water level is about 2 m above the pump level which is not far off the bottom of the borehole. This constrains the pumping regime, if it is considered safe practice to keep the pump from pumping dry. It is assumed that the current pumping regime is stable, i.e. the cone of depression has stabilised. However, the pumping water level should be recorded to provide a long term view. Apart from the construction constraints, the specific capacity data also suggest the sustainable yield has been approached due to the limited saturated thickness of the aquifer.

The permeability of the saturated sand and gravel is calculated using the equation:

$$k = \frac{T}{b}$$

T = aquifer transmissivity (m^2/day);
k = permeability (m/day);
b = saturated thickness.

Therefore for the estimates of T given above, k = 50–60 m/d.

Based on the estimated transmissivity and the hydraulic gradients, the groundwater flow velocity can be estimated based on the equation:

$$v = \frac{T \cdot i}{b \cdot n_e}$$

where: v = average groundwater velocity (m/day);
T = aquifer transmissivity (m^2/day);
n_e = effective porosity (dimensionless)
i = hydraulic gradient; and,
b = aquifer thickness (m).

The gradient is estimated to be 0.005 and the porosity is assumed to be in the order of 10%. Therefore the velocities are in the order of 2.5–3 m/d.

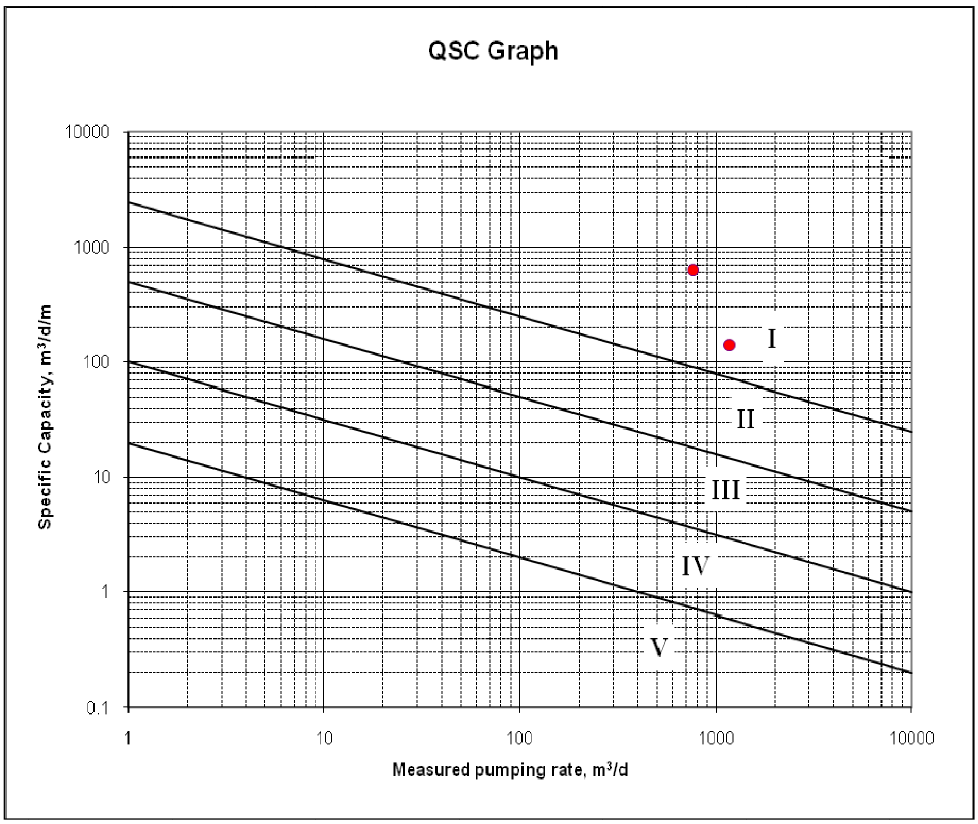

Figure 9 QSC Graph: Meelick Borehole (Portlaoise WS)

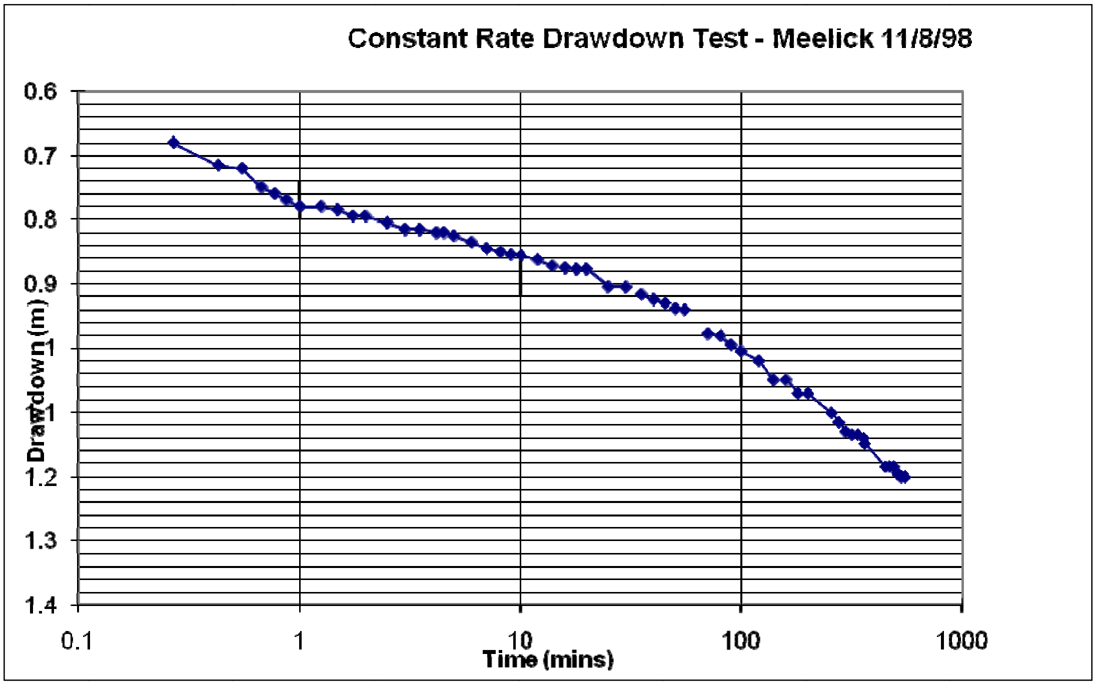

Figure 10 Test pumping at Meelick (GSI, 1998)

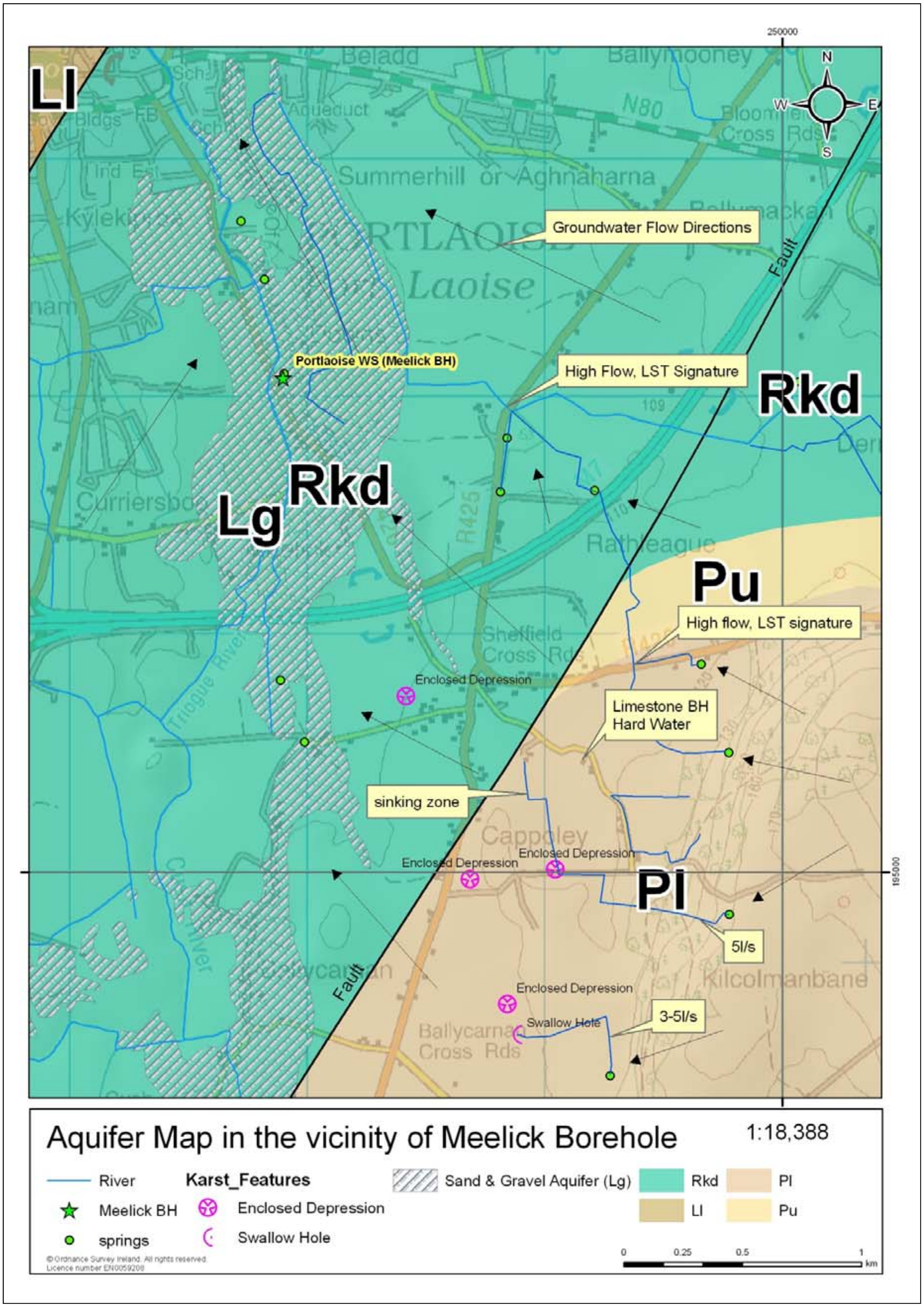

Figure 11 Aquifer Map for Meelick

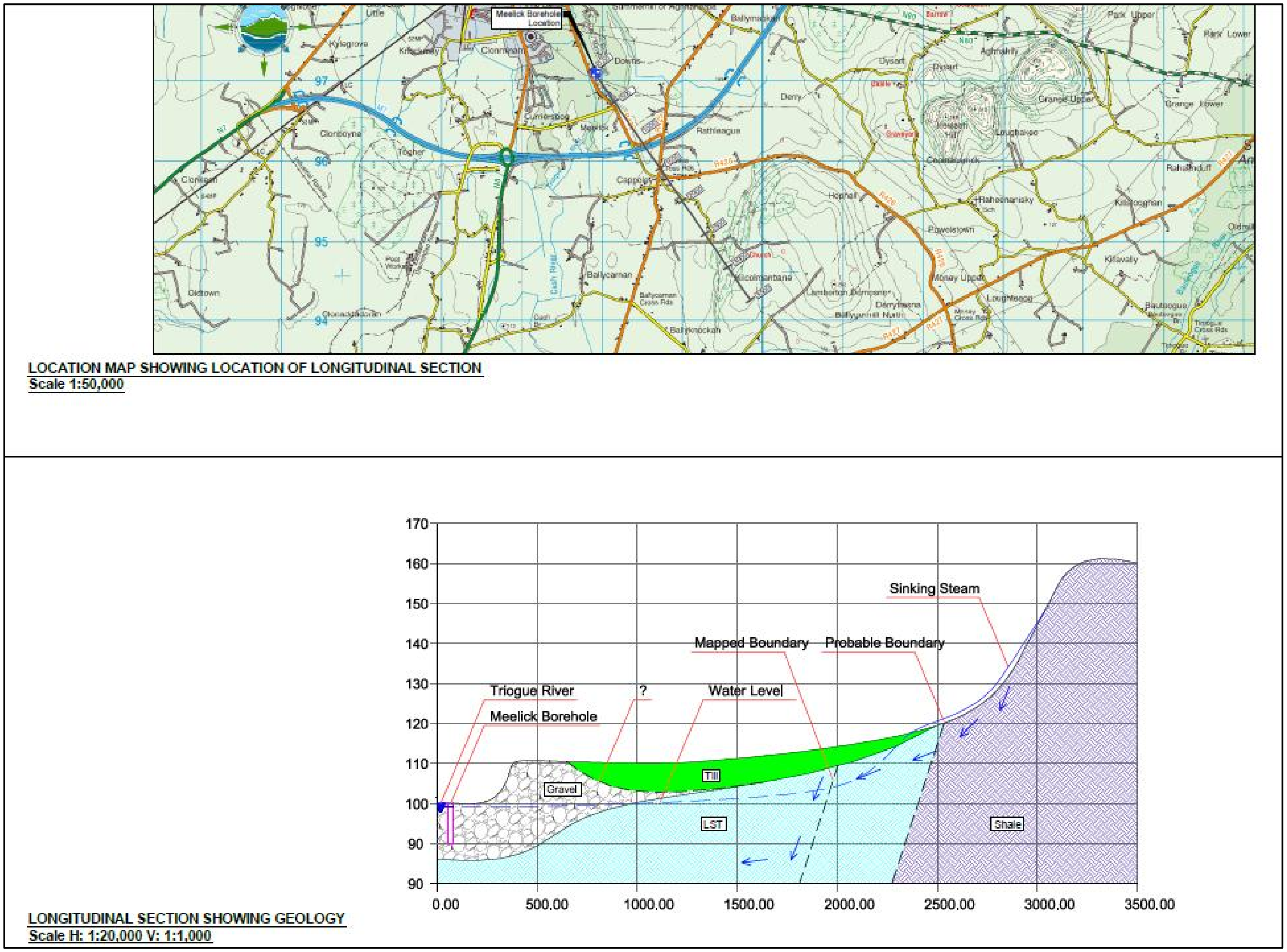

Figure 12 Cross Section illustrating conceptual model for Meelick SPZ

10 Zone of contribution

10.1 Conceptual model

The current understanding of the geological and hydrogeological situation is given as follows. A schematic cross-section illustrating the conceptual model is shown in Figure 12.

The regional topography gently declines northwards, apart from a series of hills to the east and south east of Portlaoise. The streams and rivers concentrate around the River Triogue, which meanders from south of Portlaoise to Mountmellick before joining the River Barrow. Karstified Limestones dominate the area, extending eastwards to a faulted boundary with the Namurian Shales, which correspond to the hilly areas. A linear sand and gravel deposit occupies the valley floor along the course of the Triogue.

The regional groundwater flow is assumed to be NNW and groundwater in the bedrock discharges into the river and the gravels near the river.

The 14 m deep borehole, 50 m from the river, is drawing water from the relatively narrow and shallow gravels overlying the karstified aquifer. Under the current pumping regime, the water level is below the river level, thus may be inducing river water into the gravels.

The gravels and the river are a discharge zone for a large topographic area although it is the saturated gravels encompassing the borehole that primarily provide the supply. It is difficult therefore, to accurately delineate the ZOC for the borehole as it could potentially include the entire topographic and groundwater catchment to the gravels and the river upstream of the borehole. Potential recharge from Kilcolmanbane / sinking streams could end up in the borehole via the gravels. The boundaries, described below are considered to represent the most likely zone of contribution.

10.2 Boundaries

The boundaries of the area contributing to the source are considered to be as follows (Figure 13):

The **Northern Boundary** is based on a combination of hydrogeological mapping and the uniform flow equation (Todd, 1980).

The uniform flow equation (Todd, 1980) is:

$x_L = Q / (2\pi * T * i)$ where

Q is the daily pumping rate (1200 m^3/d)
T is Transmissivity (taken from aquifer characteristics 200 m^2/d)
i is the background non-pumping gradient (0.005).

The uniform flow equation suggests the borehole could pump from 200 m downgradient. The horizontal permeabilities may be greater in the sand and gravel, given the orientation of the esker material and the overall groundwater flow direction and gradient. Therefore the 200 m distance is delineated to be conservative, despite the possible contribution from the river and that there is a kink in the river 90 m north of the borehole, and the position of the original Tobergaddy spring 'inside' that kink in the river.

The **Western and North-western boundaries** are defined by the Triogue river which is considered to be a hydraulic boundary within the gravels. The borehole is 50 m from the river and the pumping water level is approximately 7 m below the river, so that water is potentially being drawn into the gravels. The alluvium is coarse grained and the river is assumed to be in full hydraulic connection with the gravels. However the relatively large drawdown suggests that the borehole cannot pull water easily all the way from the river to the borehole. Therefore it is not expected to draw water from the other side of the river, and further it is not proposed to include the river catchment back upstream. The western boundary extends as far south to include the majority of the gravel on the east side of the river. There is some uncertainty as to the location of this boundary and its extension to the southern boundary. It is possibly over conservative as it extends past a bend in the river just down from the borehole.

The **Southern Boundary and Eastern Boundaries** are considered to be the topographic catchment to the portion of the gravel aquifer that the borehole draws water from. The gravels and the river are a discharge zone for a large topographic area although it is the saturated gravels encompassing the borehole that primarily provide the supply. It is difficult therefore, to accurately delineate the zoc. There is uncertainty about the groundwater flow directions in the underlying karst aquifer and as such uncertainty on the groundwater catchment to the gravels delivering water to the borehole. It is considered, based on hydrogeological mapping, that the stream flowing through Rathleague is a significant gaining stream. It does not appear to sink along its course. There may be conduits that draw the sinking streams outside the ZOC as drawn, and vice versa. The southern boundary sweeps off the hill at Kilcolmanbane in a northwesterly direction allowing groundwater to flow off the hill and then swing north through the limestones.

10.3 Recharge and water balance

The term 'recharge' refers to the amount of water replenishing the groundwater flow system. The recharge rate is generally estimated on an annual basis, and is assumed to consist of the rainfall input (*i.e*. annual rainfall) minus water loss prior to entry into the groundwater system (*i.e*. annual evapotranspiration and runoff). The estimation of a realistic recharge rate is critical in source protection delineation, as this dictates the size of the zone of contribution to the source (*i.e*. the outer Source Protection Area).

At Meelick, the main parameters involved in the estimation of recharge are: annual rainfall; annual evapotranspiration; and a recharge coefficient. The recharge coefficient is estimated using Guidance Document GW5, Groundwater Working Group 2005, which is given in Appendix 2. The recharge over the high and moderately vulnerability areas, comprising moderately permeable till, is mainly diffuse and is in the order of 60% and 35% respectively. There are portions of the area where 'wet' (gleys) are present, particularly along the stream at Rathleague, and accordingly the recharge is a little less — in the order of 30%. In the extremely vulnerable area, at Knockcolmanbane hill, there are 'wet' and 'dry' soils present over the till, thus the recharge is in the order of 25–70%. Point recharge occurs via enclosed depressions and sinking streams. Across the sand and gravels (high water table present) the recharge is taken to be 85%.

These calculations are summarised as follows:

Average annual rainfall (R)	900 mm
Estimated P.E.	450 mm
Estimated A.E. (95% of P.E.)	428 mm
Effective rainfall	472 mm
Recharge coefficient	80%
Recharge	**378 mm**

Water balance: The area described above and shown in Figure 12 is 2.7 km^2, which is 30% greater than that required for the current pumping rate. As it is believed that the source cannot sustain it, the abstraction rate is not increased by 50%. The greater area allows for uncertainty in flow directions and includes the most likely area that feeds the gravels.

11 Source protection zones

The Source Protection Zones are a landuse planning tool which enables an objective, geoscientific assessment of the risk to groundwater to be made. The zones are based on an amalgamation of the source protection areas and the aquifer vulnerability. The source protection areas represent the horizontal groundwater pathway to the source, while the vulnerability reflects the vertical pathway.

Two source areas are delineated and shown in Figure 14:

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

The Inner Protection Area (SI) is based on the 100-day time of travel. Based on the indicative aquifer parameters presented in Section 8.6, the groundwater velocity is 2.5–3.0 m/d, and hence the 100-day time of travel distance is taken to be 300 m.

The Outer Protection Area (SO) is bounded by the complete catchment area to the source, i.e. the zone of contribution (ZOC), described in Section 10 – Zone of Contribution.

Groundwater source protection zones are shown in Figure 15 and the percentage breakdown for the categories is given in Table 11-1.

Table 11-1 Source Protection Zones

Source Protection Zone		% of total area (2.7km^2)
SI/E	Inner Source Protection area / <3 m to water table	1% (0.02 km^2)
SI/H	Inner Source Protection area / High vulnerability	4% (0.11 km^2)
SO/X	Outer Source Protection area / ≤1 m subsoil	15% (0.4 km^2)
SO/E	Outer Source Protection area / <3 m subsoil	24% (0.66 km^2)
SO/H	Outer Source Protection area / High vulnerability	40% (1.1km^2)
SO/M	Outer Source Protection area / Moderate vulnerability	16% (0.42 km^2)

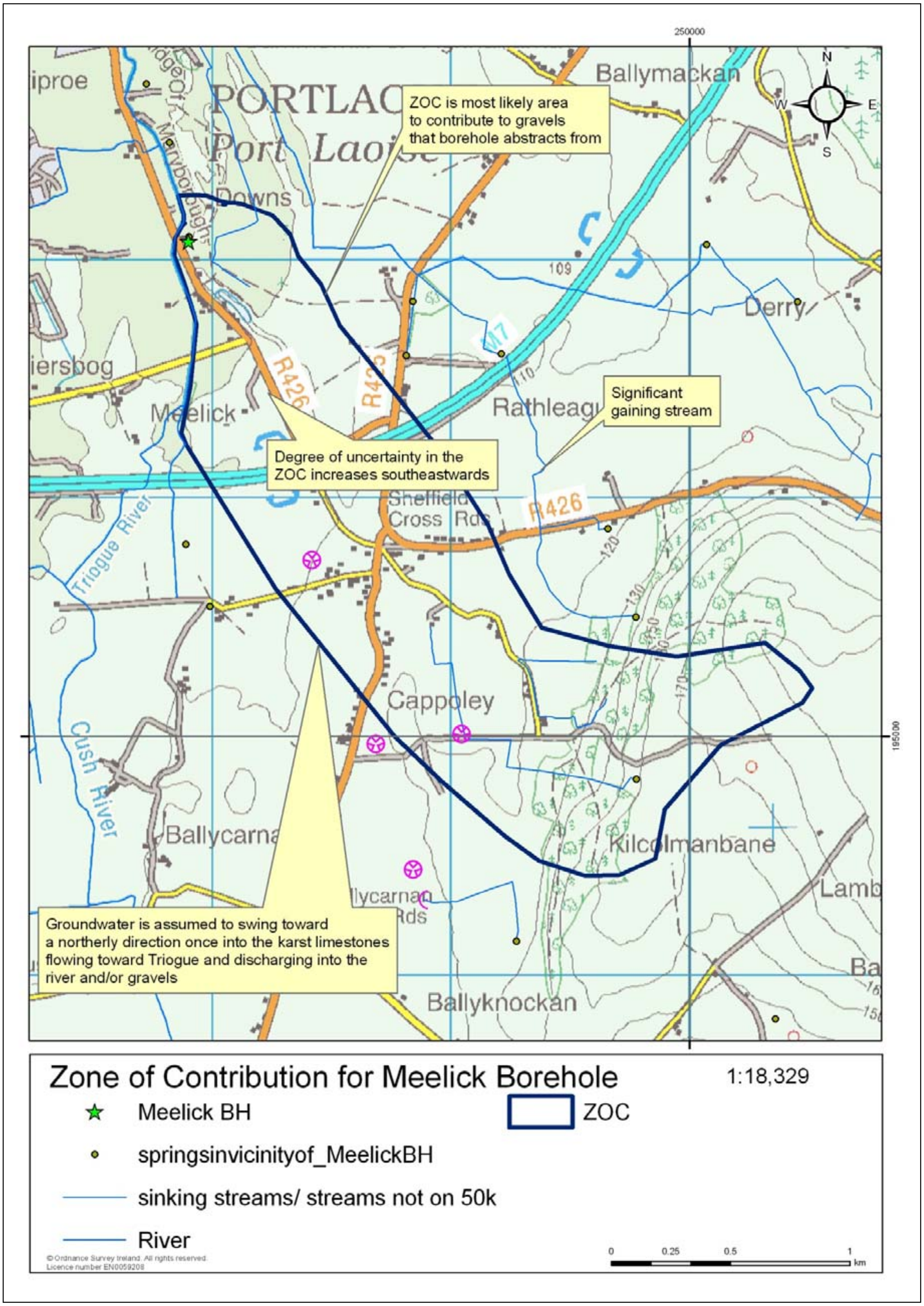

Figure 13 ZOC for Meelick

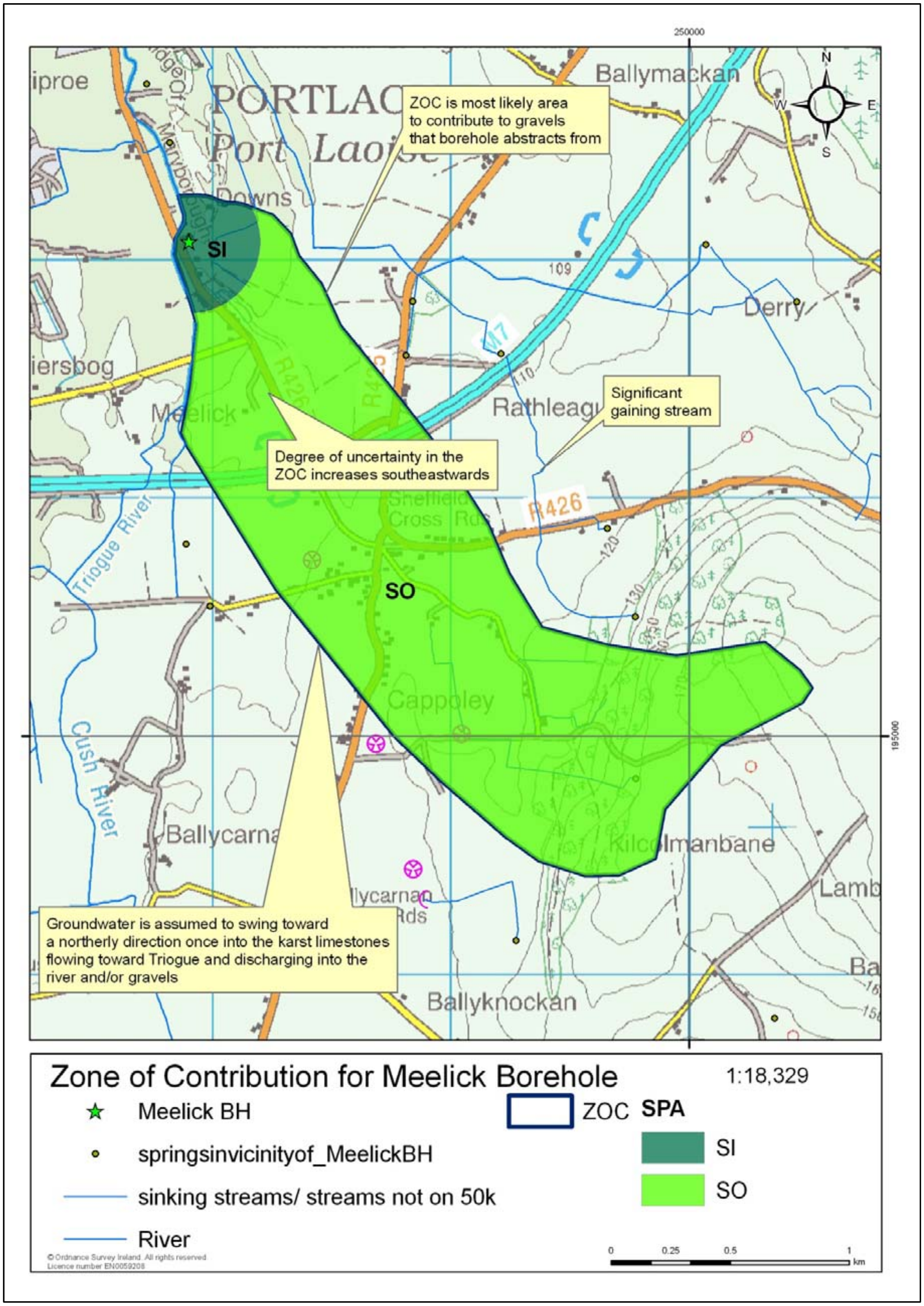

Figure 14 Meelick Groundwater Source Protection Areas

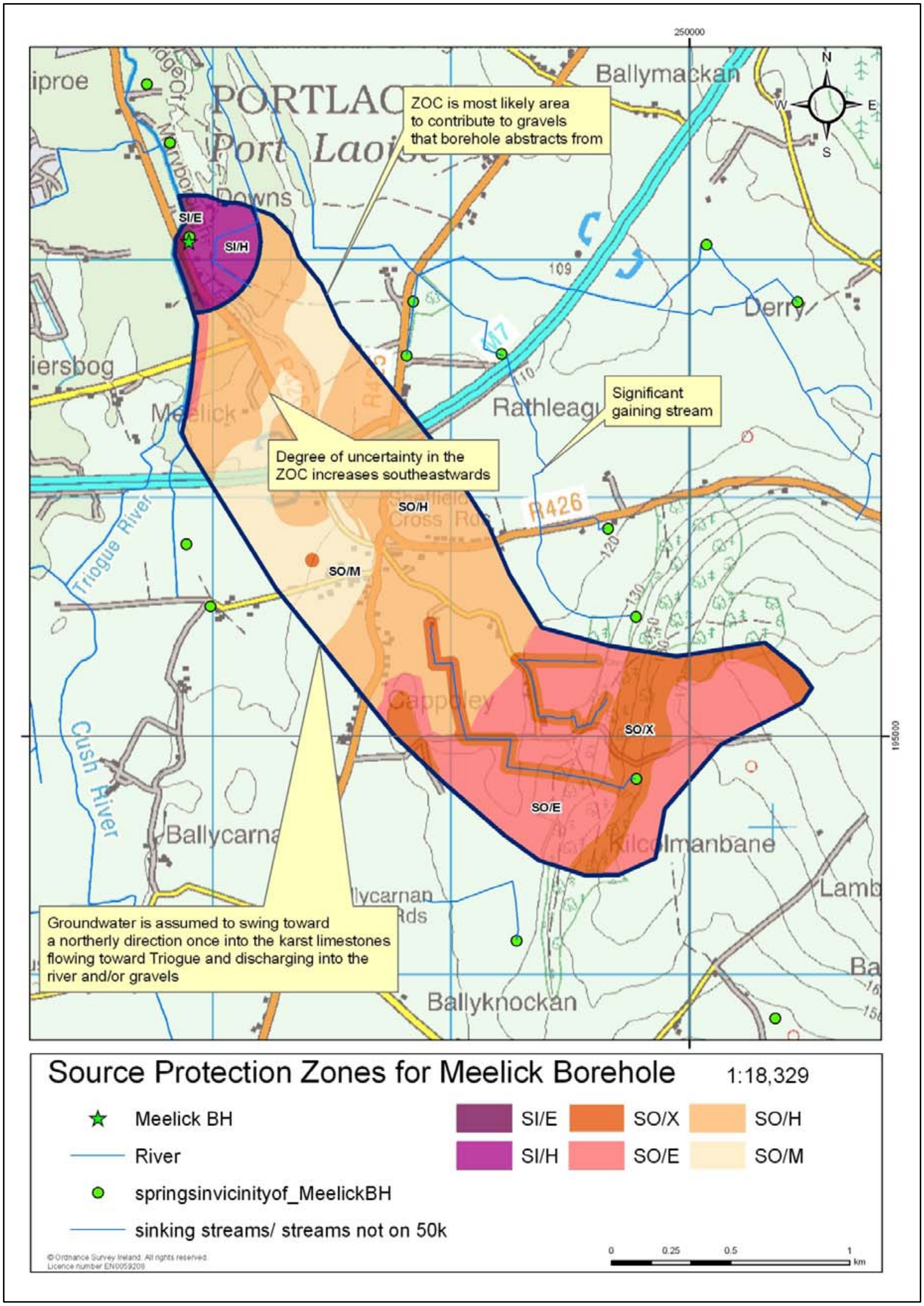

Figure 15 Meelick Groundwater Source Protection Zones

12 Potential pollution sources

The borehole, which is not covered or grouted but is finished above ground level, is contained in a metal housing within a fenced and gated Local Authority compound. The borehole is toward the back of the compound and the slope is away from the borehole toward the road and the river. The water table is just on the boundary of being extreme to high (slightly greater than 3 m below ground level). There is no evidence of faecal coliforms but total coliforms are present in a number of samples, and these are possibly due to the lack of a cover on the borehole.

The inner protection area encompasses a 300 m buffer around the borehole, the majority of which is '**highly**' vulnerable to contamination. Land use in this area is a mixture of urban and rural activities. In general the water quality is good, but elevated chloride suggests an anthropogenic source.

Across the rest of the outer protection area (SO), the groundwater vulnerability is '***extreme'*** (both '**E'** and '**X'**) or '**high'** or '**moderate**'. There are number of houses, farms and farm yards across the area which pose a risk to the source. The sinking streams provide a direct route into the bedrock karst aquifer, although not a direct route into the sands and gravels.

There are a number of roads present in the ZOC. The main potential contaminants from this source are surface water runoff contaminated with hydrocarbons and metals. The traffic density is high indicating that the risk of contamination is high.

The presence of the gravels at the source are probably the reason for the relatively good water quality, as they filter and attenuate the water discharging from the karstified bedrock and direct recharge.

13 Conclusions

The Meelick Borehole is a component of the Portlaoise Water Supply Scheme and also augments Ballyroan Water Supply. It draws water from a sand and gravel deposit that overlies a karstified aquifer, at an abstraction rate of approximately 1200 m^3/day. It is suggested that this rate is close to, or at the limit of, the current configuration of borehole depth, pump depth and borehole construction.

The groundwater vulnerability with the Inner Source Protection Area is '***extreme'*** or '***high***'. Chloride concentrations have been historically high. The recent apparent decrease in Nitrate is possibly influenced by recent wet summers.

Over the majority of the remainder of the area, the vulnerability is predominantly **High.** The uppermost slopes and crest of Knockcolmanbane are mapped as '***extreme'*** (both '**E'** and '**X'**) and thus represent a high level of risk to the source, in particular as the streams sink into the karst aquifer which can ultimately reach the borehole.

The ZOC encompasses an area of 2.7 km^2. The Source Protection Zones are based on the current understanding of the groundwater conditions and the available data. Additional data obtained in the future may require amendments to the protection zone boundaries.

14 Recommendations

The well head protection needs to be improved and a local hazard survey.

The pumping water level should be continuously recorded to confirm sustainability.

15 References

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Gately, S., Somerville, I., Morris, J.H., 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 15, Galway-Offaly*. Geological Survey of Ireland.

Misstear, B. (1998) *Analysing Pumping Test Data by the Logan Method*. The GSI Groundwater Newsletter No. 34, Geological Survey of Ireland.

Cronin, C., Furey, A. (1998) *Assessing Groundwater Analyses: Some Useful Tips.* The GSI Groundwater Newsletter No. 33, Geological Survey of Ireland.

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APPENDIX 1 Links of selected features to OSI mapping

Location of Tobergaddy.
http://maps.osi.ie/publicviewer/#V1,647828,697122,7

Location of sinking streams in Cappoley
http://maps.osi.ie/publicviewer/#V1,649217,695369,7
http://maps.osi.ie/publicviewer/#V1,648847,695370,7

Location of sinking streams in Ballycarnan
http://maps.osi.ie/publicviewer/#V1,648821,694357,7

Location of farm well in limestone
http://maps.osi.ie/publicviewer/#V1,649105,695496,7

APPENDIX 2 Recharge coefficient table

Table 1: Recharge coefficients for different hydrogeological settings.

'ulnerability category		Hydrogeological setting	Recharge coefficient (rc)		
			Min (%)	Inner Range	Max (%)*****
Extreme	1.i	Areas where rock is at ground surface	60	80-90	100
	1.ii	Sand/gravel overlain by 'well drained' soil	60	80-90	100
		Sand/gravel overlain by 'poorly drained' (gley) soil			
	1.iii	Till overlain by 'well drained' soil	45	50-70	80
	1.iv	Till overlain by 'poorly drained' (gley) soil	15	25-40	50
	1.v	Sand/ gravel aquifer where the water table is = 3 m below surface	70	80-90	100
	1.vi	Peat	15	25-40	50
High	2.i	Sand/gravel aquifer, overlain by 'well drained' soil	60	80-90	100
	2.ii	High permeability subsoil (sand/gravel) overlain by 'well drained' soil	60	80-90	100
	2.iii	High permeability subsoil (sand/gravel) overlain by 'poorly drained' soil			
	2.iv	Moderate permeability subsoil overlain by 'well drained' soil	35	50-70	80
	2.v	Moderate permeability subsoil overlain by 'poorly drained' (gley) soil	15	25-40	50
	2.vi	Low permeability subsoil	10	23-30	40
	2.vii	Peat	0	5-15	20
Moderate	3.i	Moderate permeability subsoil and overlain by 'well drained'soil	25	30-40	60
	3.ii	Moderate permeability subsoil and overlain by 'poorly drained' (gley) soil	10	20-40	50
	3.iii	Low permeability subsoil	5	10-20	30
	3. iv	Basin peat	0	3-5	10
Low	4.i	Low permeability subsoil	2	5-15	20
	4.ii	Basin peat	0	3-5	10
High to Low	5.i	High Permeability Subsoils (Sand & Gravels)	60	85	100
	5.ii	Moderate Permeability Subsoil overlain by well drained soils	25	50	80
	5.iii	Moderate Permeability Subsoils overlain by poorly drained soils	10	30	50
	5.iv	Low Permeability Subsoil	2	20	40
	5.v	Peat	0	5	20

Acknowledgement: many of the recharge coefficients in this table are based largely on a paper
submitted by Fitzsimons and Misstear.
C

APPENDIX 3 Test pumping data

SITE ______ **Meelick** **DATE** **11/08/1998**

Groundwater Section
Geological Survey of Ireland **PUMPING TEST** **PUMPING WELL** **Project Title**
Page No.

Borehole Name	**Meelick**	**Well Depth**	**12.2 m**	**Datum Point**	**Top of Casing**
Borehole No.	**BH (ME1)**	**Well Diameter**	***" or 10" with 4" rising main**	**Height of Datum**	
Well Owner	**County Council**	**Pump Depth**	**13.72 m**	**Ground Elevation**	
Location		**Aquifer**	**Cross Patrick/Allenwood**	**Datum Elevation**	
Grid ref.				**Weather**	**Good, drizzle in morni**
6" Sheet No.	**13**			**Observer**	**Jenny Deakin, Colette**

Date	Time	Elapsed Time	Water level below datum	Drawdown	Discharge		Discharge	Rema
		Mins	(m)	(m)	Meter	Spot	(m3/d)	
		0	3.03		678611310			
		0.27	3.71	0.68				
		0.43	3.745	0.715				
		0.55	3.75	0.72				
		0.67	3.78	0.75				
		0.77	3.79	0.76				
		0.87	3.8	0.77				
		1	3.81	0.78			763	
		1.25	3.81	0.78				
		1.5	3.815	0.785				
		1.75	3.825	0.795				
		2	3.825	0.795				
		2.5	3.835	0.805				
		3	3.845	0.815				
		3.5	3.845	0.815				
		4.17	3.85	0.82				
		4.5	3.85	0.82				
		5	3.855	0.825	678613960			
		6	3.865	0.835				
		7	3.875	0.845			769	
		8.08	3.88	0.85				
		9	3.884	0.854				
		10	3.885	0.855	678616630			
		12	3.892	0.862			767.5	
		14	3.902	0.872				
		15			678619295			
		16	3.905	0.875				
		18	3.907	0.877			763	
		20	3.907	0.877	678621945		765	
		25	3.935	0.905	678624600			
		30	3.935	0.905			760.5	
		33			678628825			
		35.25	3.947	0.917			762	
		40	3.955	0.925	678632530			
		45	3.96	0.93				
		46			678635695			
		50	3.968	0.938	678637810			