Cavan County Council

Establishment of Groundwater Source Protection Zones

Kingscourt Water Supply Scheme

Descart Boreholes

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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.

Cavan County Council contracted GSI to delineate source protection zones for groundwater public water supply sources in Co. Cavan. In the current phase of investigations the sources for which delineations have been requested are Kingscourt and Ballyconnell.

This report documents the delineation of the source protection zones for the Kingscourt Descart test wells. The source protection zones for the Kingscourt Mullantra supply are provided in a separate report.

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

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APPENDICES

Appendix 1 Point Data, Water Quality Data & Borehole Data

1 Introduction

Groundwater Source Protection Zones (SPZ) have been delineated for the Kingscourt Public Water Supply Scheme 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 SPZ Delineation.

The Descart test wells (labelled bore wells BW02 and BW03 by Cavan County Council) are located in the townland of Descart, Carrickmacross, Co. Monaghan which lies approximately 3.8 km east-northeast of Kingscourt town centre. Production wells have not yet been drilled and the sources have not yet been commissioned.

Kingscourt is currently supplied by the Mullantra borehole source (BW01) (500 m^3/day) and by Ervey Lough (500 m^3/day). Cavan County Council plan to phase out the abstraction from Ervey Lough by 2013 and replace it with two additional production boreholes, at the sites of test wells BW02 and BW03 (also formerly known as TW13 and TW10 respectively). The overall proposed scheme yield is 1,408 m^3/day for BW01, BW02 and BW03 (WYG, 2003). Source protection zones have also been delineated for the Mullantra source and are described in a separate report.

The objectives of the study were:

- To outline the principal hydrogeological characteristics of the Descart area where the test wells are located.
- To delineate source protection zones for the test wells.
- To assist Cavan County Council in protecting the water supply from contamination.

The protection zones are intended to provide a guide in the planning and regulation of development and human activities to ensure groundwater quality is protected. More details on protection zones are presented in 'Groundwater Protection Schemes' (DELG/EPA/GSI, 1999).

2 Methodology

The methodology applied to delineate the SPZ consisted of data collection, desk studies, site visits and field mapping, and subsequent data analysis and interpretation.

A desk study of existing data sources was carried out prior to a site visit. Site visits and walk-over, and field mapping of the study area were conducted on 08/07/2010 and, 9, 10, 27 and 28/09/2010. An interview was carried out on 08/07/2010 with the scheme caretaker.

While specific fieldwork was carried out in the development of this report, the maps produced are based largely on the readily available information and mapping techniques using inferences and judgements from experience at other sites. As such, the maps may not 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.

3 Location, site description and well head protection

The two wells are located in separate fields approximately 250 m apart in the townland of Descart in County Monaghan, 3.8 km east-northeast of Kingscourt (Figure 1).

Borehole BW02 is located in the corner of a field, is overgrown with scrub and lies 350 m north of Tobermennan Bridge (see Photo 1). The well head comprises a 300 mm diameter steel casing rising approximately 0.1 magl with a concentric 200 mm steel casing rising to 0.45 magl within. There is an unsecured well cap on the inner casing. The borehole log records the presence of a cement seal in the annulus between the two casings from 0 to 9.14 mbgl.

Borehole BW03 is located in a grassy field 360 m northwest of Tobermennan Bridge (see Photo 2). The borehole is capped at ground level with a water tight seal. The borehole is artesian (overflowing) and the seal (or possibly the casing) leaks slightly. There is a rising main passing up through the cap which currently supplies the nearby residential farm under the natural artesian pressure. The borehole has a 150 mm steel casing from 0 m to 29 mbgl. There is no record of a grout seal installation on the borehole log.

Photo1: Borehole BW02

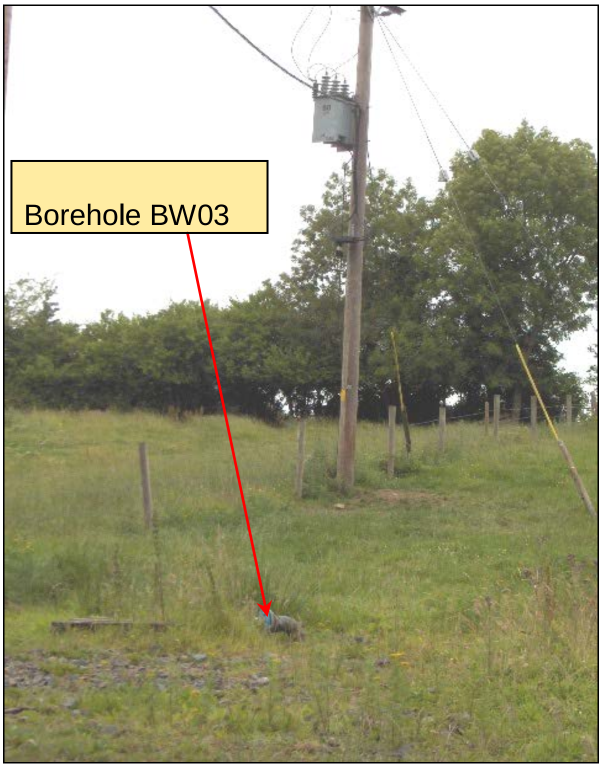

Photo2: Borehole BW03

4 Summary of well details

The well details are derived from various hydrogeological investigation reports and accompanying borehole logs prepared between 1996 and 2003 by KT Cullen & Co Ltd. and WYG. The borehole logs for boreholes BW02 and BW03 together with tables summarising key data extracted from the reports (Tables A1.1 to A1.5) are provided in Appendix 1.

Boreholes BW02 (TW13) and BW03 (TW10) were drilled by Dunnes Water Services Ltd. with KT Cullen & Co Ltd. as hydrogeological consultants in January 1998 and February 1996 respectively.

Borehole BW02 was drilled as one of a pair of boreholes. An initial trial well (TW12) was drilled at the site to a depth of 135 mbgl. It encountered a large volume of water between 8 m and 20 mbgl, which was subsequently cased off during the drilling process. Borehole BW02 was then drilled to target this shallow groundwater.

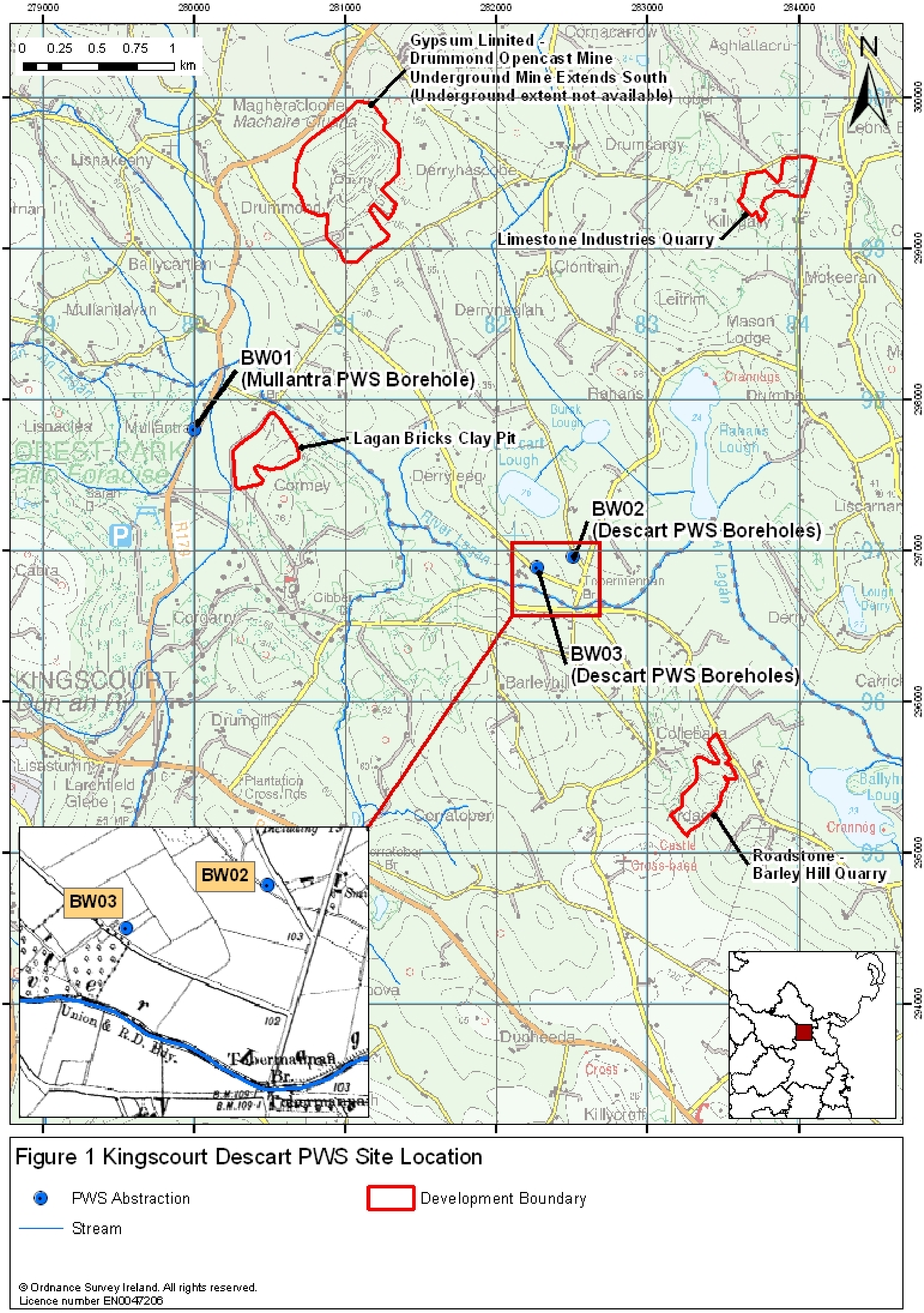

Figure 1 Kingscourt Descart PWS Site Location

Borehole BW03 was drilled to a depth of 91 m where a cavern was intersected and resulted in an artesian overflow of 1,300 m^3/day. The well was plugged with an inflatable packer three months after drilling. It is understood that this packer is currently stuck in the well and cannot be (easily) removed. The artesian supply from BW03 to the nearby farm suggests the packer is compromised.

Table 4-1: Well Details for Descart Boreholes

	BW02	BW03
Grid ref. (GPS)	X: 282514 Y:296953	X: 282281 Y:296881
Other Names	TW13; Borewell no. 2	TW10; Borewell no. 3
Townland	Descart, Co. Monaghan	Descart, Co. Monaghan
Source type	Trial Borehole	Trial Borehole
Drilled	January 1998	February 1996
Owner	Cavan County Council	
Elevation (Ground Level)	~31 m OD	~ 34.5 m OD
Depth (m)	19.2	91
Depth of casing	200mm: 19.2 m (slots 10.2 to 19.2) 300mm: 9.14 m	29 m
Grout Seal	0 to 9.14 in casings annulus	none
Diameter	200 mm	150 mm
Depth to rock	8.8 m	17.5 m
Static water level	0.02 mbgl (Feb 1998)	Artesian
Pumping water level	11.39 mbgl for 1557 m^3/day (Feb 1998, unsteady) 11 to 12 mbgl for ~ 900 m^3/day (Feb – April 2003)	5.49 mbgl for 2072 m^3/day (Mar 1996) 3.5 mbgl for 1260 m^3/day (Feb – Apr 2003)
Consumption (Co. Co. records)	Not yet commissioned.	Not yet commissioned.
Pumping test summary: (i) abstraction rate m^3/d	1557 m^3/day (70hr, Feb 1998)) ~ 900 m^3/day (6 wk, Feb – April 2003)	2072 m^3/day (30 hr, Mar 1996) 1260 m^3/day (6 wk, Feb – April 2003)
(ii) specific capacity	137 m^3/d/m (Feb 98) 75 m^3/d/m (Apr 03)	377 m^3/d/m (unsteady) (Mar 96) 360 m^3/d/m (Apr 03)
(iii) transmissivity	47	114

Details of pumping tests carried out on the boreholes are recorded in Table A1.1 in Appendix 1.

5 Topography, surface hydrology, landuse

The test wells are at an elevation of approximately 31 to 34 mAOD. The topography of the study area is dominated by northwest to southeast oriented drumlins to the north, west and east of the boreholes. The overall slope of the boreholes' locality is to the southeast towards the Lagan River, which flows roughly southeast between 100 m to 250 m southwest of the boreholes. To the south and south east on the opposite side of the River Lagan, the bedrock cored Barley Hill ridge rises to above 120 m AOD.

Drainage density is high to the west of the boreholes with numerous streams draining through the drumlins and flowing towards the Lagan River. Immediately north of the boreholes, surface water courses are intercepted by Descart, Bursk and Rahans Loughs, which flow into the Lagan *via*

Rahans Lough (see Figure 1). To the east and south of the boreholes drainage density is generally low with large areas mapped with no surface water features.

The landuse in the catchment is predominantly agricultural with most fields given over to pasture. There is a large opencast and underground gypsum mine operated by Gypsum Ltd. located 2.3 km northeast of the boreholes in the townland of Drummond. Roadstone operate a large limestone quarry 1.5 km to the southeast at Barley Hill. There are numerous domestic residences and residential farms along the roadsides in the vicinity of the boreholes.

6 Hydrometeorology

Establishing groundwater source protection zones requires an understanding of general hydrometeorological trends across the area of interest. This information was obtained from Met Eireann.

Annual rainfall: 1013 mm. The closest meteorological station to boreholes BW02 and BW03 is Kingscourt Garda Station[1], located 3.7 km west-southwest in Kingscourt town centre. The annual average rainfall from 1961 to 1990 was 1013 mm (Fitzgerald and Forrestal, 1996).

Annual evapotranspiration losses: 416 mm. The closest synoptic weather station to the study area is Clones, located 41 km to the northwest. Average potential evapotranspiration (P.E.) at Clones between 1961 and 1990 was 438 mm (Fitzgerald and Forrestal, 1996). The contoured mean annual potential evapotranspiration for Ireland shows that Kingscourt lies close to the 450 mm/yr contour and that therefore, Clones is likely to adequately represent the study area P.E. Actual evapotranspiration (A.E.) is then estimated as 95% of P.E., to allow for seasonal soil moisture deficits giving an Actual Evapotranspiration of 416 mm.

Annual Effective Rainfall: 597 mm. The annual effective rainfall (i.e. potential recharge) is calculated by subtracting actual evapotranspiration from rainfall.

7 Geology

7.1 Introduction

This section briefly describes the relevant characteristics of the geological materials that underlie the site. It provides a framework for the assessment of groundwater flow and delineation of the source protection zones.

The desk study data used comprised the following:

- Reports on groundwater resources investigations for the Kingscourt Regional Water Supply Scheme between 1996 and 2003 (KT Cullen/White Young Green)
- Boreholes' logs of trial wells and production wells from Dunnes Water Services Ltd and KT Cullen/ WYG, 1995 to 2002
- Geology of Meath. Bedrock Geology 1:100,000 Scale Map, Sheet 13. Geological Survey of Ireland (Geraghty, M. and McConnell, B., 1999)

[1] Note: This rainfall station closed in 1991 and was replaced by Kingscourt Drummond, 3.9 km to the northeast on the Gypsum Limited opencast mine site.

- Gypsum Limited borehole data and Hydrogeological Reports between 2003 and 2010
- EPA Subsoils Map (Teagasc, 2006)

7.2 Bedrock geology

Sheet 13, the Geology of Meath published by the GSI indicates that the area is underlain by the bedrock types described in Table 7-1. Table 7-1 shows the strata in stratigraphic order from youngest to oldest. The distribution of the various bedrock units is shown in Figure 2.

Table 7-1: Bedrock Descriptions around the Descart locality

Bedrock Formation	Generalised Rock Unit Classification	Geological Description	Max thickness (m)[2]
Kingscourt Sandstone (KS)	Permo-Triassic Sandstones (PTS)	Red Sandstone	400
Kingscourt Gypsum Formation (KG)	Permo-Triassic Mudstones & Gypsum (PTMG)	Mudstone with Gypsum and Anhydrite units	120
Cabra, Corratober, Clontarin & Carrickleck Formations (NamSstSH)	Namurian Undifferentiated (NU)	Interbedded Sandstones and Shales. Carrickleck shales commonly ferruginous. Ironstone bands in Ardagh (occasional) and Corratober formations.	Carrickleck ~ 170 m, Clontrain ~ 60 m, Corratober ~ 100 m, Cabra ~ 90 m
Carrickleck Sandstone Member	Namurian Sandstone (NSA)	Buff coloured sandstone	~ 60 (within Carrickleck Fmn)
Ardagh Shale Formation	Namurian Shales (NSH)	Black shale, contains minor limestone beds.	150
Milverton Group (Undifferentiated) (MLV)	Dinantian Pure Bedded Limestones (DPBL)	Micrite, crinoidal grainstone/ packstone with localised chert. Some thinly bedded argillaceous limestone. Extensively dolomitised in parts.	> 850
Fingal Group (FNG)	Dinantian Upper Impure Limestones (DUIL)	Dark limestone shale and micrite	> 378

The bedrock geology of the area comprises Kingscourt Sandstone strata overlying, in turn, Kingscourt Gypsum, Namurian Sandstone and Shales, and Dinantian Limestone (see Figure 2 and Table 7-1). The strata dip westwards at approximately 10 degrees in a half-graben structure towards the north to south trending Kingscourt Fault (Gardiner and McArdle, 1992). Further north to south trending faults occur to the west of the boreholes between the boreholes and the Kingscourt fault.

Two kilometres to the southeast in the vicinity of Ardagh on Barley Hill, the Milverton Group limestone abuts a northeast trending fault with Ardagh Shale, and Fingal Group shale and muddy limestone to the south. This fault forms a major structural boundary between the Milverton Group limestones of the Ardagh Platform to the north and the shales, calcarenites and limestones of the Moynalty Basin to the south.

[2] Maximum thickness values taken from Geraghty and McConnell, 1999.

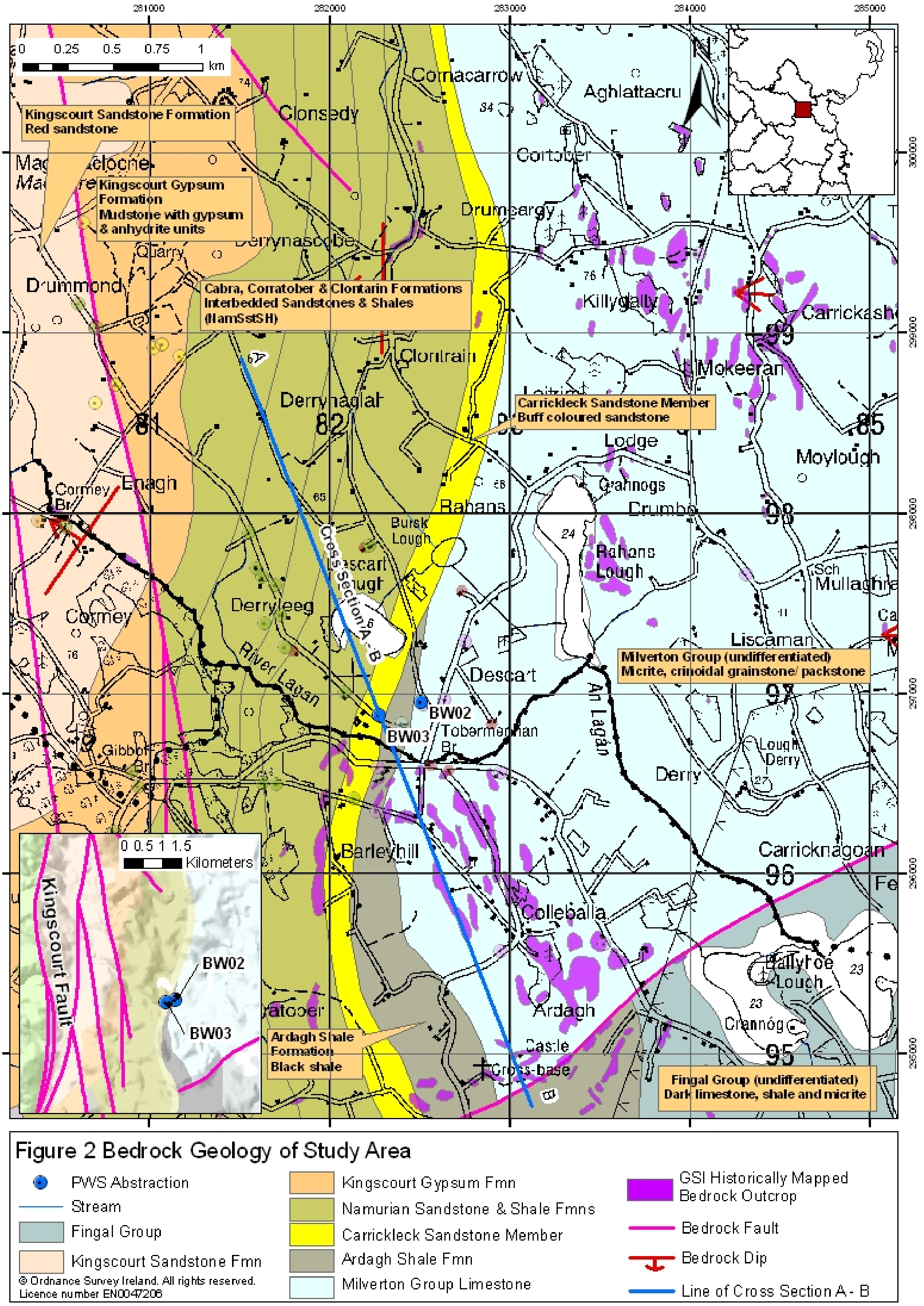

Figure 2 Bedrock Geology of the Study Area

The stratigraphic sequence in the vicinity of the test wells is recorded in the borehole logs for boreholes BW02 and TW12 (which are adjacent to each other), and BW03. At the site of BW02 and TW12 the logs record: shallow red sandstone; over thick white limestone with some interbedded shale; over white-brown sandstone at depth. At BW03 the log records bedrock of white limestone; over thick grey-black shale; over thick white-brown sandstone which contained a 7 m deep cavity at 82 to 89 mbgl. It is considered here that the strata logged in these boreholes as “red sandstone”; and, “white-brown sandstone” were misinterpreted and are likely to have been dolomitised limestone bedrock. This is supported by:

- Hydrochemistry data, which show that the large inflows from these strata are saturated with respect to the mineral dolomite (see Section 9.3).
- A large karst cavern such as at BW03 is more likely to occur in dolomitised limestone than in sandstone. (Multiple cavities from 2 to 7 m in depth were encountered in borehole OW05).
- Interpretation as dolomitised limestone agrees with the bedrock map of the area which shows Milverton Group Limestone outcrop at BW02 and TW12. This limestone is known to be extensively dolomitised. At BW03, the map shows shale overlying Milverton Group limestone and a thick sandstone layer would not be expected with this configuration;
- Similar reinterpretations of the borehole logs also appear valid for boreholes OW05 and TW11 located on Barley Hill directly south of the trial boreholes.

Approximately 100 karst features are known to the north and northeast of the test wells, in the Co. Monaghan part of the Milverton Group outcrop. A swallow hole has been mapped on top of Barley Hill at KF01 (data from R. Meehan) (see Figure 6). A second swallow hole occurs to the south of KF01 according to the Monaghan GWPS main report (GSI, 2002). The caverns encountered in BW03 and OW05 may be part of a deep paleokarst conduit system in the limestone/dolomitised limestone. The upper surface of the Milverton Group limestone was eroded to varying depths before deposition of the overlying Namurian strata (Geraghty *et al,* 1999). As such, karstification may also occur at the boundary surface between the Milverton Group and the overlying Namurian strata. The extensive dolomitisation enhances the permeability of limestone by creating additional void space and can further increase the likelihood of karstification (GSI, 2004a). Due to the regional north-south trend in both the faults of the area, and the bedding strike, it is likely that karstification and dolomitisation will have developed preferentially with the same north-south orientation.

7.3 Soil and subsoil geology

The subsoil and soil distributions across the area are illustrated in Figures 3 and 4 respectively.

Till subsoils cover the majority of the study area. Till derived from Lower Palaeozoic sandstones and shales is mapped across the majority of the area west, north and east of test wells. To the north and east of Descart on the limestone bedrock, this till is thought to form a thin skim over a thicker deposit of limestone-dominated till. Till derived from limestone is mapped at the surface on the flanks of Barley Hill itself and in pockets to the east of this. South and southwest of Barley Hill, the tills are mapped as being derived from Namurian shales and sandstones.

Cut away peat is found around Descart, Bursk and Rahans Loughs, extending southeast from Rahans Lough along the east of Barley Hill and the River Lagan, and in small pockets elsewhere.

The River Lagan is generally flanked by alluvial soils. Bedrock outcrop is mapped on Barley Hill, and in the Killygally – Mokeeran area, both of which host major limestone quarries (see Figure 1). Rock outcrop is also mapped on the eastern side of Rahans Lough.

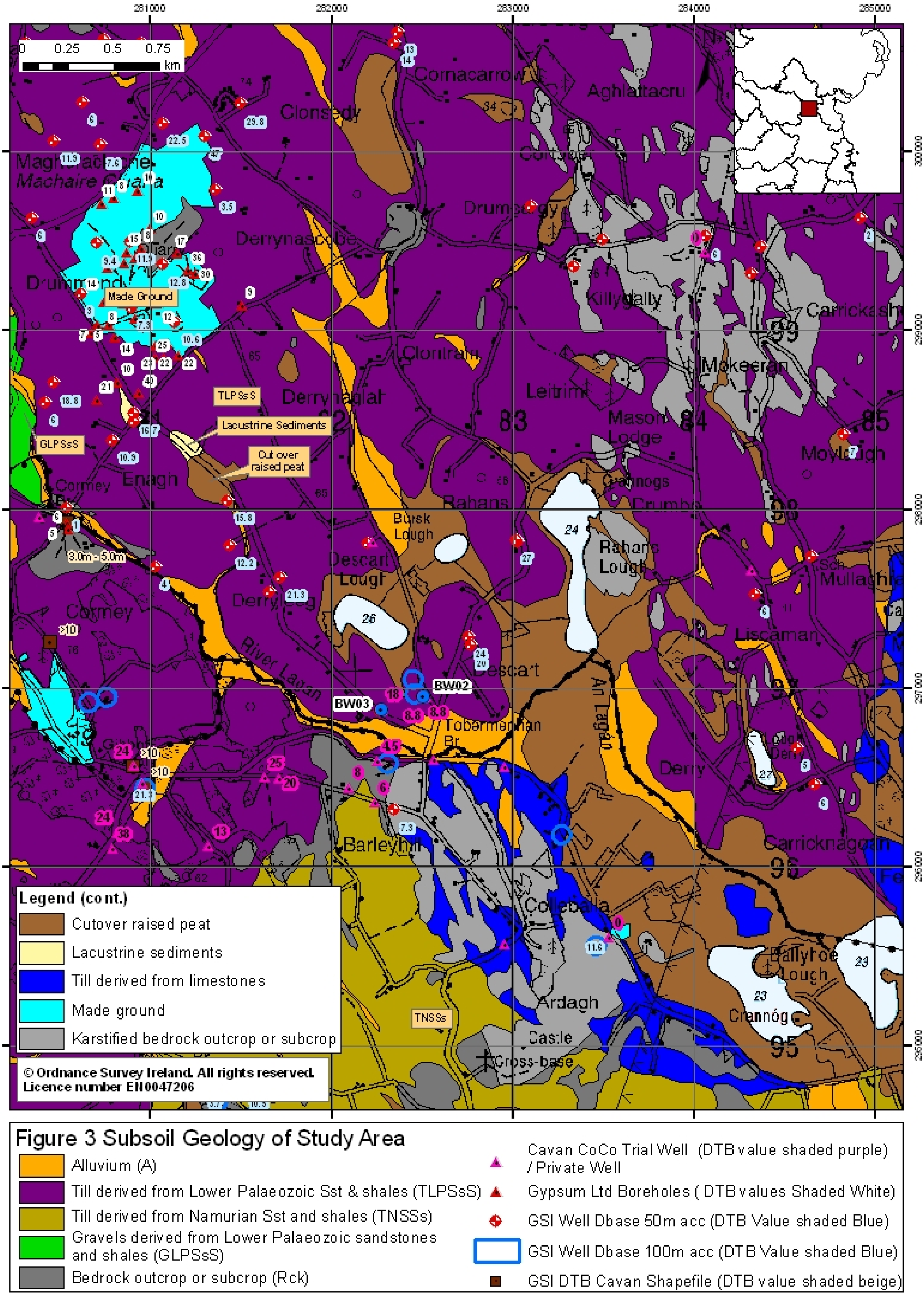

Figure 3 Subsoil Geology of Study Area

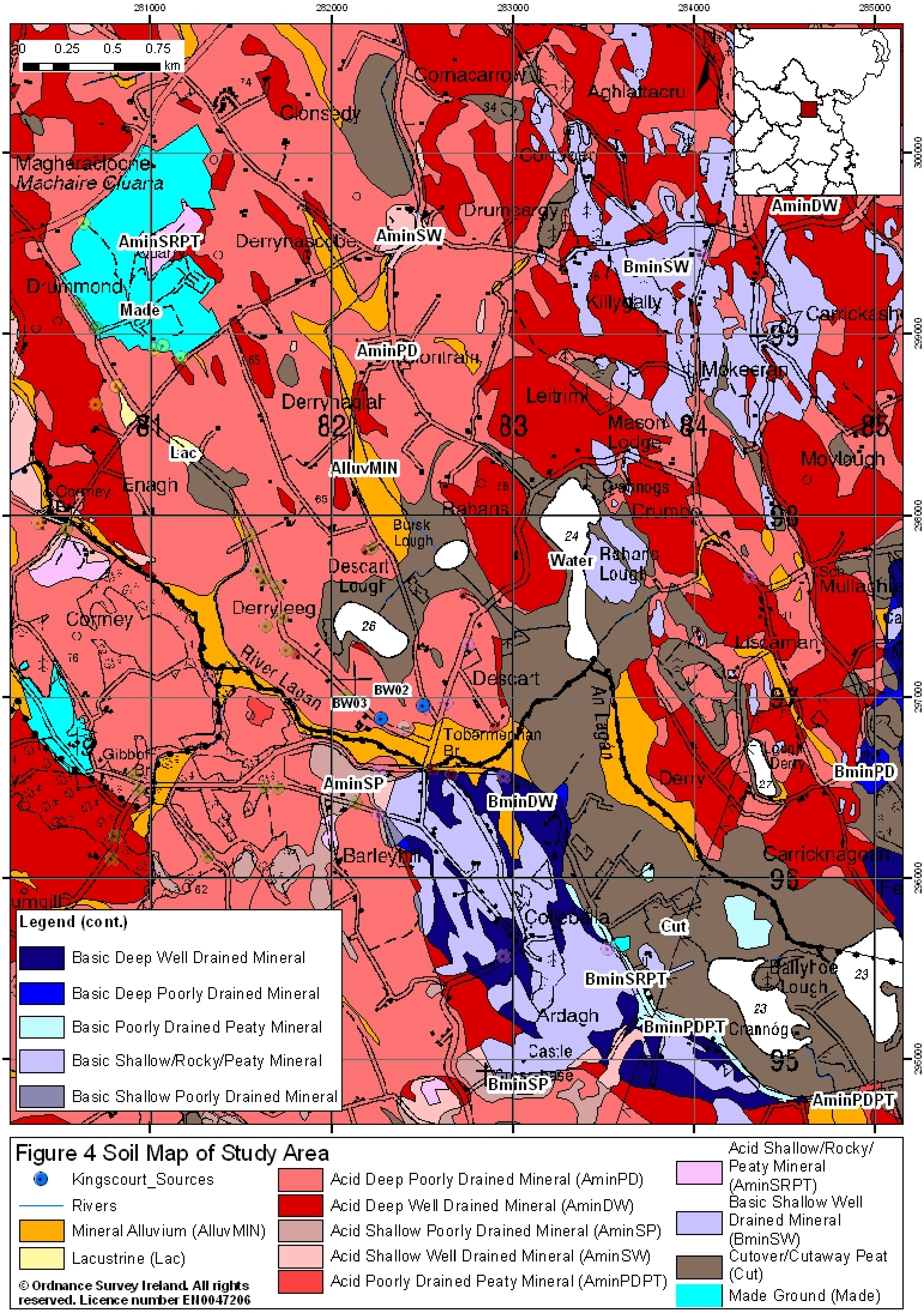

Figure 4 Soils Map of Study Area

The EPA and GSI Web Mapping classify the soils at and to the west of the test wells as predominantly acidic, mineral, poorly drained soils. Alluvium and cut peat distributions are as per the soil map. Soils on drumlins to east and north of the test wells are generally classified as acid, mineral, deep, well drained soils, but with poorly drained mineral soils in the inter drumlin hollows. Soils are classified as basic, mineral, shallow, well drained, and basic, mineral, deep, well drained in areas of limestone bedrock outcrop at Barley Hill and on high ground to the northeast.

It is envisaged that, due to the predominance of shale in the Lower Palaeozoic and Namurian-derived tills, these materials are of low permeability. This is corroborated by borehole logs for the test wells and from other trial wells to the west, which show subsoil dominated by clay. The GSI classify the areas where the shale till is just a thin skim over limestone till, and the alluvial subsoil areas as moderate permeability. The areas of cut peat are classified as low permeability.

The subsoil permeability observations correlate with the mapped soil types and are supported by field observations of well drained lands to the north, east and south of the test wells and predominantly poorly drained lands to the west and southwest. The subsoils logged at various trial boreholes across the study area are summarised in Table A1.1 in Appendix 1.

7.4 Depth to bedrock

The depth to bedrock (DTB) data for the area are shown on Figure 4. These show that in the drumlin areas to the west and northwest of boreholes BW02 and BW03, DTB is generally greater than 10 m. In the inter-drumlin low area at borehole BW03, this drops to 8.8 m. Further east there are fewer data, however the available data suggest that the DTB in the inter-drumlin areas and away from mapped bedrock outcrop is between 5 and 10 m, with DTB possibly increasing to greater than 10 m at the drumlin summits. A GSI well database borehole on the eastern slope of Barley Hill, adjacent to the northern boundary of the quarry, suggests that DTB between the eastern flank of the hill and the River Lagan may exceed 10 m in places, however the GSI interpret the DTB of this area as generally being between 3 m and 10 m.

Areas of bedrock outcrop and encompassing areas of rock close to surface (*i.e*. DTB <3 m) are shown on the GSI groundwater vulnerability map of the area. The area mapped as rock close to the east of the test wells, and along the northern bank of the River Lagan, is considered here to have DTB of 3 to 10 m based on the available DTB data and landscape assessment. The DTB and vulnerability have been changed accordingly and the relevant area is highlighted in Figure 5.

8 Groundwater vulnerability

Groundwater vulnerability is dictated by the nature and thickness of the material overlying the uppermost groundwater 'target'. This means that the vulnerability relates to the permeability and thickness of the subsoil. 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).

The vulnerability map is shown in Figure 5. In terms of subsoil coverage within the catchment of the wells, the area can be divided into the following zones:

- To the west of the test wells, the low subsoil permeability and DTB >10 m combine to give predominantly low vulnerability, except in some inter-drumlin low areas where DTB decreases and vulnerability is therefore moderate, or where bedrock outcrop occurs and vulnerability becomes extreme.

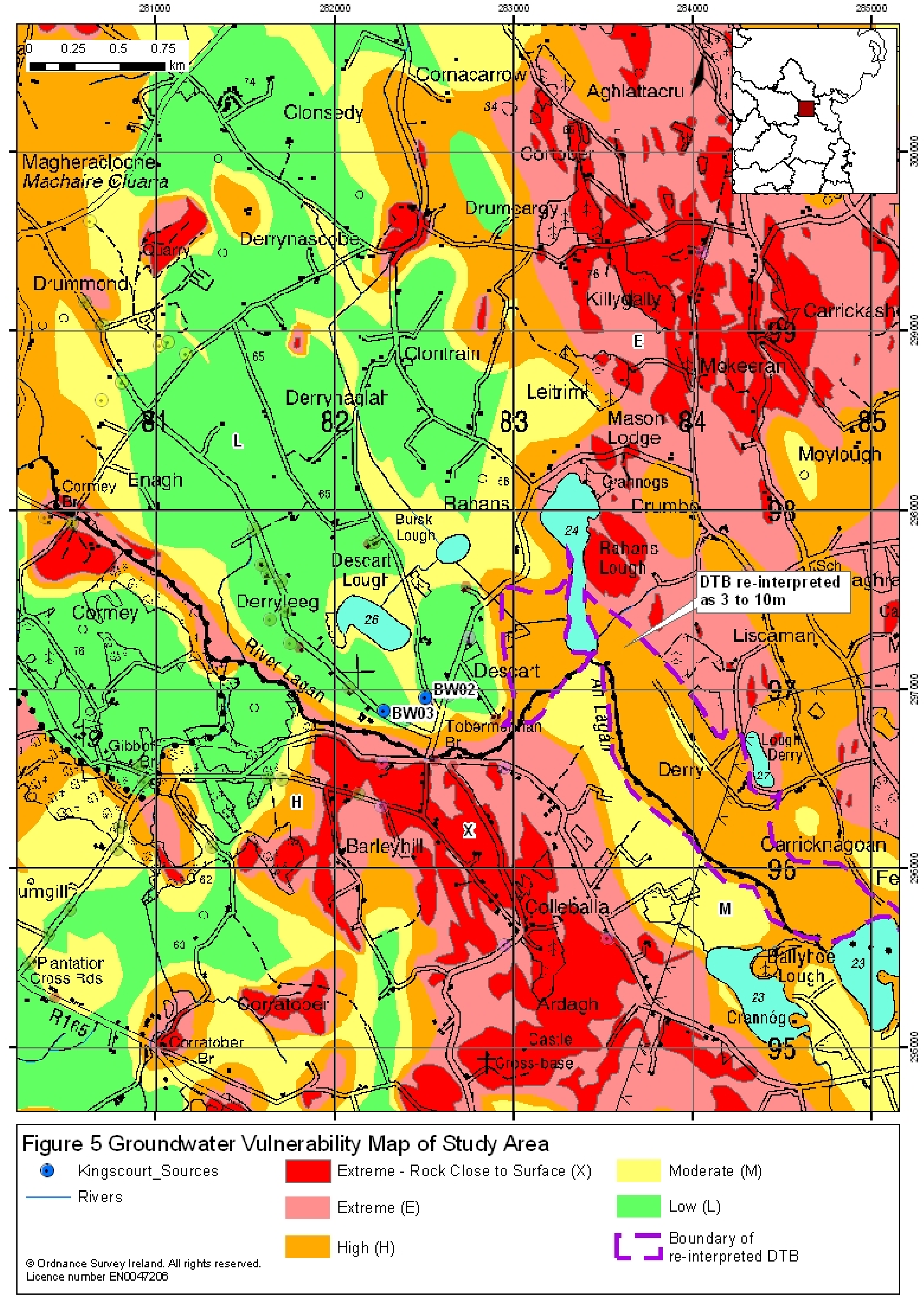

Figure 5 Groundwater Vulnerability Map of Study Area

- To the east of the test wells, the moderate permeability and the DTB combine to give generally high vulnerability, reducing to moderate at the drumlin peaks due to increased DTB[3]. The vulnerability decreases to moderate in the cutover peat area on the south flank of the Lagan River due to the peat low permeability.
- To the south and northeast of the test wells, where large areas of bedrock outcrop occur, the vulnerability is classified as extreme.

9 Hydrogeology

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

- GSI Website, Database and Groundwater Body Initial Characterisation Summaries
- County Council Staff
- EPA website and Groundwater Monitoring database
- Reports on groundwater resources investigations for the Kingscourt Regional Water Supply Scheme between 1995 and 2005 (KT Cullen, White Young Green)
- Gypsum Limited borehole data and Hydrogeological Reports between 2003 and 2010

9.1 Groundwater body and status

The boreholes are located at the boundary of the Kingscourt (IE_NB_G_017) and Carrickmacross (IE_NB_G_016) Groundwater Bodies which have been classified as being of Good Status. The groundwater body descriptions are available from the GSI website: www.gsi.ie and the 'status' is obtained from the Water Framework Directive website: www.wfdireland.ie/maps.html.

9.2 Groundwater levels, flow directions and gradients

Groundwater levels have been recorded sporadically at trial wells across the study area between 1995 and 2010. Groundwater monitoring has been conducted routinely within the stratified aquifers underlying the Gypsum Ltd site to the northwest of the test wells. The water level data from the data sources have been collated and are presented in Tables A1.2 to A1.4 in Appendix 1. Table A1.4 and Figure A1.1 in Appendix 1 show the aquifer intersected by each monitoring point. A groundwater level monitoring round was carried out on 27 and 28 September 2010 as part of this report in a wide network of monitoring points across the study area. The groundwater elevation in metres above Ordnance Datum (mAOD) has been estimated for each groundwater depth and the resulting groundwater elevations at each monitoring point are shown in Figure 6. Interpreted contours of groundwater elevation derived from the point data are also shown.

The available data suggest that:

- There is a groundwater high at Barley Hill. Recharge to the limestone bedrock outcrop creates a mound which radiates groundwater flow out into the bedrock to the north and northeast, towards the River Lagan. There may also be a small component of flow circulating to the west into the confined limestone strata.
- Lateral hydraulic gradients in the limestone bedrock vary from 0.036 on Barley Hill to approximately 0.005 between Mokeeran and the River Lagan (average of 0.021).

[3] Note: In the area on the north side of the river Lagan where DTB has been re-interpreted as 3 to 10 m the resulting vulnerability has been revised from extreme (E) to high (H) on Figure 5. The affected area is highlighted on Figure 5.

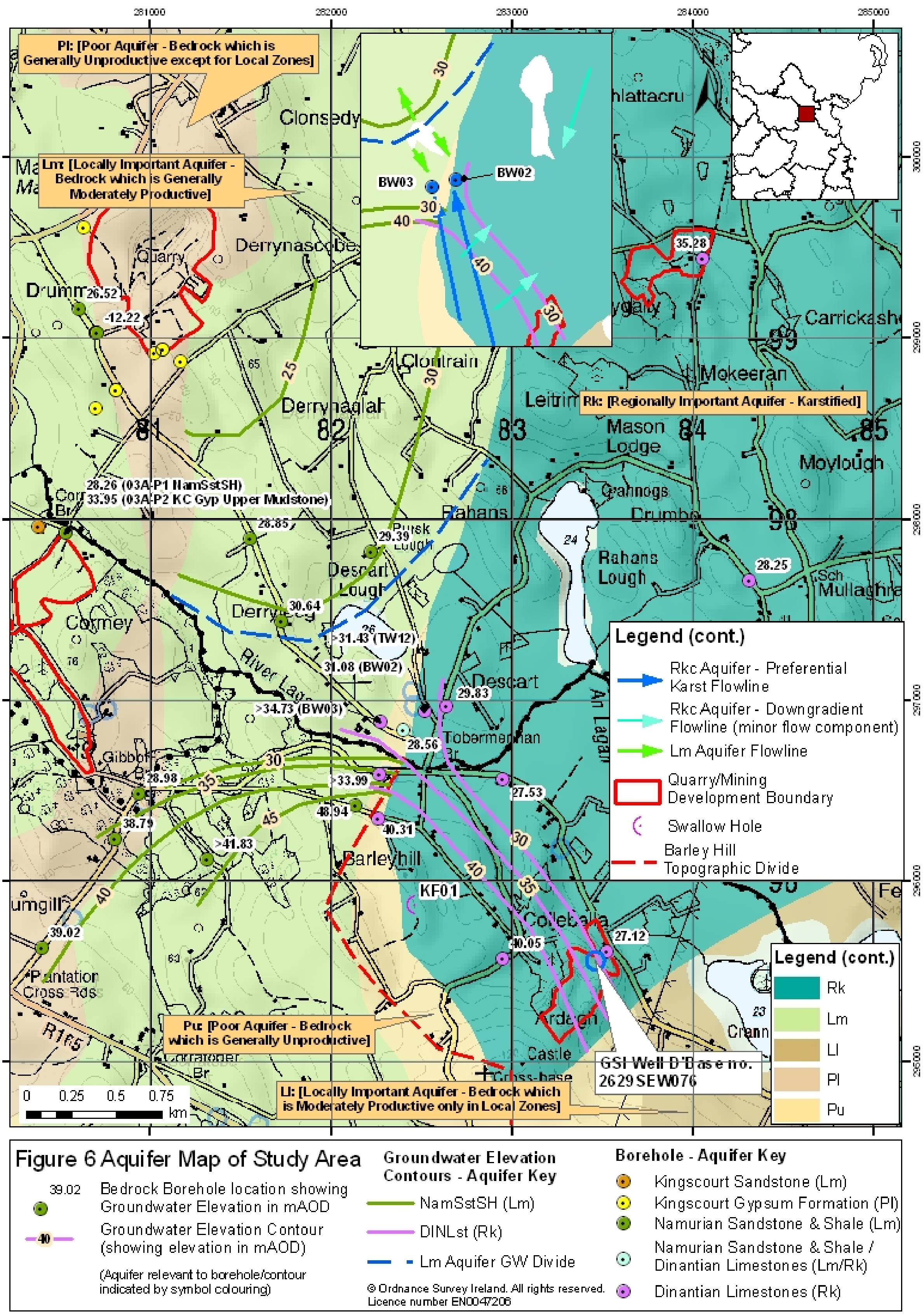

Figure 6 Aquifer map of Study Area

- The easterly gradient off Barley Hill is high for a karstified aquifer and suggests that karst connectivity and transmissivity in this direction is low; needing a high gradient to transmit relatively low volumes of water in the low transmissivity direction (see Section 9.4). There is a contrast between the high borehole yields to the north of Barley Hill (TW11, TW12, BW02 and BW03) and low yields to the east (GSI Well Database record 2629SEW076) (Section 9.4), which supports the idea of increased transmissivity and flow northwards. As such, groundwater flow is considered to be predominantly northwards in the likely direction of preferential karst conduit flow
- Natural discharge from the karst system may be to the River Lagan. Boreholes intersecting the karst north of the river appear to draw water beneath the river from the south, facilitated by karst conduits and a large head between Barley Hill and the boreholes.
- It is assumed that the fault boundary between the karstified limestone and shale bedrock at the southeast of Barley Hill (i.e. major structural boundary between limestone platform and subsiding basin) is a no-flow boundary. This agrees with the contrasting aquifer types across the boundary (see Section 9.4). Flow paths in the shale aquifers are assumed to follow topographic gradients and discharge to local surface water features. There may be some minor leakage northwards across the boundary, close to the boundary.
- In the Namurian bedrock, the lateral hydraulic gradient varies from 0.073 northwards from Barley Hill, to approximately 0.005 in the vicinity of the gypsum mine (average of 0.039).
- Recharge to the Namurian sandstone and shale outcrop at Barley Hill flows north and northwest towards the River Lagan. Runoff from this outcrop on the eastern flank of Barley Hill will flow onto the limestone outcrop where it will contribute to limestone recharge, particularly at karst features, such as the swallow hole at KF01.
- Groundwater levels in the Namurian bedrock north of the River Lagan are drawn down by dewatering at the gypsum mine such that a groundwater divide (see Figure 6) occurs in the vicinity of Descart Lough. 'Namurian' groundwater to the north and west of the divide flows to the mine, and to the south and east, flows past the test wells to the River Lagan.
- There is a groundwater high at the limestone bedrock outcrop at Killygally and Mokeeran. This suggests that the limestone groundwater flow from this area would be south towards the River Lagan. Long term pumping at the test wells could potentially divert some of this flow away from the river and towards the boreholes.
- The groundwater level data suggest that the vertical hydraulic gradient is downwards at Barley Hill (recharge) and upwards at the River Lagan/test wells (discharge).

9.3 Hydrochemistry and water quality

Boreholes BW02 and BW03 are not included in any routine monitoring programmes. The water quality was assessed during the initial pumping tests on the boreholes in 1996 (BW03) and 1998 (BW02), and again during the 2003 pumping test. The laboratory results for the monitoring events have been compared to the EU Drinking Water Council Directive 98/83/EC Maximum Admissible Concentrations (MAC) and the European Communities Environmental Objectives (Groundwater) Regulations 2010 recently adopted in Ireland under (S.I. No. 9/2010) as part of the implementation of the Water Framework Directive (2000). The data are summarized graphically in Figures 6 to 8 for borehole BW02, and Figures 9 to 11 for borehole BW03. The data interpretation is summarised below. Dolomite saturation indices for boreholes BW02, TW12, BW03 and TW11 are shown in Table 9-1[4]. The available data are tabulated in Table A1.6 in Appendix 1.

[4] In general a Saturation Index (SI) range of -0.5 to +0.5 is indicative of saturation for the relevant mineral. The saturation index for each sample was calculated using major ion concentration data with the PHREEQC modelling code.

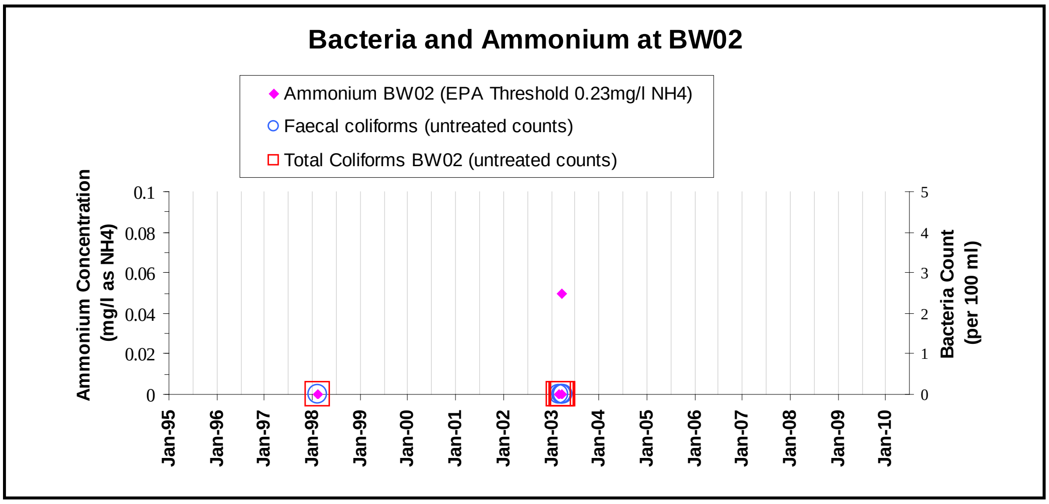

Figure 7 Key Indicators of Agri and Domestic Contamination (BW02): Bacteria and Ammonium

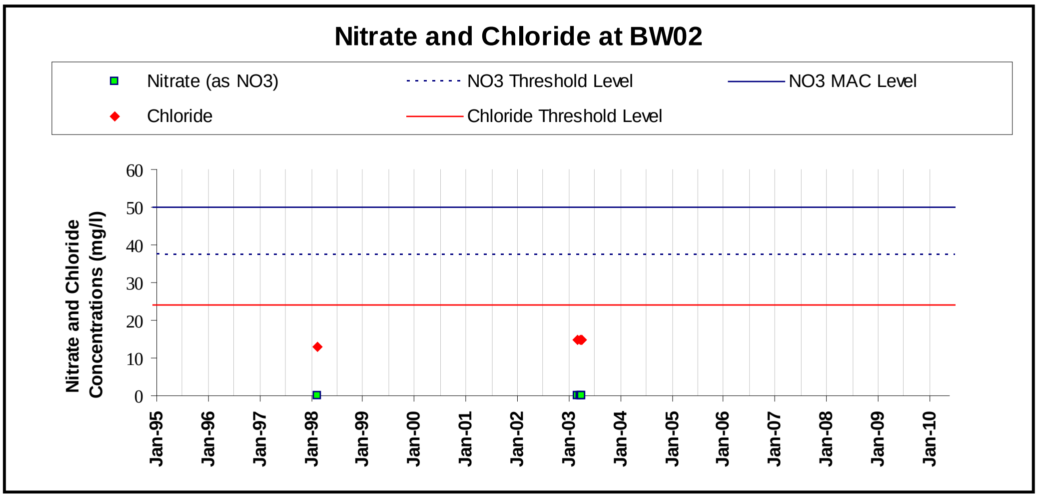

Figure 8 Key Indicators of Agri and Domestic Contamination (BW02): Nitrate and Chloride

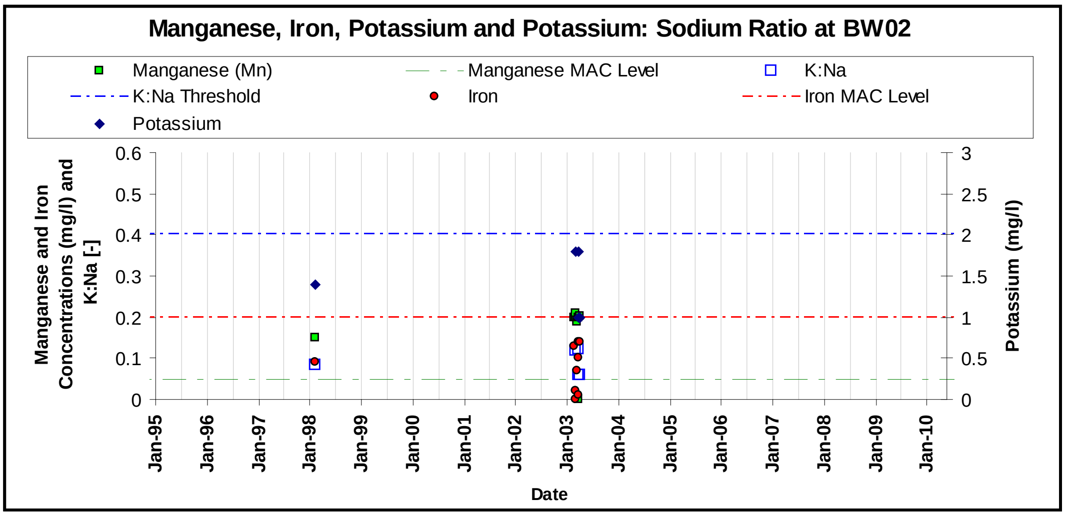

Figure 9 Key Indicators of Agri and Domestic Contamination (BW02): Mn, Fe, K and K:Na ratio

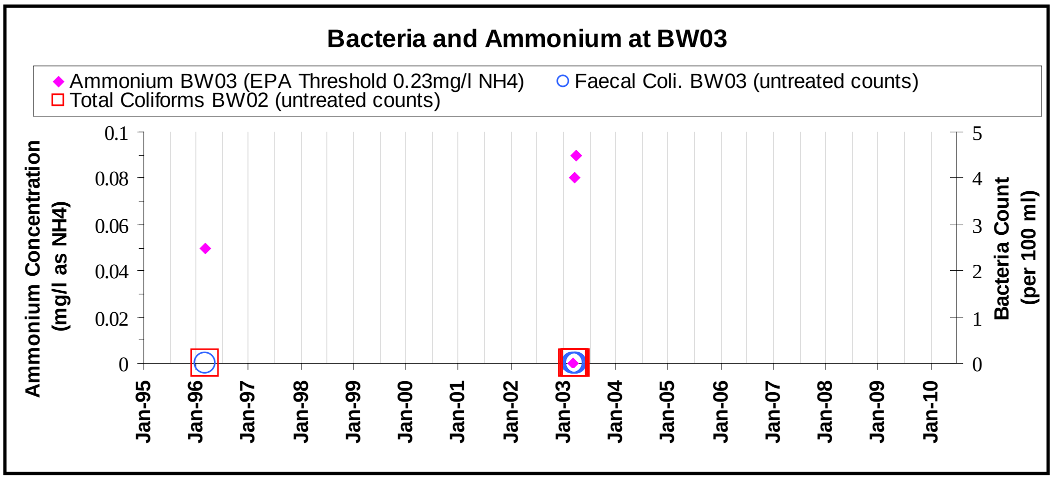

Figure 10 Key Indicators of Agri and Domestic Contamination (BW03): Bacteria and Ammonium

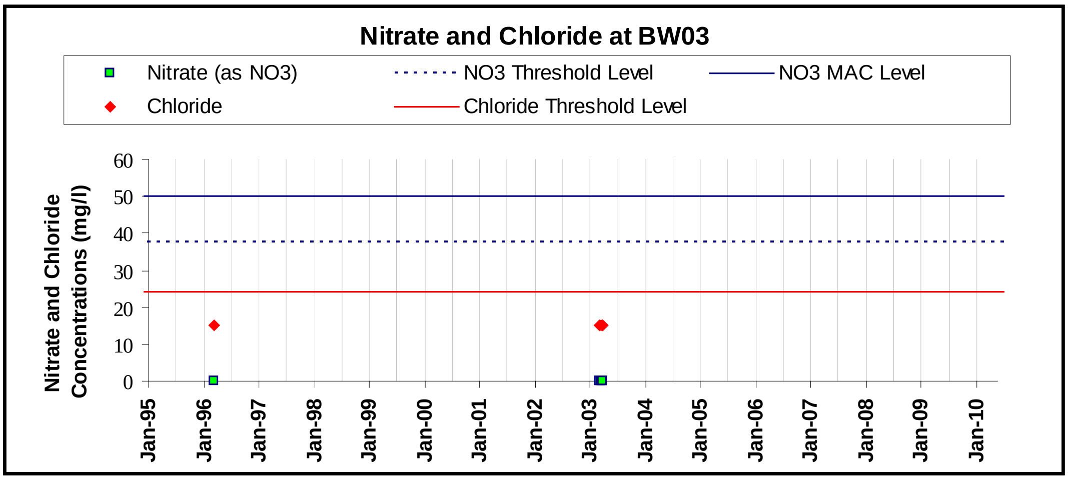

Figure 11 Key Indicators of Agri and Domestic Contamination (BW03): Nitrate and Chloride

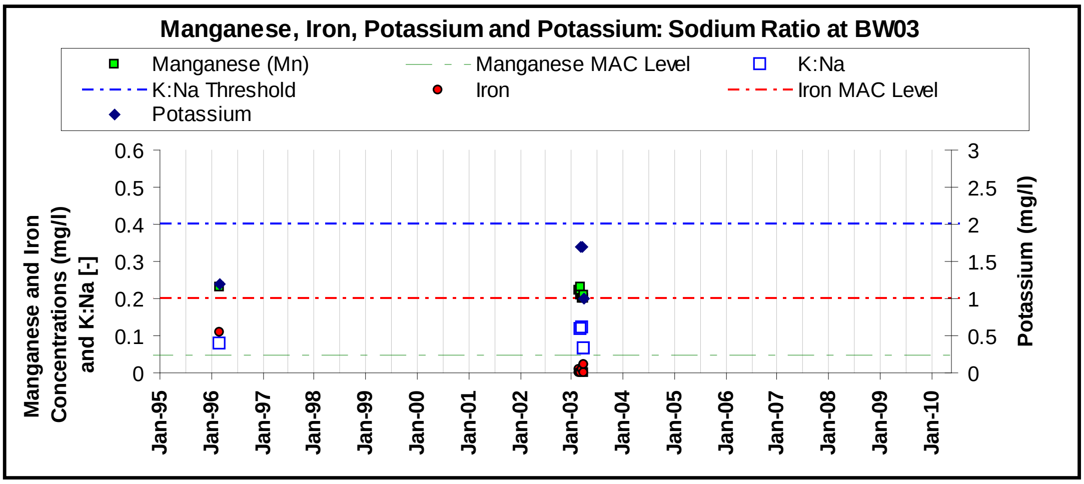

Figure 12 Key Indicators of Agri and Domestic Contamination (BW03): Mn, Fe, K and K:Na ratio

<u>BW02 (screened 10.2 to 19.2 mbgl in probable dolomitised limestone within the Milverton Group Limestone)</u>

- The water is moderately hard (165 to 216 mg/l as $CaCO_3$) and has a calcium bicarbonate hydrochemical signature with a significant magnesium component. All samples from the borehole were saturated with respect to dolomite (see Table 9-1). The average conductivity is 376 µS/cm and average pH is slightly alkaline at 7.8.

- No total or faecal coliforms were detected. Ammonium was detected at the laboratory detection limit on one out of three samples during the 2003 pumping test but was below all relevant assessment thresholds. Nitrate was not detectable in any of the samples in 1998 or 2003. This may indicate confined reducing conditions in the aquifer. Chloride concentrations were at natural background concentrations, with an average of 15 mg/l.
- The sulphate, potassium, sodium, magnesium and calcium levels and the K:Na ratio are within normal ranges.
- The concentrations of iron are detectable but below the MAC value. Manganese concentrations exceeded the MAC value in all samples (Figure 8). Elevated manganese concentrations suggest reducing conditions in the aquifer.
- Other trace metals were either within the normal range for good quality drinking water or were not detected. Similarly, organic compounds and herbicides have not been detected.

<u>BW03 (inflow from cavern at 82 to 89 mbgl in probable dolomitised limestone within the Milverton Group Limestone)</u>

- The water is moderately hard (152 to 195 mg/l as $CaCO_3$) and has a calcium bicarbonate hydrochemical signature with a significant magnesium component. All samples from the borehole were saturated with respect to dolomite. The average conductivity is 347 µS/cm and average pH is slightly alkaline at 7.7.
- No total or faecal coliforms were detected at the borehole. Ammonium was detected in several samples but was below all relevant assessment thresholds.
- Nitrate was not detectable in any of the samples in 1998 or 2003. This may indicate confined reducing conditions in the aquifer. Chloride concentrations were at natural background concentrations, with an average of 15 mg/l.
- High turbidity and silt was recorded during both pumping tests indicating that the cavern may be at least partially filled with unconsolidated sediments.
- The sulphate, potassium, sodium, magnesium and calcium levels and the K:Na ratio are within normal ranges.
- The concentrations of iron are detectable but well below the MAC value. Manganese concentrations exceeded the MAC value in all samples (Figure 8). Elevated manganese concentrations suggest reducing conditions in the aquifer.
- Other trace metals were within either within the normal range for good quality drinking water or were not detected. Similarly, organic compounds and herbicides have not been detected.

The data suggest that the groundwater from both boreholes is unpolluted but is affected by elevated manganese concentrations resulting from confined, reducing aquifer conditions.

Table 9-1: Dolomite Saturation Index (SI) Values

Borehole ID	Date	SI_{Dol}	Borehole ID	Date	SI_{Dol}	Borehole ID	Date	SI_{Dol}
TW11	05/02/1998	-1.3	**BW03**	11/03/2003	-0.2	**BW02**	11/03/2003	0.0
TW11	16/04/2002	-0.5	**BW03**	25/03/2003	-0.4	**BW02**	25/03/2003	0.1
TW11	22/04/2002	-0.8	**BW03**	04/04/2003	-0.4	**BW02**	04/04/2003	-0.1
BW03	07/03/1996	0.2	**BW02**	12/02/1998	0.6	**TW12**	12/02/1998	0.8

9.4 Aquifer characteristics

Boreholes BW02 and BW03 predominantly abstract water from dolomitised limestone layers within the Milverton Group Limestone. There may also be a component of flow from the northwest from the Namurian Shale bedrock into the shallow borehole BW02. The limestone is classified by the GSI as a *Regionally Important Karstified Aquifer (Rk)*. The Namurian shale rock unit is classified as a *Poor Aquifer (Pu)* while the Namurian sandstone and the Undifferentiated Namurian rock units further west are classified as *Locally Important Aquifers which are Generally Moderately Productive (Lm)* (see Figure 6). Boreholes BW03 and TW12 are artesian, indicating that the deeper limestone aquifer is confined or at least leaky confined (with upwards leakage)[5]. The data suggest that the groundwater intersected by borehole BW02 is confined by the CLAY overburden.

At borehole BW02, the majority of the flow intersected by the shallow borehole occurred in the heavily weathered top 5 m of the aquifer (WYG, 2003). This shallow, transmissive layer is likely to be present at rockhead across the study area. It is likely to be particularly transmissive in weathered dolomitised limestone strata such as at borehole BW02. Deeper groundwater flow occurs along bedding planes and through faults, fractures and fissures in the bedrock in both the *Lm* and *Rk* aquifers. In the *Rk* aquifer, the permeability of many of the fracture and fissure pathways has been enhanced by karstification. This characteristic will be exacerbated where dolomitisation creates additional interconnected void space. Evidence of large karst conduits with large groundwater inflows occurred at depth in probable dolomitised limestone strata in boreholes BW03 and OW05. The 1,260 m^3day, high specific capacity (360 m^3/day) abstraction sustained over a 6 week pumping test on borehole BW03 suggests that extensive karstification and dolomitisation occurs in the vicinity of the borehole in order to sustain the large abstraction.

It is likely that the karstified aquifer is anisotropic (i.e. greater transmissivity in the north-south direction than east-west). Karstification is likely to be focused along the north-south oriented faults and joints in the bedrock, and possibly along bedding planes which also strike north-south. This gives increased transmissivity in these directions. Boreholes BW03 and OW05 intersect caverns and are aligned north-south, which supports this suggestion. Furthermore, yields in boreholes to the north of the Barley Hill outcrop (e.g., BW03 and TW11) are greater than those in boreholes to the east (e.g., GSI Well Database record no. 2629SEW076).

Analysis of the 2003 pumping test data for boreholes BW02 and BW03 suggests a transmissivity range for the *Rk* aquifer of 47 m^2/day to 114 m^2/day (average of 80 m^2/day). Transmissivity at borehole TW03 located 3 km south-southeast of the test wells and intersecting the Namurian bedrock *Lm* aquifer, is recorded to have a transmissivity of 28 m^2/day (KTC, 1996).

Drawdown of 5.45 m was observed in the unpumped borehole TW12 (open hole 17 to 135 m in probable Dinantian limestone and dolomitised limestone) during the 2003 multi-well test. This drawdown may have been induced by either BW02 (shallow and 5 m from TW12) or BW03 (deep and 250 m from TW12), as both were pumping simultaneously.

Bulk aquifer permeability has been estimated from transmissivity by dividing by the length of the screened/open-hole section of the borehole (9 m for BW02). For borehole BW03, this is taken as the 7 m depth interval of the cavern at the base of the borehole. The estimated bulk aquifer permeabilities (K) are shown in Table 9-2.

The velocity of water moving through the aquifers to the boreholes is estimated using Darcy's Law:

$$\text{Velocity (V)} = (\text{K x Groundwater Gradient (i)}) / \text{porosity (n)}$$

[5] Confined aquifers occur where the groundwater in the water bearing rock layer is held under pressure by overlying impermeable / less permeable "confining" layers. Where the confining layer has some permeability leakage occurs.

The average natural gradients in the *Rk* and *Lm* aquifers are estimated at 0.021 and 0.039 respectively. No data on bedrock porosity are available however, the fracture porosities of the *Rk* and *Lm* aquifers are estimated at 0.05 based on experience of similar aquifers at other locations.

Table 9-2: Indicative Aquifer Hydraulic Parameters

Parameters	Source of Data	*Rk* aquifer (BW03)	*Lm* aquifer (BW02)
Transmissivity (m^2/d)	Calculated (based on pumping test data)	80	28
Permeability (m/d)	Estimated from T value (average) divided by the average screen/open hole length	10	0.22
Effective Porosity	Assumed (based on GSI regional experience)	0.05	0.05
Groundwater gradient	Assumed based on topography and field observations	0.021	0.039
Velocity (m/d)	calculated based on above	4.2	0.17

The average velocity of groundwater moving through the *Rk* and *Lm* aquifers is estimated as 4.2 m/d and 0.17 m/d respectively. The aquifer parameters are summarized in Table 9-2.

10 Zone of Contribution

The Zone of Contribution (ZOC) is the complete hydrologic catchment area to the test wells (source), or the area required to support an abstraction from long-term recharge. The size and shape of the ZOC is controlled primarily by (a) the total discharge, (b) the groundwater flow direction and gradient, (c) the subsoil and rock permeability and (d) the recharge in the area. This section describes the conceptual model of how groundwater flows to the source, including uncertainties and limitations in the boundaries, and the recharge and water balance calculations which support the hydrogeological mapping techniques used to delineate the ZOC.

10.1 Conceptual model

The test wells BW02 and BW03 abstract from the *Rk* limestone aquifer. Borehole BW02 is shallow and may also receive a minor input from the Namurian *Lm* aquifer immediately to the northwest. BW03 is deep and intersects a cavern which is considered to be in a dolomitised limestone layer of the *Rk* aquifer. Vertical hydraulic gradients at the boreholes, which result in artesian conditions in BH03 and TW12, suggest that upwards flow of confined groundwater is occurring in the vicinity of the boreholes. As such BW02 is also likely to be influenced by discharge from the deeper, confined, dolomitised limestone strata. Water quality data from each of the boreholes indicate saturation with respect to dolomite, reinforcing the hypothesis of the abstractions deriving from dolomitised strata. To date the groundwater has been unpolluted but with naturally elevated levels of manganese which are common in confined aquifers.

The *Rk* aquifer is mainly recharged at bedrock outcrop and karst features on Barley Hill, and where the overlying subsoils are thin. As well as direct recharge to the limestone outcrop, karst features are also likely to intercept runoff from the Namurian outcrop on the eastern flank of the crest of Barley Hill. Groundwater flow is mainly northwards from Barley hill along preferential karst flow paths with the River Lagan (and possibly nearby low-lying lakes) being the most likely natural discharge boundary. Flow to the south is prevented by a no flow boundary at the southern end of Barley hill, where the limestone abuts *Pu* and *Pl* aquifers. A minor component of groundwater flow is directed east off Barley Hill in the direction of steepest hydraulic gradient, but the magnitude of the flow is likely constrained by low transmissivity in that direction. Abstraction from the test wells is likely to induce northerly flow underneath the river to the boreholes. Groundwater flow from the north in the *Rk* aquifer currently appears to be directed toward the River Lagan.

The *Lm* aquifer to the northwest of the test wells is recharged by diffuse infiltration. The data suggest that the bulk of this recharge flows northwest toward the Drummond gypsum mine dewatering system. A southwest to northeast groundwater divide in the vicinity of Descart Lough separates the test wells from the dewatering system. Recharge to the southeast of the divide will flow towards the Lagan River in the weathered upper bedrock zone. There is only a small recharge area to the southeast of the divide such that groundwater flow volumes from this region are likely to be low in comparison with the *Rk* aquifer. A small component of the *Lm* aquifer flow may discharge into the weathered upper *Rk* aquifer and be intercepted by BW02. Direct recharge to the *Lm* aquifer at Barley Hill is expected to flow north and northwest to the River Lagan.

The conceptual model for the Descart study area is illustrated in the cross section in Figure 13.

10.2 Boundaries of the ZOC

The ZOC has been delineated across both the *Rk* and *Lm* aquifers. A single ZOC has been delineated for both boreholes. The boundaries of the areas contributing to the test wells are considered to be as follows (Figure 14):

<u>In the *Rk* aquifer</u> the **southeastern boundary** is the no-flow boundary between the *Rk* aquifer and the *Pu* and *Pl* aquifers to the south. The southern and northern extremes of the **western boundary** are defined by the geological boundary between the limestone and Namurian shale. To the west of this the limestone becomes confined and does not receive any recharge. For the middle section, the ZOC boundary extends west of the geological boundary to account for runoff from the eastern, upper slopes of Barley Hill, which is likely to flow onto the limestone surface and enhance the limestone recharge either diffusely or at karst features. As such the majority of the western boundary is defined by the topographic divide along the top of Barley Hill. The **northeastern boundary** is delineated with the same orientation as the geological faults and karst preferential flow paths. The positioning of the boundary has been determined by the water balance (Section 10.3), with the boundary given an easterly position sufficient to include the required recharge footprint within the ZOC. The **northern boundary** for the *Rk* aquifer curves around the north side of BW02 from the northeastern boundary to intersect the limestone geological boundary. The separation distance from the borehole is conservatively based on the Uniform Flow Equation downgradient distance (x_L) (Todd, 1980). This is calculated to be 130 m based on the average parameters from Table 9-1:

> $x_L = Q / (2\pi * T * i)$ where:
> Q is the daily pumping rate (proposed maximum demand for the scheme = 1400 m^3/day);
> T is the *Rk* aquifer Transmissivity (taken from aquifer characteristics); and
> i is gradient in the *Rk* aquifer.

A small extension has been added to the ZOC in the <u>*Lm* aquifer to the northwest of borehole BW02</u>. This is to account for the possibility of some groundwater in the *Lm* aquifer discharging into the upper weathered *Rk* aquifer and then into the borehole. The northwestern boundary of this extension is taken as the *Lm* aquifer groundwater divide. The southwestern and northeastern boundaries are conservatively delineated as flowlines (+/- 20^{O} to allow for possible flow direction variation) which discharge into the *Rk* aquifer ZOC area. It is considered that pumping from BW02 will have a negligible impact on the position of the groundwater divide, as the abstraction from borehole BW02 will predominantly derive from the *Rk* aquifer dolomitised limestone.

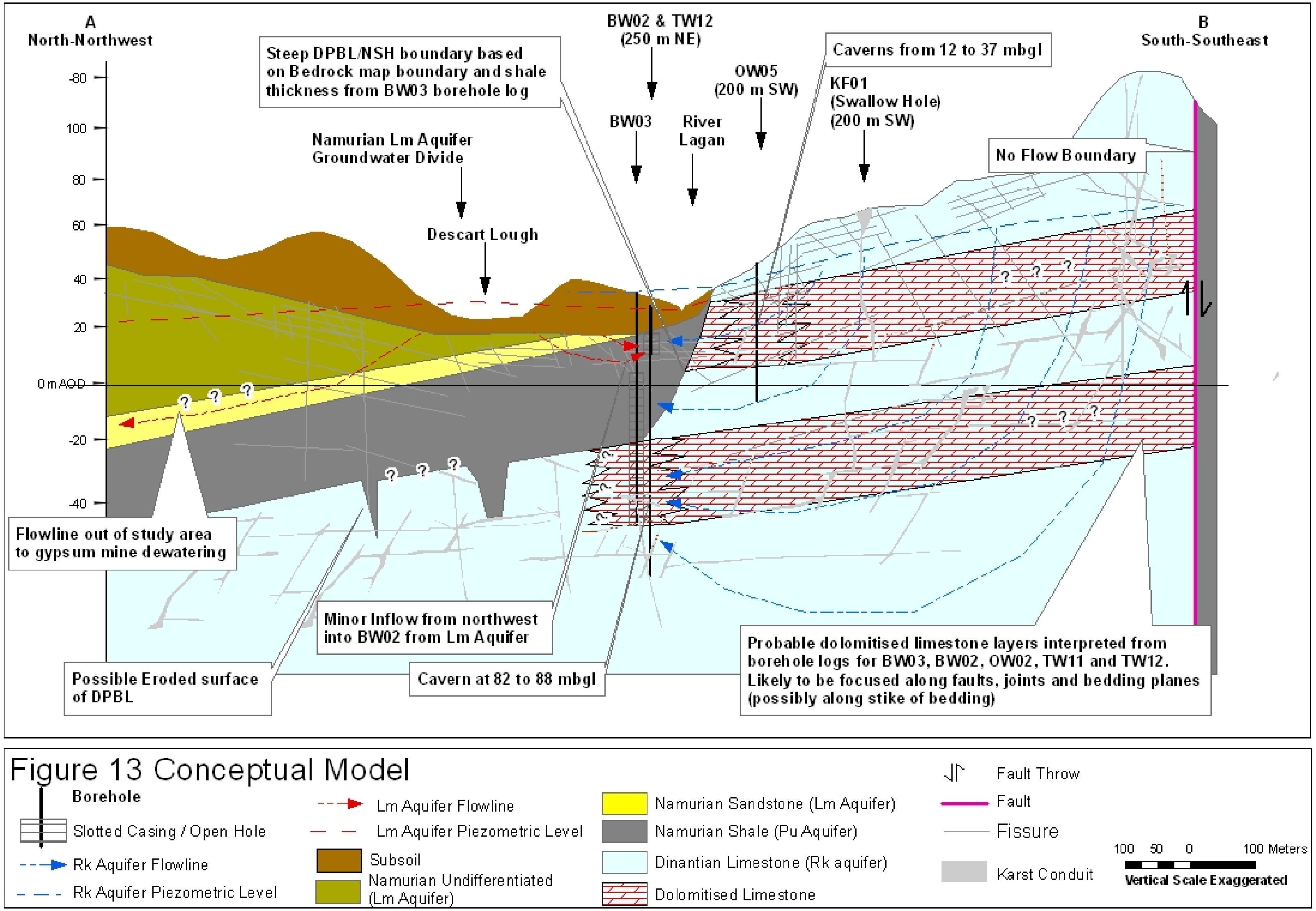

Figure 13 Conceptual Model

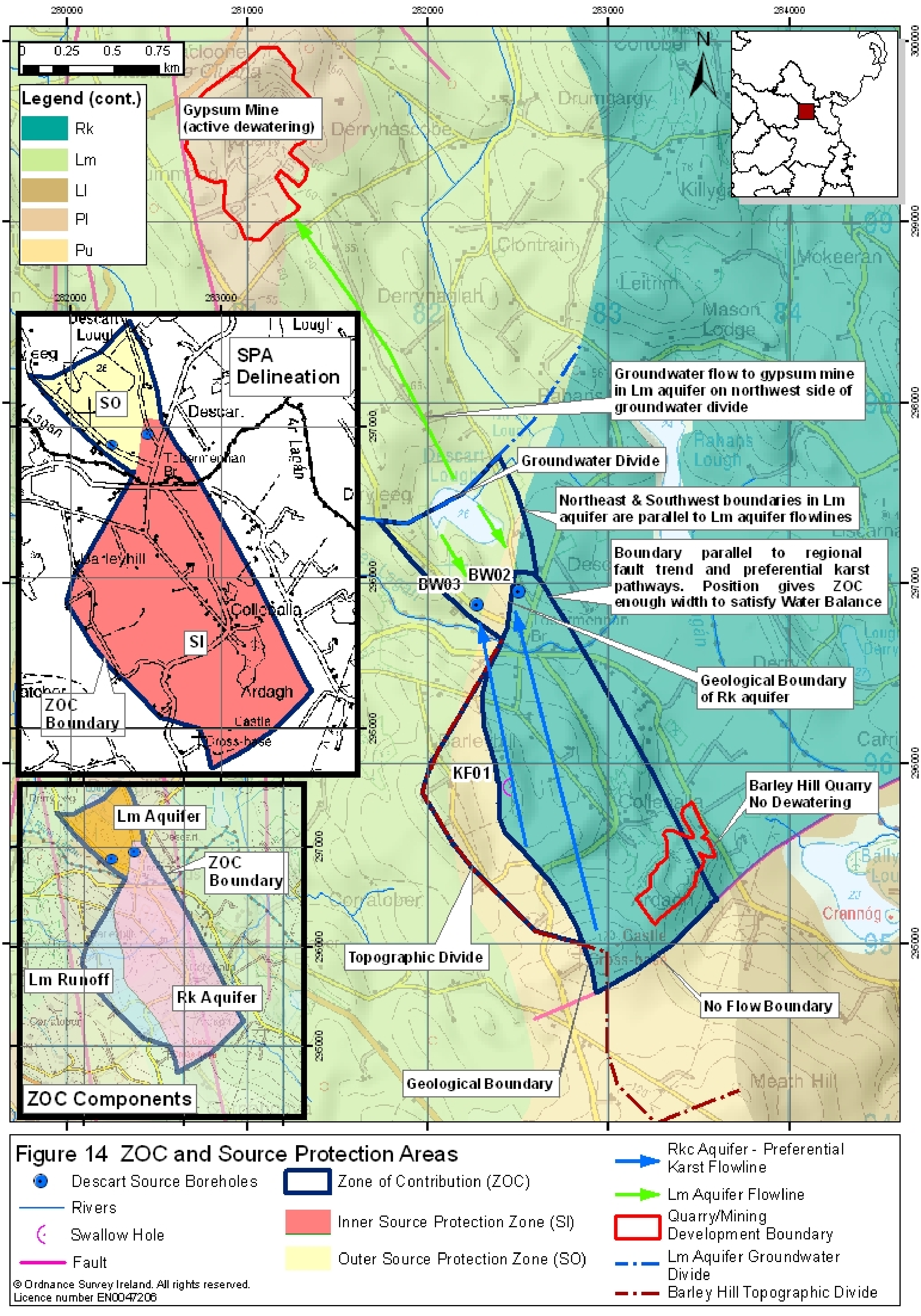

Figure 14 Zone of contribution and Source Protection Areas

10.3 Recharge and water balance

The vast majority of the water abstracted from boreholes BW02 and BW03 is expected to come from the *Rk* aquifer. As such, the recharge rate and water balance have been calculated for the *Rk* aquifer component of the abstraction alone. The calculation does not include the minimal input from the *Lm* aquifer northwest of BW02, and additional contributions from runoff via karst point recharge which are difficult to quantify, and so the resulting ZOC is likely to be conservative.

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 assumed to consist of input (*i.e*. annual rainfall) less water loss prior to entry into the groundwater system (*i.e*. annual evapotranspiration and runoff). The estimation of a realistic recharge rate is important in source protection delineation, as it will dictate the size of the ZOC to the source (and therefore the Outer Source Protection Area). The recharge is estimated as follows.

Potential recharge is equivalent to 597 mm/yr *i.e.* (Annual Effective Rainfall, see Section 6).

Actual recharge has been estimated to be 481 mm/yr, which is 81% of potential recharge; this value is based on averaging of the recharge for the different settings outlined in Table 10-1.

Runoff losses: 116 mm (19% of potential recharge). Rejected potential recharge is assumed to runoff to surface water *via* surface and interflow.

These calculations are summarised in Table 10-2.

Table 10-1 Recharge coefficients for the *Rk* aquifer component of the ZOC area

Vulnerability	Location in Study Area	Additional Factors	% Area	Recharge Coefficient Guidance		Chosen Recharge Coefficient	Calculated Recharge Component
				Inner Range	Outer Range		(mm/yr)
Low	Low permeability till subsoils in the vicinity of the test wells and on the crest of Barley Hill	Moderate to steep slope on Barley Hill and drumlins.	0.8	5 - 15%	2 - 20%	0.05	3.9
Moderate	Moderate permeability alluvial subsoils to southeast and south of test wells.	Low drainage density	1.2	30 - 40%	25 - 60%	0.5	6.0
	Thinner low permeability till subsoils in the vicinity of the test wells and on the crest of Barley Hill	Moderate to steep slope on Barley Hill and drumlins.	1.2	10 - 20%	5 - 30%	0.1	5.8
High	Thinner moderate permeability till and alluvial subsoils to southeast and south of test wells.	Low drainage density	2.7	50 - 70%	35 - 80%	0.7	13.0
	Thin low permeability till subsoils in the vicinity of the test wells and on the crest of Barley Hill	Moderate to steep slope on Barley Hill and drumlins.	2.3	23 - 30%	10 - 40%	0.23	10.9

Vulnerability	Location in Study Area	Additional Factors	% Area	Recharge Coefficient Guidance		Chosen Recharge Coefficient	Calculated Recharge Component
				Inner Range	Outer Range		(mm/yr)
Extreme (E)	Till subsoils to southeast and south of test wells with well drained soils.	Low drainage density. Karst Features. Steep Slope.	29.1	50 - 70%	45 - 80%	0.75	139.8
	Till subsoils to east and south of test wells with poorly drained soils	Low drainage density	1.8	25 – 40%	15 - 50%	0.4	8.8
Extreme (X)	Bedrock outcrop at Barley Hill and Killygally/Mokeeran	Low drainage density. Karst Features. Steep Slope.	60.9	80 – 90%	60 – 100%	0.9	292.8

Table 10-2 Recharge Calculation Summary for *Rk* aquifer component of the ZOC area

Parameter	Coefficient	Rate
Average rainfall (R)		1013 mm/yr
Estimated P.E.		438 mm/yr
Estimated A.E. (95% of P.E.)		416 mm/yr
Effective rainfall		597 mm/yr
Potential recharge		597 mm/yr
Averaged runoff losses	(19%)	116 mm/yr
Bulk recharge coefficient	0.81	
Recharge		481 mm/yr

The water balance calculation states that the recharge over the area contributing to the source should equal the discharge at the source. At a recharge of 481 mm/yr, an average yield of 1,408 m^3/day, which is the proposed scheme yield, would require an *Rk* aquifer recharge area of 1.07 km^2. During the February 2003 multi-well pump test, boreholes BW02 and BW03 were pumped at a combined rate of 2,160 m^3/day. This is approximately 150% of the target yield. The ZOC has been delineated conservatively for this maximum tested value to allow for unexpected increases in demand and for expansion of the normal (100% demand) ZOC under prolonged drought conditions. This requires an *Rk* aquifer recharge area of 1.6 km^2. The area of the ZOC described above is 1.49 km^2 (equivalent to 1995 m^3/day), which is slightly below the target area, and is shown in Figure 14.

Point recharge of runoff from the *Lm* aquifer area (0.41 km^2) on the crest of Barley Hill has not been quantified, however it is likely to increase the total available recharge volume for the ZOC footprint to at least the 150% of proposed demand value of 2,160 m^3/day.

In the same way as for the *Rk* aquifer, the bulk recharge coefficient for the northwestern ZOC extension onto the *Lm* aquifer is estimated as 0.06 (6%). The ZOC extension has an area of 0.35 km^2, which implies that the recharge to the ZOC from this additional area is only 35 m^3/d.

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 protection areas have been delineated, the Inner Protection Area and the Outer Protection Area.

The Inner Protection Area (SI) is designed to protect the source from microbial and viral contamination and it is based on the 100-day time of travel (TOT) to the supply (DELG/EPA/GSI 1999). Based on the indicative aquifer parameters presented in section 8.5, the groundwater velocity is 4.2 m/d and 0.17 m/d in the *Rk* and *Lm* aquifers respectively. The 100-day TOT distance therefore, is 420 m in the *Rk* aquifer and 17 m in the *Lm* aquifer. The Outer Protection area (SO) is the remainder of the ZOC outside the SI.

Parts of the ZOC delineated in the *Rk* aquifer lie outside the relevant 100-day TOT limit, however flow paths in individual karst conduits can greatly exceed the calculated average for the bulk aquifer. As such, the entire *Rk* aquifer ZOC is conservatively classified as SI. The extension of the ZOC onto the *Lm* aquifer on eastern flank of the crest of Barley Hill is also classified as SI because runoff from this area is likely to rapidly enter the karst system.

Borehole BW03 is cased off from the *Lm* aquifer such that inflow to the borehole only comes from the *Rk* aquifer at depth. Furthermore the strongly artesian *Rk* aquifer suggests that any leakage along the casing will be upwards out of the *Rk* aquifer rather than downwards from the *Lm* aquifer. As such, no SI zone is delineated around BW03 in the *Lm* aquifer. Nonetheless, BW03 is located 80 m inside the ZOC boundary, which provides protection to the area surrounding the wellhead. Borehole BW02 is physically sited in the SI zone on the *Rk* aquifer at a minimum of 50 m from the *Lm* aquifer. As such, it is already buffered by an SI zone exceeding the 17 m requirement of the *Lm* aquifer. As a result, no additional SI area has been delineated on the *Lm* aquifer footprint northwest of the boreholes. The *Lm* aquifer in this area is classified as SO.

The Inner and Outer Protection Areas are illustrated in Figure 14.

The groundwater Source Protection Zones across the entire ZOC are shown in Figure 15 and are listed in Table 11-1. They include SI/X, SI/E, SI/H, SI/M, SI/L, SO/H, SO/M and SO/L. Over 70% of the ZOC is designated as SI/X or SI/E.

Table 11-1 Source Protection Zones for Entire ZOC Area

Source Protection Zone		% of Total Area	Area (km^2)
SI/X	Inner Source Protection area / Extreme vulnerability, ≤1 m subsoil	41.4	0.93
SI/E	Inner Source Protection area / Extreme vulnerability, <3 m subsoil	28.2	0.64
SI/H	Inner Source Protection area / High vulnerability	8.2	0.19
SI/M	Inner Source Protection area / Moderate vulnerability	4.3	0.10
SI/L	Inner Source Protection area / Low vulnerability	2.4	0.05
SO/E	Outer Source Protection area / Extreme vulnerability, <3 m subsoil	0.0	0.00
SO/H	Outer Source Protection area / High vulnerability	0.3	0.01
SO/M	Outer Source Protection area / Moderate vulnerability	5.3	0.12
SO/L	Outer Source Protection area / Low vulnerability	9.9	0.22

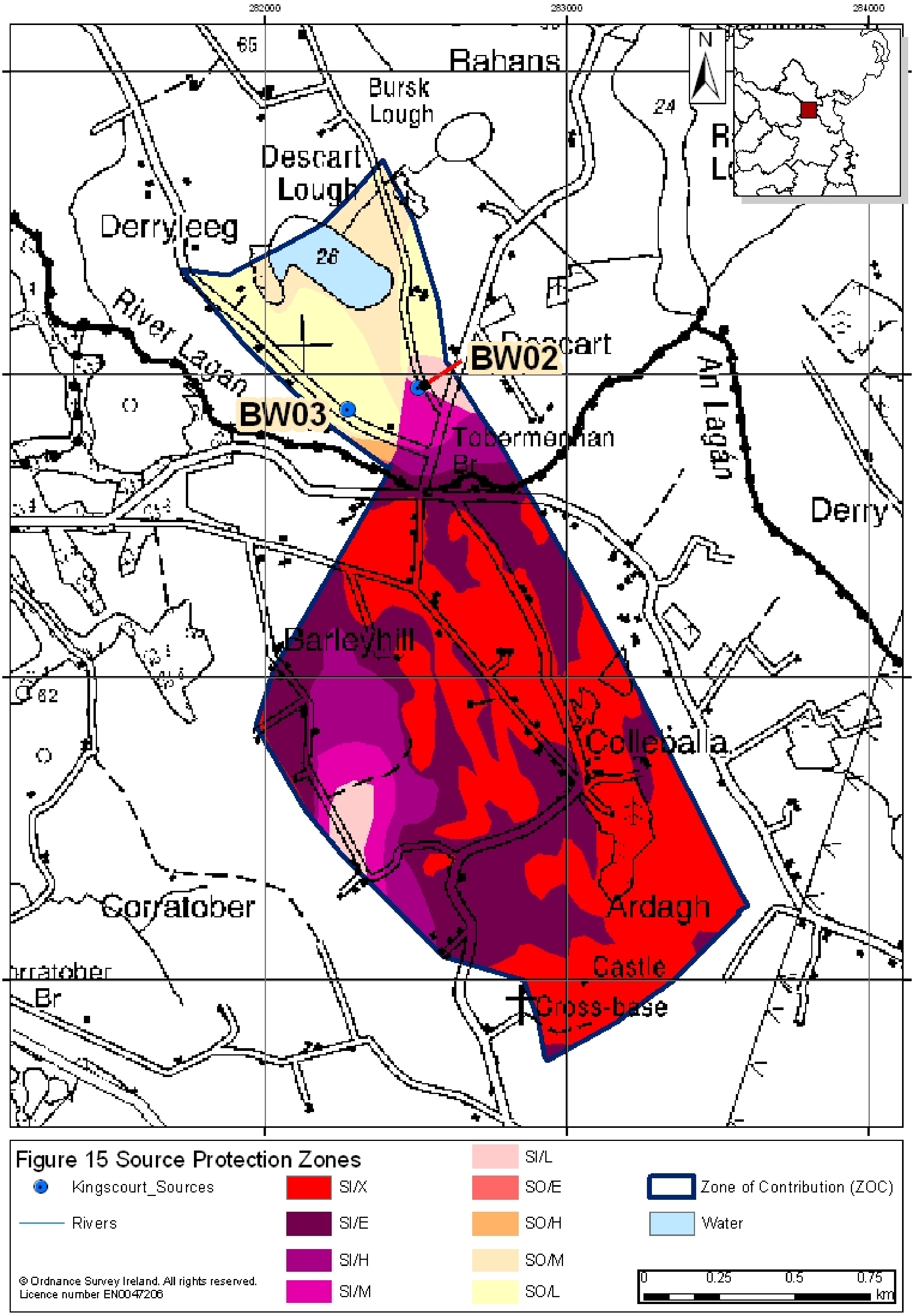

Figure 15 Source Protection Zones

12 Potential pollution sources

The two test wells currently have negligible well head protection and are vulnerable to direct contamination from surface spills or animal activity.

The landuse within the ZOC is primarily agricultural with numerous residential farms and pastureland for grazing animals. Agricultural activities such as grazing and landspreading of agricultural waste present a potential risk of microbial pollution to the boreholes as well as the potential for elevated concentrations of ammonia, nitrate, phosphate, chloride, potassium, BOD, COD, TOC and pesticides. Testing to date suggests that the water quality at the test wells is good, however testing has been infrequent and the wells have only been pumped during the testing period. Given the *Rk* aquifer classification and presence of large areas of extreme vulnerability within the ZOC/SI, the potential risk from cryptosporidium and viruses is high.

Several third class roads traverse the ZOC. The main potential contaminants from this source are surface water runoff contaminated with hydrocarbons and metals. However, the low traffic density locally, as well as the groundwater vulnerability around the boreholes, suggests that the risk of such contamination is low.

13 Conclusions

The Descart expansion of the Kingscourt Water Supply Scheme is proposed to comprise two production wells to be drilled at the sites of the existing test wells BW02 and BW03. The boreholes will predominantly abstract water from the dolomitised limestone bedrock, which is classified as an *Rk* aquifer. The total scheme demand is 1,408 m^3/day. The existing test wells have a proven yield of 2,160 m^3/day, approximately 150% of the proposed total demand. The ZOC for the test wells has been delineated conservatively on the basis of a demand of 2,160 m^3/day.

The delineated ZOC contains areas classified as SI and SO. Parts of the SI are classified as Extreme vulnerability with rock at or very close to the surface in places. Groundwater quality appears to be relatively good but this is based on just limited testing to date.

The *Rk* component of the ZOC (i.e. the main source for the abstraction) encompasses an area of 1.5 km^2 which incorporates a diffuse recharge footprint of 1,955 m^3/day, *i.e.* approximately 150% of the total demand of the scheme. There is a further contribution of approximately 24 m^3/day from the *Lm* aquifer component northwest of the boreholes, and an unquantified point-recharge component from runoff from the eastern flank of Barley Hill.

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

Comprehensive well head protection should be implemented at all trial well locations across the study area including the test wells BW02 and BW03 and at the proposed production wells once these are commissioned.

A suitable groundwater level monitoring regime should be set up across the ZOC to identify annual fluctuation in the groundwater flow directions during the current non-pumping conditions and changes to these baseline conditions once full scale pumping is initiated.

Groundwater quality at the boreholes should be monitored closely in the first year after commissioning of the boreholes to confirm the unpolluted condition of the groundwater through the entire annual cycle. The good quality experienced to date may be because of reasonably long residence times in the confined aquifer conditions. When the wells start pumping the confined status may change in parts of the aquifer, along with, consequently, the water quality.

A tracer test should be carried out once the full scale pumping is established in order to confirm flowlines to the borehole from the Barley Hill area.

The ZOC contains SI/X and SI/E designations. Source specific landspreading exclusion zones should be developed for the test wells to take account of the landspreading risk associated with this designation.

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APPENDIX 1

- Borehole Logs – BW02 & BW03
- Table A1.1 – Kingscourt Trial Wells & Observation Wells - Data from KTC & WYG 1995 to 2003
- Table A1.2 – Kingscourt Trial Wells & Observation Wells - Groundwater Level Data from KTC & WYG 1995 to 2003
- Table A1.3– Kingscourt Trial Wells & Observation Wells - WYG Groundwater Level Data November 2001 to March 2002
- Table A1.4 – Kingscourt Trial Wells & Observation Wells – Data from PC Fieldwork, WYG 2003 and Gypsum Ltd (Minerex) 2003 & 2010
- Table A1.5 – GSI Well Database Records within the Study Area
- Table A1.6 –Water Quality Data For Kingscourt Trial Wells and Gypsum Ltd Monitoring Wells
- Figure A1.6 – Data Points in the Vicinity of Descart PWS Site
- List of abbreviations used in Appendix tables

WELL LOG

Well No.	Description	Location
TW 13	Kingscourt Water Supply	Descart, Co.Monaghan

BW02

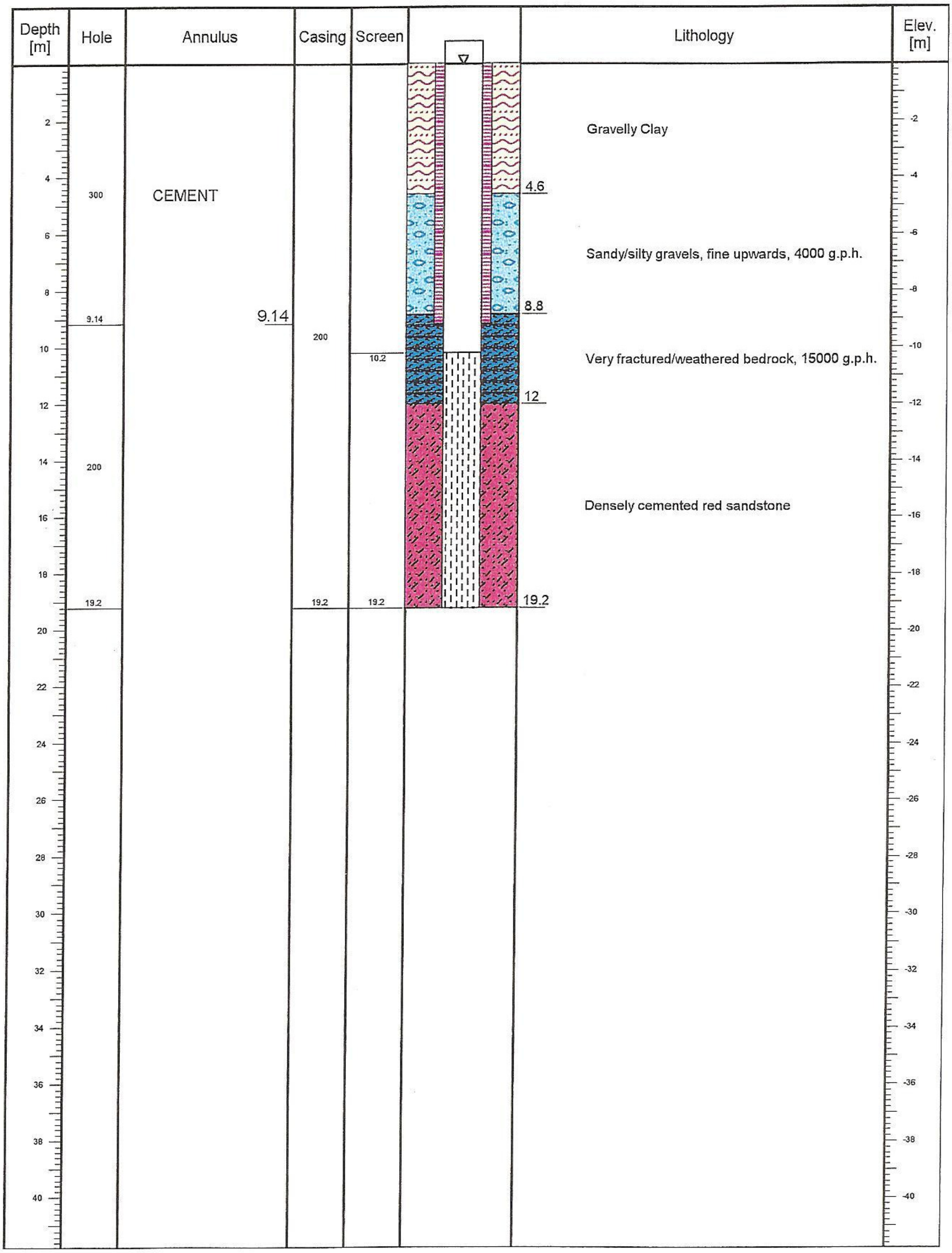
Date Drilled	Driller
January 1998	Dunnes Water Services

Water Level (mbtoc)	-0.02

All diameters in mm
All depths in metres

Scale

Vertical	Horizontal
200.0	30.0



Completed Well Design

BW03

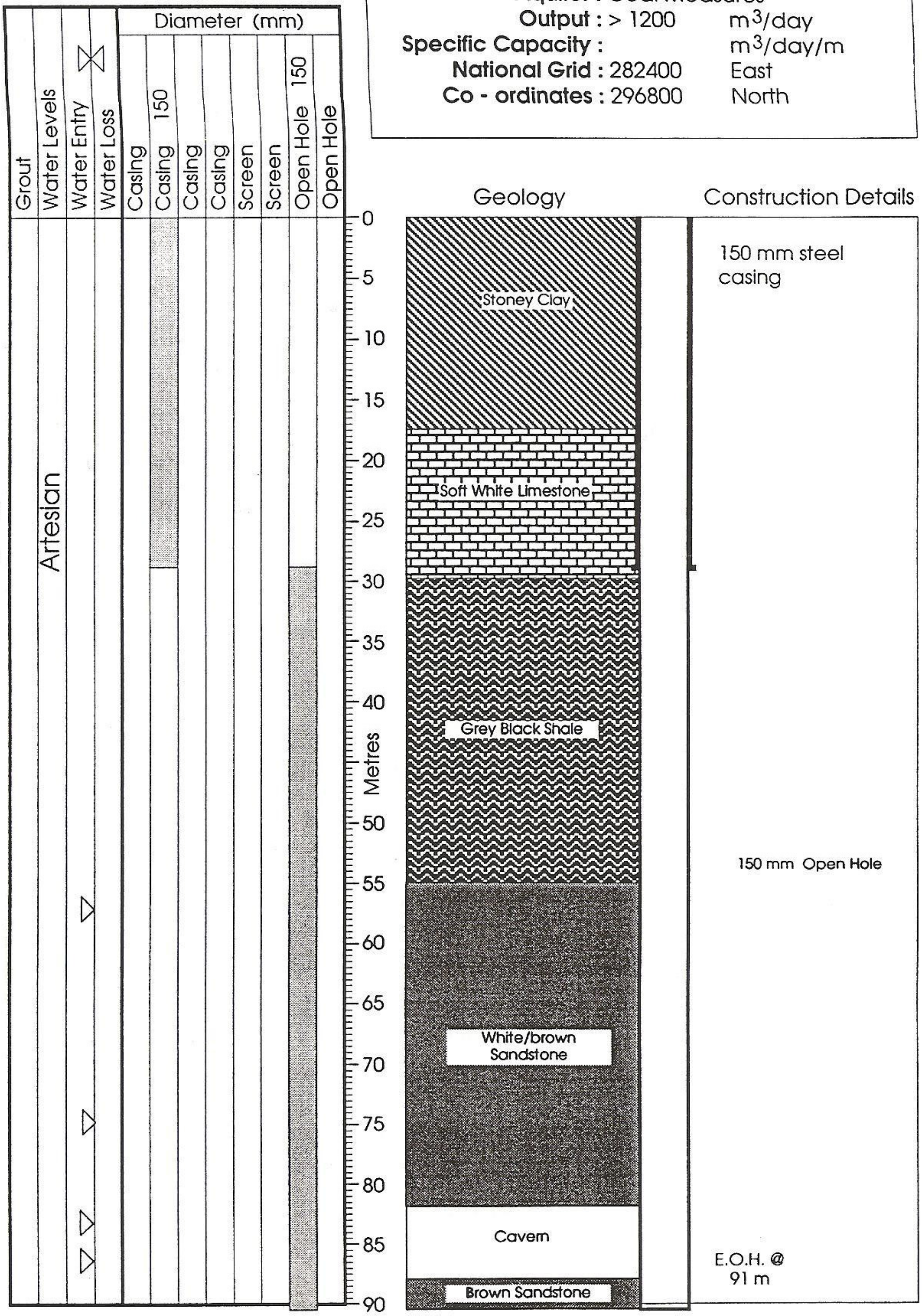
Trial Well No.10

Client : P.H. McCarthy
Project : Kingscourt RWSS
Location : Descart
County : Monaghan
Date : February 1996
Driller : Dunnes Water Services
Aquifer : Coal Measures
Output : > 1200 m^3/day
Specific Capacity : m^3/day/m
National Grid : 282400 East
Co - ordinates : 296800 North

Remarks

The cavern was a compltete void the drilling tools dropped when this was encountered.

A pumping test was carried out and the well was pumped at a rate 1134 m3/day for 30 hours . This rate was not suffiecient to lower the water level below the top of the casing



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Hydrogeological & Environmental Consultants

Figure No.

Name	Source	Other Names	X	Y	Drill Date	Driller	Casing	Screen / OH	Final Diameter mm	Water Strikes mbgl
TW01	KTC 1998		279152	294568	15/12/1994	Dunnes Water Services Ltd	5m 250mm SC	OH 5 - 91.44m	200	
TW02	KTC 1998		280853	293118	14/12/1994	Dunnes Water Services Ltd	150mm SC to 8m	OH 8 to 91.4m	150	27, 29, 34, 52, 56 and 76m
TW03	KTC 1998		281078	293825	Feb-95	Dunnes Water Services Ltd	150mm to 12m	OH 12 to 137m	150	28, 40, 73, 123 and 134m
TW04	KTC 1998		281217	292498	Feb-95	Dunnes Water Services Ltd	150mm SC to 6m	OH 6m to 91m	150	53 and 66m
BW01	KTC 1998	TW05, TW5, Borewell No.1	280006	297801	May-95	Dunnes Water Services Ltd	300mm SC to 70m with grouted annulus, 200mm SC 0 to 72m	Galvanised 200mm, 0.4mm slot wellscreen 72 to 113 with closed sump 113 to 120m.	200	28m, 40m, 74 to 115m
TW06	KTC 1998		279600	295810	Jul/Aug-95	Dunnes Water Services Ltd	200mm SC to 20m, 150mm SC 0 to 45m	150 mm OH 45 to 99m	150	
TW07	KTC 1998		281689	294534	Aug-95	Dunnes Water Services Ltd	150mm SC to 14m	OH 150mm 14 to 121m	150	Main inflow (45 - 52), (82-88)&(94-109)m, WS @ 25, 48, 82 and 95
TW08	KTC 1998		280528	295768	Feb-96	Dunnes Water Services Ltd	150mm SC to 26 m	OH 26 to 107m	150	Main inflow (88-94)m. WS @ 80 & 84m.
TW09	KTC 1998	PW9	282098	296445	Feb-96	Dunnes Water Services Ltd	200mmSC to 30m	OH 30 to 82m	200	25, 28, 45, 54, 69 and 79m.
BW03	KTC 1998	TW10, Borewell No.3	282281	296881	Feb-96	Dunnes Water Services Ltd	150mm SC to 29m	OH 29m to 91m	150	Main Inflow (82 - 88m, cavern). Inflows @ 57, 74 & cavern.
TW11	KTC 1999		282255	296593	Jan-98	Dunnes Water Services Ltd	OH at 200mm to 91m??, 125mm uPVC liner 0 to 64.8	125mm uPVC screen 64.8 to 91.4m	200 OH with 125mm PVC liner	Main inflow in white Sst below 64.8m (540 to 1080m3/d)
TW12	KTC 2000		282524	296952	Jan-98	Dunnes Water Services Ltd			150 OH, collapsing	Inlfow in Gravels. Large inflow in upper Red Sst (cased off). Lst Inflow ~ 500-700m3/d below 122m
BW02	KTC 2001	TW13, Borewell No.2	282514	296953	Jan-98	Dunnes Water Services Ltd	200mm SC to 19.2m	Casing slotted 10.2 to 19.2m	200	Water in gravels; Main Inflow 8.8 to 10.2m.
TW14	KTC 1999		280957	296468	19/02/1999	Dunnes Water Services Ltd	200mm SC ro 37.8m	OH at 200mm 37.8 to 91m	200	Main inflow in cavities in Sst (50 to 55mbgl, 1620m3/d); Lesser inflow at 40 to 45m (324m3/d)
TW14A	KTC 2002		280915	296565	21/11/2001	Dunnes Water Services Ltd	500mm SC to 5m, 250mm SC 0 to 24.38 (300mm hole), 200mm SC grouted in place 0 to 63.09m	OH at 200mm 63.09 to 91.44m	200	Major Inflows between (66 & 68)m & at 90m
TW15	KTC 2002		280790	296103	26/10/2001	Dunnes Water Services Ltd	500mm SC to 5m, 200mm SC grouted into rock at 0 to 45.7m	OH at 200mm 45.7 to 122m	200	Inflow at 24 to 31.4m sealled off by 200mm casing; Inflow @ 45m; Main inflow at in shale just below gypsum at 82m, increasing below 82m
TW16	KTC 2002		281631	296499	02/11/2001	Dunnes Water Services Ltd	500mm SC to 5m, 200mm SC grouted into rock at 0 to 38m	OH at 200mm 38 to 107m	200	Main inflows at 45m & at 53m, no signif inflow below 53m
OW01	KTC 2002		280418	295625	09/11/2001	Dunnes Water Services Ltd	200mm SC to 7m, 150mm SC to 37m	OH @ 150mm 37 to 69m; 125mm slotted PVC liner 0 to 65m	150 with 125mm PVC liner	Assume similar to TW08
OW02	KTC 2002		280820	296193	31/10/2001	Dunnes Water Services Ltd	200mm SC to 6m, 150mm SC to 37m	OH @ 150mm 38 to 61, 150mm SC slotted 24 to 30m	150mm	Inflow at 28 to 30m
OW04	KTC 2002		281712	296497	26/10/2001	Dunnes Water Services Ltd	200mm SC to 6m, 150mm SC to 24.3m	OH @ 150mm 24.3 to 52	150mm	Inflow at 28 to 30m & 46 to 48m
OW05	KTC 2002		282240	296361	25/10/2001	Dunnes Water Services Ltd	150mm SC to 22m	OH @150mm 22 to 52, 125mm slotted PVC liner 0 to 48m	150 with 125mm PVC liner	Inflow @ 20 to 22m, 42 to 44m
OW06	KTC 2002		281324	296115	24/10/2001	Dunnes Water Services Ltd	150mm SC to 25m	OH @150mm 25 to 52, 125mm slotted PVC liner 0 to 52m	150 with 125mm PVC liner	Inflow @ 13 to 15m and 50 to 52m
C35/3c	NERDO 1981				01/06/1905	GSO	200mm SC to 52m, 150mm SC 0 to 82m	12m Johnson Well screen - assume 82-94m	150mm?	
MHPW1	KTC 2002		285214	294203						
MHPW2	KTC 2002		285214	294203						
MHOW	KTC 2002		285214	294203						
DW01	KTC 2002		280302	295472						
DW02	KTC 2002		280442	295280						
DW03	KTC 2002		282664	296576						
DW04	KTC 2002		282409	296820						
DW05	KTC 2002		-	-						
DW06	KTC 2002		281740	294418						
DW07	KTC 2003		282087	297002	1991					
DW08	KTC 2002		281806	297233						
DW09	KTC 2003		281760	297256						
BH02	PC Fieldwc	DW10	281735	297430						
DW11	KTC 2003		281650	297388						
DW12	KTC 2003		281708	297598						
DW13	KTC 2003		281635	297643						
DW14	KTC 2003		281602	297691						
DW15	KTC 2003		282199	297811						
DW16	KTC 2003		282638	296949						
DW17	KTC 2003		282901	296834						
DW18	KTC 2003		282758	297289						
DW19	KTC 2003		282737	297576						
DW20	KTC 2003		280117	298051						
DW21	KTC 2003		280058	297946						
DW22	KTC 2003		279802	297283	1965					
DW23	KTC 2003		279848	297218						
DW24	KTC 2003		279871	297107						
DW25	KTC 2003		279877	297379						

Name	Source	Other Names	Top of Casing	Type	TD	DTB	Subsoil (KTC logs)	Lithology	WL Meas Ref	SWL	SWL Date	Yield	Comments
			mAOD Poolbeg		m	m				mbgl	Assumed		
TW01	KTC 1998		inaccessible (2002)		91.44	7.5	Gravelly Clay	Permo-Triassic Sst		2.5	Dec-94		
TW02	KTC 1998		inaccessible (2002)		91.4	33.5	Silty, gravelly Clay	Namurian Sandstones & Shales		2.03	Jan-95		Close to a high yielding domestic well
TW03	KTC 1998				137	9.5	Silty, gravelly Clay	Namurian Sandstones & Shales		2.32	Feb-95		
TW04	KTC 1998				91	2.5	Clay	Namurian Sandstones & Shales		29	Feb-95		
BW01	KTC 1998	TW05, TW5, Borewell No.1			120	39	Brown Boulder Clay	Permo-Triassic Sst		0.8	May-95		Located 13 m from NERDO borehole C35/3c
TW06	KTC 1998				99	2	Clay	Permo-Triassic Sst		-			
TW07	KTC 1998				121	10	Silty, gravelly Clay	Namurian Sandstones & Shales		17.5	Aug-95		
TW08	KTC 1998		52.86		107	11	Red Clay	10-74m KC Gypsum Fmn / Namurian Sst & Shale		11.95	19/02/1996		Upper portion of hole intercepted gypsum beds (20 to 75m) with Namurian shale & SST below. Main inflow from grey black shales. TOC from KTC 2002 Table 2.
TW09	KTC 1998	PW9	67.89		82	7.5	Stoney CLAY	Namurian Sandstones & Shales		11.67	29/02/1996		Main inflow from black shales, may have masked inflow from underlying SST. Sst collapsing below 82m. TOC from KTC 2002 Table 2.
BW03	KTC 1998	TW10, Borewell No.3			91	17.5	Stoney Clay	Through Namurian Sandstones into Dinantian Limestones		Artesian			Inflow encountered in SST. Main inflow from cavern in the SST, possibley Dinantian Karst, Not possible to determine underlying rock type due to cavern infill. Cavern was an empty void mostly, no drilling needed. All inflows artesian. WELL PLUGGED TO STOP OVERFLOW in approx June1996.
TW11	KTC 1999		36.7		91.4	7.6	Gravelly CLAY	Namurian Sandstones & shales		0.6mbtc	Jan-98		TOC from KTC 2002 Table 2.
TW12	KTC 2000				135	8.8	Gravelly Clay to 4.6m over sandy silty gravels (fining upwards) to 8.8m	Through Red Sst (Nam) into Limestone (DIN) below 122m		0.6mbtc	Jan-98		
BW02	KTC 2001	TW13, Borewell No.2			19.2	8.8	Gravelly Clay to 4.6m over sandy silty gravels to 8.8m	Red Sandstone (Namurian)		0.02mbtc	Jan-98		432m3/d yield est for gravel subsoil. 1540m3/d yield est for frac, weathered bedrock immediately under gravels. Annulus cemented to 9.14m.
TW14	KTC 1999		39.55		91	21.3	Gravelly Clay (0 to 12.2m) / over coarse Boulder Clay (12.2 to 21.3m)	KC Gysum Fmn (Gypsum 21.3 to 30.5m) / mudstone/ NAM Sst&Shale (31.7 to 62.5m)/Sst		7.06 mbtc	19/02/1999		Annulus cemented to 31.7 m. High Fe & Mn. High SO4. TOC from KTC 2002 Table 2.
TW14A	KTC 2002		41.16		91.4	24.4	Red CLAY (0-3m)/Brown-red CLAY with Gravel (3-12)/Red CLAY (12-24.4)	PT into NAM. Interbeded Red & White sst to 54m/ shales interbeded with black mudst.		9.75	21/11/2001		Originally intended to be an Observation well for TW14 (would have been OW03), drilled for 6 week Multi-well pump test. More secure location than TW14, therefore used TW14A as the Trial well and TW14 as the observation well. TOC from KTC 2002 Table 2.
TW15	KTC 2002		59.7		122	38	Brown CLAY and sand (0-10m)/ Red Boulder CLAY (10-15)/ Red Gravelly CLAY (15-30)/coarse silty GRAVEL (30-34)/ coarse clayey GRAVEL (34-38)	PT into NAM. Weatherd broken shale to 31.4m/…/Gypsum 45 to 82m/interbedded Sst & Shale to 122m		19.26	26/10/2001		TOC from KTC 2002 Table 2.
TW16	KTC 2002		70.77		107	25	Red CLAY	NAM Interbedded Siltstone, Sst & Shale		15.97	02/11/2001		TOC from KTC 2002 Table 2.
OW01	KTC 2002		54.93		69	34	red CLAY (0-6)/ Gypsum (6-11)/ SILT (11-13)/ red-brown CLAY (13-34)	PT into NAM. Clayey SST over SST over interbedded Shale and SST		13.8	09/11/2001		Observation well for TW08, drilled for 6 week Multi-well pump test. TOC from KTC 2002 Table 2.
OW02	KTC 2002		53.69		61	24	Red BOULDER CLAY (0-18)/Brown BOULDER CLAY (18-24m)	PT into NAM. White Limestone		13.32	31/10/2011		Observation well for TW15, drilled for 6 week Multi-well pump test. TOC from KTC 2002 Table 2.
OW04	KTC 2002		73.68		52	20	Red CLAY	NAM. Interbedded SST and Shale		17.61	26/10/2001		Observation well for TW16, drilled for 6 week Multi-well pump test. TOC from KTC 2002 Table 2.
OW05	KTC 2002		63.33		52	6	Limestone Boulder & CLAY	NAM into Milverton Group DIN Lst. Interbedded Sandstone and Limestone. Cavities encountered in SST and Lst.		21.26	25/10/2001		Cavities in SST at 18 to 20m, between SST & Lst @ 30 to 37m and in Lst at 49 to 51m. Observation well for TW09 (PW9), drilled for 6 week Multi-well pump test. TOC from KTC 2002 Table 2.
OW06	KTC 2002		44.54		52	13	Red BOULDER CLAY	NAM (into DIN Lst?). Limestone Bedrock		Artesian	24/01/2001		Observation well relevant to TW14, 15 & 16, drilled for 6 week Multi-well pump test. TOC from KTC 2002 Table 2.
C35/3c	NERDO 1981		40		104	48	Alluvium (~0 to 13); Boulder Clay (~13 to 48)	Triassic Marl/Triassic SST		0.4	24/03/1980		Trial Well by NERDO in 1981. Hole collapsing / running sand in SST overnight. (3 hr pump test at 1.5lps when hole TD = 73, lined to 70m & infilled to 60m with running sand). Revert mud used between 82 & 104m, broken down with Na-hypoChlorite.
MHPW1	KTC 2002												Meath Hill GWS Pumping Well No.1
MHPW2	KTC 2002		34.12										Meath Hill GWS Pumping Well No.2. TOC from KTC 2002 Table 2.
MHOW	KTC 2002		38.66										Meath Hill GWS abaondoned well. TOC from KTC 2002 Table 2.
DW01	KTC 2002			Borehole	57.91				TOC 6" (6" SC & 4" Liner)	18.92	12/02/2003	Single House	Private Well located 280m from TW08. Emmet Carolan
DW02	KTC 2002			Dug	3				Top of 1m dia concrete ring	0.56	12/02/2003	Single House	Private Well. Patrick
DW03	KTC 2002			Dug	4.267				Top of Concrete Cover	1.57	12/02/2003	Single House	Private Well. Tommy Martin
DW04	KTC 2002			Borehole	>30.5				TOC 6" (6" SC & 4" Liner)	0.46	11/02/2003	Single House	Private Well. Brenie Doogan (0429667160)
DW05	KTC 2002												Private Well located located at Cabra Castle. Not in use in 2002. 2005 report has note saying Cabra Castle Estate say no well at this location. 2 No. GSI 100m acc BHs in this area (Sheppard Estate)
DW06	KTC 2002												Private Well. Mc Enniffe
DW07	KTC 2003			Borehole	32				TOC 6" (6" SC & 4" Liner)	9.14	11/02/2003	Single House	Hickey (0429668154)
DW08	KTC 2002			Dug	3.7				Top of 1m dia concrete ring	0.47	11/02/2003	2 Houses & Cattle Shed	Private Well located 180m from TW09. Austin Quigley (0879631422)
DW09	KTC 2003			Borehole					Top of Liner (6" SC & 4" Liner)	15.19	11/02/2003	Single House	Mary Georgan (042 9667156)
BH02	PC Fieldwo	DW10											
DW11	KTC 2003			Borehole	83.82				TOC 6" (6" SC & 4" Liner)	21.73	11/02/2003	Single House	Sean Byrne (0429661256work)
DW12	KTC 2003												Tommy Connaughton (0429327969 work)
DW13	KTC 2003												
DW14	KTC 2003												
DW15	KTC 2003			Dug	1.7				Top of Wall (Square well with steps)	0.7	12/02/2003		Cunningham
DW16	KTC 2003												Braydon (Scotland)
DW17	KTC 2003			Dug	6.98				Top of 1m dia concrete ring	0.9	12/02/2003	1 House & Cattle Shed	Tony Doogan (0429667566)
DW18	KTC 2003			Borehole								1 House & Farm	Peter McGahon
DW19	KTC 2003			Dug	3.35				Timber covering well (1m dia concrete ring)	1.79	12/02/2003	Single House	Ger McGahon
DW20	KTC 2003												McKeown
DW21	KTC 2003			Borehole	41.15				TOC 6" (6" SC)	0.85	12/02/2003	2 Houses	Ger/Frank McEnteer
DW22	KTC 2003			Dug	4.7				Top of 1m dia concrete ring	1.76	12/02/2003	1 House & Cattle	Ramsay
DW23	KTC 2003			Dug									
DW24	KTC 2003												Cabra Woods B&B
DW25	KTC 2003												

			Pumping Test No. 1 -->KTC 1995, 1996, 1998 & 1999										
Name	Source	Other Names	P Test	Pumping Test Rate (CDT)	SWL	SWL Date	Drawdown	Estimated Safe Yield (KTC, 1998)	T	S	P Test achieved Steady State?	Pump Test Obs Wells	Pump Test Comments
				m3/day	mbREF		m	m3/day	m2/d				
TW01	KTC 1998			-			-	<10					
TW02	KTC 1998		72 hr test. Early Jan95	1211	2.03mbgl	Jan-95	14.39	800			No	OW No.1. 80m from TWNo2, exact location not recorded	
TW03	KTC 1998		72 hr test. 07/03/95	1119 - 523	2.32	07/03/1995	2.95 - 13.26	600	28	0.0004	No	Domestic Well. 30m from TW03, exact location not recorded	Ptest Q decreased from 1119 to 523m3/d "to accommodate a neighbouring well owner"
TW04	KTC 1998			-			-	200					
BW01	KTC 1998	TW05, TW5, Borewell No.1	Step test (29/5/95) & 10 day Test (30/5 to 9/6/95)	635	0.8	29/05/1995	42.79	500	21	0.00017	No	OBS No.1 (i.e. NERDO C35/3c), located 13m from Twno.5, exact location no given.	
TW06	KTC 1998			-			-	<10					
TW07	KTC 1998		48 hr test. 23-25/08/95	731	17.5	23/08/1995	18.24	400			No	Obs No.1, Obs No.2 & Obs No.3 (locations not given)	Test shortened due to interference with a nearby domestic well
TW08	KTC 1998		72 Hr test. Barrier boundary encountered (19/2/96).	1027	11.95	19/02/1996	9.44	500			No	None	
TW09	KTC 1998	PW9	72 Hr test. Barrier boundary encountered. Pumping rate had to be cut back towarsd end of test. (29/2/1996)	850	11.67	29/02/1996	23.63	400			No	None	
BW03	KTC 1998	TW10, Borewell No.3	30 Hr test (1134m3/d) (date not recorded, no drawdown from artesian); 24hr on 6/3/96 (2072m3/d, v cloudy discharge), artesian overflow = 1300m3/d.	2072	Artesian	06/03/1996	5.49	>1300			Yes		
TW11	KTC 1999		71hr test (2-5/2/98)	1824	0mbgl	02/02/1998	30.49	1200			Yes	None	4No. 100min steps at start = 550, 1060, 1546, 1922m3/d
TW12	KTC 2000				Artesian	Feb-98							
BW02	KTC 2001	TW13, Borewell No.2	70 hr test (Feb 98)	1557	0.02mbgl	Feb-98	11.37	800			No	TW12 (5m from TWNo.13)	4No. 100min steps at start = 532, 1031, 1593, 2239m3/d. Final rate cut back to 1557m3/d after 440mins. Level recovered after 440min then dropping again by end test. Rate of ddn increases after 9m
TW14	KTC 1999		72 hr test (Feb 1999)	2462	7.06 mbtc	19/02/1999	17.88	1200			No	TW Nos. 9, 10 & 11 --> no impact from pumping TW14.	3 No. 100 min steps at start = 767.6 (s = 1.1m), 1504.8 (s= 3.2m) & 2688 m3/d --> dropped to 2462m3/d as pumping head increased (s=17.88). Drawdown still 14.47 m after 60 min recovery
TW14A	KTC 2002												
TW15	KTC 2002												
TW16	KTC 2002												
OW01	KTC 2002												
OW02	KTC 2002												
OW04	KTC 2002												
OW05	KTC 2002												
OW06	KTC 2002												
C35/3c	NERDO 1981		NERDO 72hr test on 25/03/1980 @ 10.6lps	915.84	0.4	24/03/1980	40		48		No		qs = 33.5m3/d/m High Fe & pH. No Observation Well Note: Used as an observation Well for TW05 on 30/05/1995 --> RWL on 30/05/1995 = 1.6mbgl (this may not have been fully recovered after TW05 step test on 29/05/95)
MHPW1	KTC 2002												
MHPW2	KTC 2002												
MHOW	KTC 2002												
DW01	KTC 2002												
DW02	KTC 2002												
DW03	KTC 2002												
DW04	KTC 2002												
DW05	KTC 2002												
DW06	KTC 2002												
DW07	KTC 2003												
DW08	KTC 2002												
DW09	KTC 2003												
BH02	PC Fieldwo	DW10											
DW11	KTC 2003												
DW12	KTC 2003												
DW13	KTC 2003												
DW14	KTC 2003												
DW15	KTC 2003												
DW16	KTC 2003												
DW17	KTC 2003												
DW18	KTC 2003												
DW19	KTC 2003												
DW20	KTC 2003												
DW21	KTC 2003												
DW22	KTC 2003												
DW23	KTC 2003												
DW24	KTC 2003												
DW25	KTC 2003												

			Pumping Test --> 6 week Multi Well Ptest on TW08, 09, 11, 14A,15 & 16, App of KTC 2002										
Name	Source	Other Names	P Test	Pumping Test Rate (CDT)	SWL @ Start Test (assume 12/03/02)	Drawdown	Recovery after 22 days	Estimated Safe Yield (KTC, 1998)	T	S	P Test achieved Steady State?	Pump Test Obs Wells	Pump Test Comments
				m3/day	mbRef	m	m	m3/day	m2/d				
TW01	KTC 1998												
TW02	KTC 1998												
TW03	KTC 1998				4.91	0.03							
TW04	KTC 1998				15.69	0.06							
BW01	KTC 1998	TW05, TW5, Borewell No.1			0.92	0.13							
TW06	KTC 1998				2.9	-0.02							
TW07	KTC 1998				13.66	-0.05							
TW08	KTC 1998		Test Start Date = 14/03/2002	410-561	11.36	14.88	7.9				No	OW01	
TW09	KTC 1998	PW9	Test Start Date = 13/03/2002	288-489	16.78	18.03	13.4				No	OW05	TW09 called PW5 in this test
BW03	KTC 1998	TW10, Borewell No.3				inaccessible							
TW11	KTC 1999		Test Start Date = 13/03/2002	789-1137	Artesian	21.55	21.55 (artesian after 4 hrs)				Yes	None	
TW12	KTC 2000				0.47	0.01							
BW02	KTC 2001	TW13, Borewell No.2			artesian								
TW14	KTC 1999				7.14	15.54							
TW14A	KTC 2002		Test Start Date = 13/03/2002	1907-2090	9.36	17.88	14.58				No	TW14	Note: 24hr Ptest carried out on TW14A on 13/11/02, App of KTC 2002
TW15	KTC 2002		Test Start Date = 14/03/2002	1015-1431	18.18	13.84	6.98				No	OW02	Note: 24hr Ptest carried out on TW15 on 7/11/02, App of KTC 2002
TW16	KTC 2002		Test Start Date = 14/03/2002	573-627	15.8	24.05	16.54				No	OW04	Note: 24hr Ptest carried out on TW16 on 9/11/02, App of KTC 2002
OW01	KTC 2002				13.14	4.85							
OW02	KTC 2002				12.05	9.01							
OW04	KTC 2002				18.49	12.04							
OW05	KTC 2002				20.84	-0.85							
OW06	KTC 2002				Artesian	artesian throughout							
C35/3c	NERDO 1981												
MHPW1	KTC 2002												
MHPW2	KTC 2002			1027 - 1047	3.52	0.57	None. WL continues to drop (by 0.18m)						
MHOW	KTC 2002				Artesian	Overflow stopped after 4 weeks; subsequent dddn = 0.15m							
DW01	KTC 2002				18.9	2.5							
DW02	KTC 2002				0.6	-0.09							
DW03	KTC 2002				1.3	0.17							
DW04	KTC 2002				Artesian	artesian							
DW05	KTC 2002				29.75	0.79							
DW06	KTC 2002				1.19	-0.04							
DW07	KTC 2003												
DW08	KTC 2002				2.63	est. 0.4 to 0.5							
DW09	KTC 2003												
BH02	PC Fieldwo	DW10											
DW11	KTC 2003												
DW12	KTC 2003												
DW13	KTC 2003												
DW14	KTC 2003												
DW15	KTC 2003												
DW16	KTC 2003												
DW17	KTC 2003												
DW18	KTC 2003												
DW19	KTC 2003												
DW20	KTC 2003												
DW21	KTC 2003												
DW22	KTC 2003												
DW23	KTC 2003												
DW24	KTC 2003												
DW25	KTC 2003												

			Pumping Test --> 6 week Multi Well Ptest on TW10, TW13, TW05 (TW05=PW5 in KTC 2003 report), KTC 2003										
Name	Source	Other Names	P Test	Pumping Test Rate (CDT)	SWL (24/02/2003)	Drawdown	Recovery	Estimated Safe Yield (KTC, 1998)	T	S	P Test achieved Steady State?	Pump Test Obs Wells	Pump Test Comments
				m3/day	mbREF	m	m	m3/day	m2/d				
TW01	KTC 1998				no data								
TW02	KTC 1998				no data								
TW03	KTC 1998				no data								
TW04	KTC 1998				no data								
BW01	KTC 1998	TW05, TW5, Borewell No.1	Test Start Date = 24/02/2003 End Date = 7/04/2003	Initial rate 980. Then 727 - 749	0.35	c.40					Yes		Nearest private wells: 100m north (DW21), DW20(further Nth) & DW22-25 (south). All monitored in detail except 20. Initial rate cut back due to excessive drawdown (nearing pump depth). NERDO C35/3c located 5m away (said 13m in 1995 test)
TW06	KTC 1998				no data								
TW07	KTC 1998				13.7	0.12							
TW08	KTC 1998				10.89	-0.05							
TW09	KTC 1998	PW9			17.99	0.04							Called PW5 in KTC 2003
BW03	KTC 1998	TW10, Borewell No.3	Test Start Date = 24/02/2003 End Date = 7/04/2003	Initial artesian = 1600, then dropped to 735 in wk 1 and then increased to 800. Pumping wk 3-4 at 900-920; wk 5-6 at 1200-1260	Artesian	3 to 3.5	Artesian after 30 secs; overflow 600m3/d in 10 hrs; 750m3/d after 3 days and after				Yes		Nearest private well 100m away, artesian, 32m deep --> probably DW4. TW10 sealed with an inflatable packer in June 1996. Not possible to remove Packer --> well diameter reduced to 100mm. Artesian flow monitored for wks 1&2 of test, then suction pump used wks 2-6.
TW11	KTC 1999				Artesian	0.59	Artesian after 4 hrs				Yes		
TW12	KTC 2000				1.66	5.45	2m from SWL after 2 hrs. Full rec by 9 days						Used as Obs Well for TW13
BW02	KTC 2001	TW13, Borewell No.2	Test Start Date = 24/02/2003 End Date = 8/04/2003	Initial rate >1200, dropped to avg of 800-900	0.17	11 to 12	2m from SWL after 6 hrs. Full rec by 9 days						TW12 used as Obs Well, 5m from TW13.
TW14	KTC 1999					0.12							
TW14A	KTC 2002					0.03							
TW15	KTC 2002					0.25							
TW16	KTC 2002					0.09							
OW01	KTC 2002				13.03	0.03							
OW02	KTC 2002				11.7	0.06							
OW04	KTC 2002				>20								
OW05	KTC 2002				20.75	0.7							
OW06	KTC 2002				Artesian	Artesian							
C35/3c	NERDO 1981				0.75	20 - 20.3							Observation well for TW05. RWL on 24/02/2003 = 0.75 mbRef (assume = mbgl)
MHPW1	KTC 2002					Artesian							
MHPW2	KTC 2002				Artesian	Artesian							
MHOW	KTC 2002					0.77							
DW01	KTC 2002				18.9	0.01							Remote from pumping wells
DW02	KTC 2002				1.2	0.41							Remote from pumping wells
DW03	KTC 2002				1.91	0.43							Relevant to TW10 (& poss TW13)
DW04	KTC 2002				Artesian	1.71							Relevant to TW10 (& poss TW13)
DW05	KTC 2002												
DW06	KTC 2002				1.34	0.09							
DW07	KTC 2003				9.25	0.14							Relevant to TW13 & TW10
DW08	KTC 2002				0.26	0.05							Relevant to TW13 & TW10
DW09	KTC 2003				15	2.3							Relevant to TW13 & TW10
BH02	PC Fieldwo	DW10			no data								
DW11	KTC 2003				21.55	0.21							Relevant to TW13 & TW10
DW12	KTC 2003				1.77	0							Relevant to TW13 & TW10
DW13	KTC 2003				no data								
DW14	KTC 2003				no data								
DW15	KTC 2003				0.78	-0.03							Relevant to TW13
DW16	KTC 2003				1.63	3.12							Relevant to TW13 & TW10
DW17	KTC 2003				1.83	2.7							Relevant to TW13 & TW10
DW18	KTC 2003				no data								
DW19	KTC 2003				1.62	0.48							Relevant to TW13
DW20	KTC 2003				no data								
DW21	KTC 2003				0.95	1.63							Relevant to TW05
DW22	KTC 2003				1.95	0.15							Relevant to TW05
DW23	KTC 2003				1.87	0.17							Relevant to TW05
DW24	KTC 2003				no data								
DW25	KTC 2003				1.71	1.64							Relevant to TW05

Table A1.1b Kingscourt Trial Wells and Observation Wells
Groundwater Level Data From KTC WYG 1995 to 2003

Name	Top of Casing	SWL	SWL Date	Source	SWL	SWL Date	Source	SWL		SWL Date	Source	SWL		SWL Date	Source
	mAOD Poolbeg	mbgl	Assumed from BH log		mbgl			mbRef (WYG 2002 Table 2)	mbgl (WYG 2002 Pump test ddn data)			mbRef	mbgl		
TW01	inaccessible (2	2.5	Dec-94	KTC 1998											
TW02	inaccessible (2	2.03	Dec-94	KTC 1998											
TW03		2.32	Feb-95	KTC 1998				4.91		13/03/2002					
TW04		29	Feb-95	KTC 1998				15.69		13/03/2002					
BW01		0.8	May-95	KTC 1998				0.92		13/03/2002			0.35	24/02/2003	WYG 2003
TW06		-		KTC 1998				2.9		13/03/2002					
TW07		17.5	Aug-95	KTC 1998				13.66		13/03/2002		13.7		23/02/2003	WYG 2003
TW08	52.86	11.95	19/02/1996	KTC 1998				11.36	10.86	14/03/02 @ 10	SWL for 6 week Multi Well Ptest on TW08, 09, 11, 14A,15 & 16, App of WYG 2002	10.89		23/02/2003	WYG 2003
TW09	67.89	11.67	26/02/1996	KTC 1998				16.78	16.28	13/03/2002 @	SWL for 6 week Multi Well Ptest on TW08, 09, 11, 14A,15 & 16, App of WYG 2002	17.99		23/02/2003	WYG 2003 (Called PW5 in WYG 2003)
BW03		Artesian		KTC 1998									Artesian	24/02/2003	WYG 2003
TW11	36.7	0.6mbtc	Jan-98	KTC 1999				Artesian	-0.5	13/03/2002 @	SWL for 6 week Multi Well Ptest on TW08, 09, 11, 14A,15 & 16, App of WYG 2002	Artesian		23/02/2003	WYG 2003
TW12		0.6mbtc	Jan-98	KTC 2000				0.47		13/03/2002		1.66		24/02/2003	WYG 2003
BW02		0.02mbtc	Jan-98	KTC 2001				Artesian		13/03/2002			0.17	24/02/2003	WYG 2003
TW14	39.55	7.06 mbtc	19/02/1999	KTC 1999				7.14		13/03/2002		7.59		23/02/2003	WYG 2003
TW14A	41.16	9.75	21/11/2001	WYG 2002	9.05	13/11/2001	SWL for 24hr Ptest on TW14A, App of WYG 2002	9.36	8.86	13/03/2002 @	SWL for 6 week Multi Well Ptest on TW08, 09, 11, 14A,15 & 16, App of WYG 2002	9.17		23/02/2003	WYG 2003
TW15	59.7	19.26	26/10/2001	WYG 2002	17.95	07/11/2001	SWL for 24hr Ptest on TW15, App of WYG 2002	18.18	17.68	14/03/02 @ 10	SWL for 6 week Multi Well Ptest on TW08, 09, 11, 14A,15 & 16, App of WYG 2002	17.68		23/02/2003	WYG 2003
TW16	70.77	15.97	02/11/2001	WYG 2002	14.93	09/11/2001	SWL for 24hr Ptest on TW16, App of WYG 2002	15.8	15.3	14/03/02 @ 10	SWL for 6 week Multi Well Ptest on TW08, 09, 11, 14A,15 & 16, App of WYG 2002	16.81		23/02/2003	WYG 2003
OW01	54.93	13.8	09/11/2001	WYG 2002				13.14		13/03/2002		13.03		23/02/2003	WYG 2003
OW02	53.69	13.32	31/10/2011	WYG 2002				12.05		13/03/2002		11.7		23/02/2003	WYG 2003
OW04	73.68	17.61	26/10/2001	WYG 2002				18.49		13/03/2002		>20		23/02/2003	WYG 2003
OW05	63.33	21.26	25/10/2001	WYG 2002				20.84		13/03/2002		20.75		23/02/2003	WYG 2003
OW06	44.54	Artesian	24/01/2001	WYG 2002				Artesian		13/03/2002		Artesian		23/02/2003	WYG 2003
C35/3c		0.4	24/03/1980	NERDO 1981								0.75		24/02/2003	WYG 2003 (Called TW5 in WYG 2003)
MHPW1				WYG 2003								0.38 (Artesian)		23/02/2003	WYG 2003
MHPW2	34.12			WYG 2003					3.52	13/03/2002	SWL for 6 week Multi Well Ptest on TW08, 09, 11, 14A,15 & 16, App of WYG 2002	Artesian		23/02/2003	WYG 2003
MHOW	38.66			WYG 2003					Artesian (60	13/03/2002	SWL for 6 week Multi Well Ptest on TW08, 09, 11, 14A,15 & 16, App of WYG 2002	4.38		23/02/2003	WYG 2003
DW01		18.92	12/02/2003	WYG 2003				18.9		13/03/2002		18.9		23/02/2003	WYG 2003
DW02		0.56	12/02/2003	WYG 2003				0.6		13/03/2002		1.2		23/02/2003	WYG 2003
DW03		1.57	12/02/2003	WYG 2003				1.3		13/03/2002		1.91		23/02/2003	WYG 2003
DW04		0.46	11/02/2003	WYG 2003				Artesian		13/03/2002		Artesian		23/02/2003	WYG 2003
DW05				WYG 2003				29.75		13/03/2002					
DW06				WYG 2003				1.19		13/03/2002		1.34		23/02/2003	WYG 2003
DW07		9.14	11/02/2003	WYG 2003								9.25		23/02/2003	WYG 2003
DW08		0.47	11/02/2003	WYG 2003				2.63		13/03/2002		0.26		23/02/2003	WYG 2003
DW09		15.19	11/02/2003	WYG 2003								15		23/02/2003	WYG 2003
DW10				WYG 2003											
DW11		21.73	11/02/2003	WYG 2003								21.55		23/02/2003	WYG 2003
DW12				WYG 2003								1.77		23/02/2003	WYG 2003
DW13				WYG 2003											
DW14				WYG 2003											
DW15		0.7	12/02/2003	WYG 2003								0.78		23/02/2003	WYG 2003
DW16				WYG 2003								1.63		23/02/2003	WYG 2003
DW17		0.9	12/02/2003	WYG 2003								1.83		23/02/2003	WYG 2003
DW18				WYG 2003											
DW19		1.79	12/02/2003	WYG 2003								1.62		23/02/2003	WYG 2003
DW20				WYG 2003											
DW21		0.85	12/02/2003	WYG 2003								0.95		23/02/2003	WYG 2003
DW22		1.76	12/02/2003	WYG 2003								1.95		23/02/2003	WYG 2003
DW23												1.87		23/02/2003	WYG 2003
DW24															
DW25												1.71		23/02/2003	WYG 2003

Table A1.1c Kingscourt Trial Wells and Observation Wells
WYG Groundwater Level Data
November 2001 to March 2002

Name	Water Level Datum	Water Level	Water Level	Water Level	Water Level
		(mb datum)	(mb datum)	(mb datum)	(mb datum)
		01/11/2001	01/03/2002	08/03/2002	11/03/2002
DW01	TOC		18.92	18.89	18.81
DW02	KERBSTONE		0.51	1	1.02
DW03	G.L		0.92	1.32	1.15
DW04	TOC		0	0	0
DW05	TOC	30.56	29.72	29.72	29.68
DW06	COVERING		1.11	1.21	1.21
OW01	TOC	13.8	13.15	13.15	13.04
OW02	TOC	13.31	12.13	12.02	11.93
OW04	TOC	18.3	18.45	18.33	18.27
OW05	TOC	21.73	20.21	21.05	20.92
OW06	TOC	0	0	0	0
TW03	TOR		8.92	8.95	4.79
TW03	TOC	5.07	4.87	4.87	8.9
TW04	TOC	16.01	15.85	15.63	15.6
BW01 (TW05)	TOC	1.54	0.8	0.95	0.89
TW06	TOC	2.94	2.91	2.9	2.91
TW09	TOC	15.14	16.48	16.45	16.47
TW11	TOC	0	0	0	0
TW12	TOC	0.53	0.47	0.48	0.49
BW02 (TW13)	TOC	0	0	0	0
TW14	TOC	9.75	7.33	7.36	7.3
TW15	TOC	18.39	18.24	18.15	18.07
TW16	TOR		15.86	15.77	15.85

MEATH HILL WELL					
PUMPING WELL	1.11	TOC		METER READING 176863.1	
MONITORING WELL	0	TOC		PUMPING @ 7800 GPH	
BACK-UP WELL	0	TOC			

Table A1.1d Kingscourt Trial Wells and Observation Wells
Data From PC Field Work, WYG 2003
and Gypsum Limited (Minerex) 2003 and 2010

Source	Name	Other Names	EASTING	NORTHING	Total Depth	DTB	Aquifer	Aquifer Comments	Geol_Member
Minerex	1-H-P		280706	298613			Kcgyp		Kcgyp_UpMst
Minerex	1-J-PD		280817	298713			Kcgyp		Kcgyp_MainDol
Minerex	1-J-PS		280817	298713			Kcgyp		Kcgyp_MidMud
Minerex	95-A-1D		281033	298913			Kcgyp		Kcgyp_MidMst
Minerex	95-A-1S		281033	298913			Overburden		Overburden
Minerex	DrGsat_DWbh		280642	299611			Kcgyp		Kcgyp_ugMine
Minerex	M101P		280616	299159			NamSstSH		NamSstSH
Minerex	M102P		280573	299540			Overburden		Overburden
Minerex	M103P		281176	298869			Kcgyp		Kcgyp_UpMst
Minerex	MW-1-P1		280707	299029			Kcgyp		Kcgyp_MainDol
Minerex	MW-1-P2		280707	299029			Kcgyp		Kcgyp_UpGyp
Minerex	MW-1-P3		280707	299029			Kcgyp		Kcgyp_UpMst
Minerex	MW-2-P1		280708	299029			Overburden		Overburden
Minerex	MW-3-P1		280713	299029			WestPh		WestP/NamSstSH
Minerex	MW-3-P2		280713	299029			Kcgyp		Kcgyp_MidMst
Minerex	MW-4-P1		281077	298938			Kcgyp		Kcgyp_LowDol
Minerex	MW-4-P2		281077	298938			Kcgyp		Kcgyp_MainDol
Minerex	O3A-P -1		280542	297922			NamSstSH		NamSstSH
Minerex	O3A-P -2		280542	297922			Kcgyp		Kcgyp_UpMst
PC	BH01		281562	297889			NamSstSH	No data. Assume NamSstSH	NamSstSH
PC	BH03	Rowntree Poultry Farm	279578	299528	121.92	21.336	PT Sst	Subsoil = "Shingles & Sandstone"	PT Sst
PC	BH04	Private BH	279273	299964			PT Sst		PT Sst
PC	BH05	St James Court BH	280150	297526	60.96	10.67	PT Sst	Brown gravelly clay (traces of wood at base) /Soft SST (500gph) to72'/ medium hard SST water strike at 130' 1000gph in broken rock. SC 0-12.2m @ 8", 0 to 26.6 @ 6"; PVC liner to TD, 120' solid, 80' screen.	PT Sst
PC	BH06	Private BH	280389	297955	36.58	0	PT Sst	Red Marl to total depth	PT Sst
PC	BH07	Machinery Manufacturer Ballycartley	280208	298813			PT Sst		PT Sst
PC	BH08	GSI No. 2629SEW131	282231	297815	20.30		NamSstSH		NamSstSH
PC	BH09	Private BH	284321	297657			DINLst		DINLst
PC	BH10	Limestone Industries Quarry Main Well	284064	299436	48.77	0	DINLst		DINLst
PC	BH11	Barley Hill Quarry (Well by Gates)	283534	295606		0	DINLst		DINLst
PC	BH12	Private BH	282957	295568	48.77		DINLst		DINLst
PC	BH13	Private BH	282958	296562			DINLst		DINLst
PC	BH14	Private BH	280125	298467	30.48		PT Sst		PT Sst
PC	GW01	Tobarmananan Spring	282565	296599			DINLst/OB		DINLst
WYG	BH02	aka DW10	281731	297431			NamSstSH	Drilled ~2005, TD ~ 30.5m, NW of DW09, assume NamSstSh	NamSstSH
WYG	BW01	aka TW05 & PW5;GSI2629503	280006	297801			PT Sst		PT Sst
WYG	BW02	aka TW13,GSI 2629SEW507	282522	296938			NamSstSH	Shallow Sst, main inflow 8.8to12mbgl	NamSstSH
WYG	BW03	aka TW10; GSI 2629SEW145	282281	296881			NamSstSH/DINLst	Drilled thru NamSstSh; OH thru NamSstSH;Main Inflow in Cavern at base (assume karst Lst, but log show Sst in last 2m below cavern	NamSstSH/DINLst
WYG	DW01		280302	295472			NamSstSH	TD = 57.9m, Nearest log = OW01 goes thru gypsum into NamSstSH at ~34m	Kcgyp/NamSstSH
WYG	DW02		280442	295280			Overburden	Dug Well	Overburden
WYG	DW03		282664	296576			Overburden	Dug Well	Overburden
WYG	DW04		282405	296834			NamSstSH/DINLst	TD > 30.5m, nearest log BW03 in NamSstSH at 30m, nearby TW12 in DINLst at 21m	NamSstSH/DINLst
WYG	DW06		281740	294418			NamSstSH	Beside TW07, Drilled but no TD data.	NamSstSH
WYG	DW07		282087	297002			NamSstSH	Drilled, TD = 32m. In NamSstSH NW of BW03/TW12. TW12 in NamSstShLst until 122m	NamSstSH
WYG	DW08		281806	297233			Overburden	Dug Well	Overburden
WYG	DW09		281760	297256			NamSstSH	Drilled, TD = ?. NW of DW07, assume NamSstSH	NamSstSH
WYG	DW11		281650	297388			NamSstSH	Drilled, TD = 84m. NW of DW09 & BH01, assume NamSstSH	NamSstSH
WYG	DW12	aka GSI 2629SEW178	281708	297598			NamSstSH	GSI data indicate TD = 52.7, DTB = 21.3m. Yield 327m3/d, Water Strike @ 45.7m. Assume NamSstSH	NamSstSH
WYG	DW13		281635	297643			NamSstSH	No data. Assume NamSstSH	NamSstSH
WYG	DW14		281602	297691			NamSstSH	No data. Assume NamSstSH	NamSstSH
WYG	DW15	aka GSI 2629SEW131	282199	297811			Overburden	Dug Well. House also has a borehole (= GSI2629SEW131;BH08) but no access	Overburden
WYG	DW16		282649	296963			DINLst	No data. Assume DINLst	DINLst
WYG	DW17		282901	296834			Overburden	Dug Well	Overburden
WYG	DW18	aka GSI 2629SEW109;NERDO 34/5b	282758	297289			DINLst	GSI data indicate TD = 28, DTB = 20m. Yield = 21.8m. Assume DINLst	DINLst
WYG	DW19		282737	297576			Overburden	Dug Well	Overburden
WYG	DW20		280117	298051			PT Sst	No data. Assume PT Sst	PT Sst
WYG	DW21		280044	297952			PT Sst	Drilled, TD = 41m. North of BW01 where DTB = 38m. Assume PT Sst	PT Sst
WYG	DW22		279802	297283			Overburden	Dug Well	Overburden
WYG	DW23		279848	297218			Overburden	Dug Well	Overburden
WYG	DW24		279871	297107			PT Sst	No data. Assume PT Sst	PT Sst
WYG	DW25		279964	297370			PT Sst	No data. Assume PT Sst	PT Sst
WYG	MHPW2	aka GSI 2629SEW053	285214	294203			DINLst	Artesian Limestone group water supply BH	DINLst
WYG	OW01		280411	295625			NamSstSH	as TW08, thru Kcgyp to Nam, gyp 5-10m, cased 0-37 into NamSst	NamSstSH
WYG	OW02		280810	296233			NamSstSH	as TW15, thru Kcgyp to Nam, no gyp enc, cased to top of rock @24m, Nam below (white Lst)	NamSstSH
WYG	OW04		281712	296497			NamSstSH	as TW16	NamSstSH
WYG	OW05		282269	296342			NamSstSH/DINLst	bet TW9 (Nam) & DinLst on Ardagh shale (Nam), several cavities in Sst & Lst beds	NamSstSH/DINLst
WYG	OW06		281324	296115			NamSstSH		NamSst
WYG	TW01	aka GSI 2629SEW502	279152	294568			PT Sst		PT Sst
WYG	TW02	aka GSI 2629SEW066	280853	293118			NamSstSH		NamSstSH
WYG	TW03	aka GSI 2629SEW067	281078	293825			NamSstSH		NamSstSH
WYG	TW04	aka GSI 2629SEW068	281217	292498			NamSstSH		NamSstSH
WYG	TW06	aka GSI 2629SEW504	279600	295810			PT Sst		PT Sst
WYG	TW07	aka GSI 2629SEW069	281689	294534			NamSstSH		NamSstSH
WYG	TW08	aka GSI2629SEW065	280528	295768			NamSstSH	Drilled thru Kcgyp; OH thru Kcgyp & Nam but water strike in Nam	NamSstSH
WYG	TW09	aka PW9; GSI2629SEW064	282142	296414			NamSstSH		NamSstSH
WYG	TW11	aka GSI 2629SEW505	282272	296590			NamSstSH		NamSstSH
WYG	TW12	aka GSI 2629506	282528	296941			NamSstSH	Drilled thru NamSstSH into DINLst; High inlfow thru shallow sst (8.8to21m), OH 17to 135m, lower inflow Lst below 122m; Hole collapsing in upper Sst => WL maybe only Upper Nam Sst by 2003 (drilled 1998) if collapse sealed off underlying Lst	NamSstSH
WYG	TW14	aka GSI2629SEW508	280947	296480			NamSstSH	Drilled thu KCgypFmn (Gypsum layer 21.3to30.5m/mudstone30.5to38.1m) into NamSstSH, OH 37.8 to TD, Inflows in NamSstSH only (via cavities)	NamSstSH
WYG	TW14A		280915	296565			NamSstSH	Drilled thru Kcgyp (gyosum 56-61m), casing grouted to 63m; Inflows in NamSstSH below 65m	NamSstSH
WYG	TW15		280790	296103			NamSstSH	Drilled thru Kcgyp (gypsum 45-82m), casing grouted to 45m, hole dry until inflow from Nam at base of gypsum at 82m	Kcgyp/NamSstSH
WYG	TW16		281631	296499			NamSstSH		NamSstSH

GSINAME	ORIGNAME	SRCNAME	TYPE	DEPTH_M	DPTH_RCK_M	DTRCONFID	DRILLDATE	EASTING	NORTHING	LOC_ACC	TOWNLAND	TOWN	COUNTY	SIXINSHTNO	SOURCEUSE	YLDCLASS	PRODCLASS	YIELD_M3D	ABSTR_M3D	OVRFLW_M3D
2629SEW028			Borehole	40	18.3	Bedrock Met	00:00:00	280010	296020	to 50m	DRUMGILL		Meath	2	Industrial use	Excellent		7200		
2629SEW064	TW9	KINGSCOURT WATER SUPPLY	Borehole	82	7.3	Bedrock Met	08/02/1996	282350	296320	to 20m	BARLEYHILL		Meath	3	Public supply (Co Co)	Excellent	II	850		
2629SEW109			Borehole	29	24	Bedrock Met	00:00:00	282760	297290	to 20m	DESCART		Monaghan	34		Poor		25.9		
2629SEW110			Unknown				00:00:00	281660	297540	to 20m	DERRYLEEG		Monaghan	34		Poor		17.3		
2629SEW112			Unknown				00:00:00	280920	298500	to 20m	ENAGH		Monaghan	34		Poor		25.9		
2629SEW113			Borehole	55		DTB Unknown	00:00:00	283340	299360	to 20m	KILLYGALLY		Monaghan	34		Poor		8.6		
2629SEW114			Borehole	60		DTB Unknown	00:00:00	283500	299510	to 20m	KILLYGALLY		Monaghan	34		Poor		17.3		
2629SEW118			Borehole	34		DTB Unknown	00:00:00	283030	297820	to 20m	RAHANS		Monaghan	34		Poor		25.9		
2629SEW131			Borehole	21.3		DTB Unknown	00:00:00	282200	297810	to 20m	DERRYNAGLAH		Monaghan	34		Moderate		43.6		
2629SEW134			Borehole	28	20	Bedrock Met	00:00:00	282770	297240	to 20m	DESCART		Monaghan	34		Poor		21.8		
2629SEW135			Borehole	34	27	Bedrock Met	00:00:00	283020	297830	to 20m	RAHANS		Monaghan	34		Poor		32.7		
2629SEW145	TW 10	CAVAN COUNTY COUNCIL- Kingscourt RWSS	Borehole	91.4	18.3	Bedrock Met	05/02/1996	282270	296870	to 10m	DESCART		Monaghan	34	Public supply (Co Co)	Excellent	I	2072		
2629SEW146			Borehole	61		DTB Unknown	00:00:00	280910	298490	to 20m	ENAGH		Monaghan	34						
2629SEW151	T 16	John Jackson's thesis/NERDO report	Borehole		4	Bedrock Met	00:00:00	281030	297680	to 10m	ENAGH		Monaghan	34	Other					
2629SEW152	T 15	GSI	Borehole		1	Bedrock Met	00:00:00	280540	298010	to 10m	DRUMMOND		Monaghan	34	Other					
2629SEW153	T 13	GSI	Borehole		15.8	Bedrock Met	00:00:00	281430	298050	to 10m	DERRYLEEG		Monaghan	34	Other					
2629SEW154	T 39	GSI	Borehole		10.9	Bedrock Met	00:00:00	280790	298390	to 10m	DRUMMOND		Monaghan	34	Other					
2629SEW155	T 12	GSI	Borehole		6	Bedrock Met	00:00:00	280420	298600	to 50m	DRUMMOND		Monaghan	34	Other					
2629SEW156	T 29	GSI	Borehole		18.8	Bedrock Met	00:00:00	280470	298710	to 10m	DRUMMOND		Monaghan	34	Other					
2629SEW157	T 11	GSI	Borehole	93	16.7	Bedrock Met	00:00:00	280910	298540	to 10m	DRUMMOND		Monaghan	34	Other					
2629SEW158	T 9	GSI	Borehole		10.6	Bedrock Met	00:00:00	281140	299050	to 20m	DERRYNAGLAH		Monaghan	34	Other					
2629SEW159	T 10	GSI	Borehole		7.3	Bedrock Met	00:00:00	280900	299130	to 20m	DRUMMOND		Monaghan	34	Other					
2629SEW160	T 19	GSI	Borehole		3	Bedrock Met	00:00:00	280620	299210	to 10m	DRUMMOND		Monaghan	34	Other					
2629SEW161	OD	GSI	Borehole		12.8	Bedrock Met	00:00:00	281070	299370	to 20m	DRUMMOND		Monaghan	34	Other					
2629SEW162	OZ	GSI	Borehole		11.9	Bedrock Met	00:00:00	280890	299500	to 20m	DRUMMOND		Monaghan	34	Other					
2629SEW163	T 31	GSI	Borehole		9.4	Bedrock Met	00:00:00	280710	299490	to 20m	DRUMMOND		Monaghan	34	Other					
2629SEW164	T 37	GSI	Borehole		6	Bedrock Met	00:00:00	280350	299630	to 20m	DRUMMOND		Monaghan	34	Other					
2629SEW165	T 6	GSI	Borehole		3.5	Bedrock Met	00:00:00	281360	299790	to 10m	DERRYNASCOBE		Monaghan	34	Other					
2629SEW167	MO-BH99	Monaghan GWPS	Borehole	6	6	Bedrock Presumed	27/06/2001	280050	298540	to 10m	BALLYCARTLAN		Monaghan	33	Other					
2629SEW168	MO-BH100	Monaghan GWPS	Borehole	10.5		Bedrock Not Met	27/06/2001	279600	299540	to 10m	LISNAKEENY		Monaghan	33	Other					
2629SEW171	EPA no. 80		Borehole				00:00:00	283100	299700	to 50m	LEONS BEG		Monaghan	34	Industrial use	Poor		7		
2629SEW172	2638		Borehole	121.9		DTB Unknown	12/02/2002	279550	299510	to 50m	LISNAKEENY		Monaghan	33	Agri & domestic use	Excellent		872		
2629SEW177			Borehole	58.8	12.2	Bedrock Met	15/10/2003	281440	297800	to 50m	ENAGH		Monaghan	34	Agri & domestic use	Moderate	IV	87.3		
2629SEW178			Borehole	52.7	21.3	Bedrock Met	21/11/2003	281720	297620	to 50m	DERRYLEEG		Monaghan	34	Domestic use only	Good		327		
2629SEW503	TW 5	Kingscourt Regional Water Supply	Borehole	120	39	Bedrock Met	01/05/1995	280100	298080	to 100m	MULLANTRA		Cavan	35	Public supply (Co Co)	Excellent	III	635		
2629SEW504	TW 6	Kingscourt Regional Water Supply	Borehole	99	2	Bedrock Met	00:00:00	279600	295810	to 100m	CORGARRY		Cavan	35	Public supply (Co Co)	Failure		10		
2629SEW508	TW 14	Kingscourt Regional Water Supply	Borehole	91.4	21.3	Bedrock Met	19/02/1999	280970	296440	to 100m	CORMEY	Gibber Bridge	Cavan	35	Public supply (Co Co)	Excellent	I	2688		
2629SEW511			Dug well	2.6		DTB Unknown	00:00:00	279800	296200	to 100m	CORGARRY		Cavan	35	Agri & domestic use					
2629SEW514	ILC 1236	Land Commission, Sheppard Estate	Borehole	9.1		Bedrock Not Met	04/06/1966	280660	296920	to 100m	CORMEY		Cavan	35	Agri & domestic use	Excellent	I	764		
2629SEW515	ILC 1237	Land Commission, Sheppard Estate	Borehole				00:00:00	280760	296950	to 100m	CORMEY		Cavan	35	Agri & domestic use					
2629SEW050		GSI BH T42	Borehole	351.7	2.1	Bedrock Met	00:00:00	280170	296750	to 100m	CORGAREY		Meath	2						
2629SEW057			Dug well	5.5		Bedrock Not Met	00:00:00	283270	296180	to 100m	ARDAGH		Meath	3	Public supply (Co Co)					
2629SEW065	TW8	KINGSCOURT WATER SUPPLY	Borehole	107	11	Bedrock Met	02/02/1996	280570	295790	to 100m	DRUMGILL		Meath	2	Public supply (Co Co)	Excellent	I	1027		
2629SEW076			Borehole	88.4	11.6	Bedrock Met	23/04/1996	283460	295560	to 100m	ARDAGH		Meath	3	Agri & domestic use	Good		273		
2629SEW505	TW 11	Kingscourt Regional Water Supply	Borehole	91.4	4.5	Bedrock Met	01/01/1998	282310	296580	to 100m	BARLEYHILL		Meath	2	Public supply (Co Co)	Excellent	I	1824		
2629SEW506	TW 12	Kingscourt Regional Supply	Borehole	135	8.8	Bedrock Met	01/01/1998	282450	297050	to 100m	DESCART		Monaghan	34	Public supply (Co Co)	Excellent		500		
2629SEW507	TW 13	Kingscourt Regional Water Supply	Borehole	19.2	8.8	Bedrock Met	01/01/1998	282460	296970	to 100m	DESCART		Monaghan	34	Public supply (Co Co)	Excellent		800		

GSINAME	ABSTRDDM	SC_M3DM	CAS1DIA_MM	WTRSTRK1_M	WTRSTRK2_M	WTRSTRK3_M	WTRSTRK4_M	WTRLOSS1_M	GENCOMMS	DRILLCOMMS	CASINGCOMS
2629SEW028											Used to pump out mine shaft
2629SEW064	26	36	200	26	45	54	78		Water entry at 80-90ft. & 150-200ft. Bhole collapsing 270ft.		72hr PT at 850 m3/d; Steady state conditions not reached. slow WL recovery after pump stopped.
2629SEW109									NERDO well 34/5b		
2629SEW110									NERDO well 34/5c		
2629SEW112									NERDO well 34/1a		
2629SEW113									NERDO well 34/2f. Depth >55m		
2629SEW114									NERDO well 34/2g		
2629SEW118									NERDO well 34/5a		water levels are m above OD, not bgl
2629SEW131			152								HARD WATER. IRON PRESENT. POUNDING BORING MACHINE.
2629SEW134			152						Drilled by Dunnes, Dundalk		MECHANICAL/POUNDING BORING MACHINE.
2629SEW135			152						Drilled by Dunnes, Dundalk		NOT IN USE AT TIME OF INFORMATION (02-10-1972).
2629SEW145		377	152	56.4	73.2	82			sustainable yield = overflow of 1300m3/d. Well plugged in May 96 at request of Co.Co. as overflow very large.		ARTESIAN CONDITIONS WATER WARM
2629SEW146			152								HARD WATER. DISUSED BOREHOLE. DUG TO 10M(1219MM) AND THEN BORED BY GYPSUM CO. LTD. SWL GREATER THAN 30.48M.
2629SEW151											
2629SEW152									From John Jackson's thesis and NERDO report.		
2629SEW153											
2629SEW154									from John Jackson's thesis and NERDO report		
2629SEW155									from John Jackson's thesis and NERDO report		
2629SEW156									from John Jackson's thesis and NERDO report		
2629SEW157									from John Jackson's Thesis and NERDO report		
2629SEW158									from John Jackson's thesis and NERDO report	Had to use 25k map becuase quarry now in area - couldn't find site on orthophotos	
2629SEW159									from John Jackson's thesis and NERDO report	Had to use 25k map - quarry now in area, couldn't locate site on orthophotos.	
2629SEW160											
2629SEW161									from John Jackson's thesis and NERDO report	Had to use 25k map - quarry in area, couldn't locate site on orthophotos.	
2629SEW162									from John Jackson's thesis and NERDO report	had to use 25k map. quarry now in area, couldn't pinpoint site on orthophotos	
2629SEW163									from John Jackson's thesis and NERDO report	had to use 25k map. quarry now in area, couldn't pinpoint location on orthophotos.	
2629SEW164									from John Jackson's thesis and NERDO report	had to use 25k map for grid ref. quarry in area so couldn't pinpoint location on orthophotos	
2629SEW165									from John Jackson's thesis and NERDO report.		
2629SEW167											
2629SEW168											
2629SEW171										owned by Limestone Industries, sampled by EPA	yield comes from EPA records
2629SEW172			127						Re-Drilled by Dunnes, Dundalk Oringinal depth 91.4m but DtB not recorded	Location from site map included	
2629SEW177	23.2	3.77	152	28.7	53.3				Drilled by Tom Connell, Blackrock, Co Dublin Shale		4 hr test
2629SEW178			152	45.7					Drilled by Tom Connell, Dublin		4 hr test
2629SEW503		14.8	200	27	40						10 day pump test
2629SEW504				30	40						
2629SEW508		470	200	41.5	44.5	51.5	54.5				72 hr test at 2688 m3/d TW 9 10 11 monitored during test no impact
2629SEW511											
2629SEW514	2.1	364	152						Drilled by contract		Yield estimated from Bailer test
2629SEW515											
2629SEW050									Info. from John Jackson's Thesis		
2629SEW057									Co. Co. Hand Pump		
2629SEW065	8.5	120.8	150	88	94				water entry 285-290ft. & 308-310ft. Lining to 84ft.		72hr PT at 1027m3/d. Flow from shale, limited extend indicated.
2629SEW076			203	42.7	76.2				Drilled by Dunnes, Dundalk White Limestone		Yield estimated by Dunnes W S Ltd
2629SEW505	30.5	59.84	250	70	80						
2629SEW506			250	16	125						
2629SEW507			300	6	10						well designed to investigate GW supply in shallow red Sst supported by gravels

Table A1.1d Kingscourt Trial Wells and Observation Wells
Data From PC Field Work, WYG 2003
and Gypsum Limited (Minerex) 2003 and 2010

Name	Ref (TOC)	TOC Measured mOD Poolbeg	TOC Measured mOD Malin	GLEst25"/6"Sp Ht mOD Malin	GLEstDTM mOD Malin	Refmagl	TOCEst mOD Malin	GWLmbRefFb03	GWLmODFb03	GWLmbgl23ap0	GWLmODFb10	DateFb2010
1-H-P		55.028	52.318								45.438	26/02/10
1-J-PD		46.425	43.715								46.175	26/02/10
1-J-PS		46.445	43.735								35.025	26/02/10
95-A-1D		62.675	59.965								17.005	08/02/10
95-A-1S		62.675	59.965								39.005	08/02/10
DrGsat_DWbh		43.79	41.08					82.05	-40.97		-41.59	19/02/10
M101P	Top 20mm dip tube	52.32	49.61			0.26		14.63	34.98		29.302	19/02/10
M102P		42.36	39.65					0.53	39.12		41.82	19/02/10
M103P		53.7	50.99					15.93	35.06			
MW-1-P1		51.82	49.11								-5.04	08/02/10
MW-1-P2		51.82	49.11								-20.49	08/02/10
MW-1-P3		51.82	49.11								49.01	08/02/10
MW-2-P1		51.32	48.61								49.87	08/02/10
MW-3-P1	Top 6" steel well cover	52.25	49.54			0.97					-8.9	08/02/10
MW-3-P2		52.27	49.56								-20.15	08/02/10
MW-4-P1		53.8	51.09								3.63	08/02/10
MW-4-P2		53.8	51.09								1.66	08/02/10
O3A-P -1	Top 6" steel well cover	41.09	38.38			0.75					31.07	08/02/10
O3A-P -2	Top 6" steel well cover	41.13	38.42			0.75					37.02	08/02/10
BH01	Top 6inch S.C.			none	39.61	-0.21	39.4	no data	no data			
BH03	Top 20mm dip tube			35.81672		-0.72	35.09672					
BH04	Top 6inch S.C.			None	58.71	-0.5	58.21					
BH05	Top 6inch S.C.			34.7804	37.79	0.18	34.9604			1.16		
BH06	Top 6-inch plastic stick-up			34.53656		-0.27	34.26656					
BH07	Top 6inch S.C.			32.342		-0.08	32.262					
BH08	Top 6inch S.C.				33.82	0.1	33.92					
BH09	Top 6inch S.C.			34.4756		-0.34	34.1356					
BH10	Top 8inch S.C.			None	46.57	0.41	46.98					
BH11	Top 8inch S.C.			29.5246		0.38	29.9046					
BH12	Top 6inch S.C.			64.9556		-0.19	64.7656					
BH13	Top 6inch S.C.			28.6844		0.03	28.7144					
BH14	Top 6inch S.C.			None	39.62	-0.74	38.88					
GW01	Ground Level				31.39	0	31.39					
BH02	Top 6inch S.C.			None	47.7	0.6	48.3	no data	no data			
BW01	Top 8inch S.C.		GL = 34.63			0	34.63	0.35	34.28			
BW02	Top 8inch S.C.			31.0896		0.45	31.5396	0.17	31.3696			
BW03	1inch pipe invert at BH			None	34.55	0.18	34.73	0	>34.55			
DW01				57.9266			57.9266	18.9	39.0266			
DW02				59.1644			59.1644	1.2	57.9644			
DW03				28.9892			28.9892	1.91	27.0792			
DW04	Top 6-inch plastic casing			28.3796		0.21	28.5896	Artesian	>28.59			
DW06				71.966			71.966	1.34	70.626			
DW07				42.672			42.672	9.25	33.422			
DW08					48.43		48.43	0.26	48.17			
DW09					47.08		47.08	15	32.08			
DW11					53.2		53.2	21.55	31.65			
DW12					48.24		48.24	1.77	46.47			
DW13					46.78		46.78	no data	no data			
DW14					42.77		42.77	no data	no data			
DW15					35.53		35.53	0.78	34.75			
DW16	Top 6inch S.C.			None	31.43	0	31.43	1.63	29.8			
DW17					30.01		30.01	1.83	28.18			
DW18					35.53		35.53	no data	no data			
DW19					28.33		28.33	1.62	26.71			
DW20					36.4		36.4	no data	no data			
DW21	Top 6inch S.C.			36.3044		0.2	36.5044	0.95	35.5544			
DW22					40.87		40.87	1.95	38.92			
DW23					40.22		40.22	1.87	38.35			
DW24					40.07		40.07	no data	no data			
DW25	Top 6inch S.C.			37.25		0.29	37.54352	1.71	35.83352			
MHPW2		34.12	31.41					Artesian	>31.41			
OW01	Top 6inch S.C.	54.93	52.22			0.14		13.03	39.19			
OW02	Top Diphole in 8" SC cover	53.69	50.98			0.335		11.7	39.28			
OW04		73.68	70.97					>20	<50.97			
OW05	Top Diphole in 6" SC cover	63.33	60.62			0.08		20.75	39.87			
OW06	Top Diphole in 6" SC cover	44.54	41.83			0.08		Artesian	>41.83			
TW01					61.75		61.75	no data	no data			
TW02					107.68		107.68	no data	no data			
TW03					89.37		89.37	no data	no data			
TW04					128.55		128.55	no data	no data			
TW06					47.02		47.02	no data	no data			
TW07					75.51		75.51	13.7	61.81			
TW08		52.86	50.15					10.89	39.26			
TW09	Top 8inch S.C.	67.89	65.18			0.175		17.99	47.19			
TW11	Top 8inch S.C.	36.7	33.99			0.64		Artesian	>33.99			
TW12	Top 8inch S.C.			31.0896		0.34	31.4296	Artesian	>31.43			
TW14	Top 8inch S.C.	39.55	36.84			0.25		7.59	29.25			
TW14A		41.16	38.45					9.17	29.28			
TW15		59.7	56.99					17.68	39.31			
TW16		70.77	68.06					16.81	51.25			

Table A1.1d Kingscourt Trial Wells and Observation Wells
Data From PC Field Work, WYG 2003
and Gypsum Limited (Minerex) 2003 and 2010

Name	WLbRf8JL10	WLmODJL10	DateJL2010	WL1bRfSp10	Date1Sp10	WL2bRfSp10	WL2mODSp10	Date2Sp10
1-H-P		45.448	11/06/10					
1-J-PD								
1-J-PS		33.085	11/06/10					
95-A-1D		16.995	02/06/10					
95-A-1S		39.005	02/06/10					
DrGsat_DWbh		-35.46	11/06/10					
M101P		29.082	11/06/10			23.09	26.52	28/09/2010
M102P		41.63	11/06/10					
M103P								
MW-1-P1		-21.14	02/06/10					
MW-1-P2		-4.94	02/06/10					
MW-1-P3		46.74	02/06/10					
MW-2-P1		49.13	02/06/10					
MW-3-P1		-10.13	02/06/10			61.76	-12.22	28/09/2010
MW-3-P2		-20.77	02/06/10					
MW-4-P1		2.97	02/06/10					
MW-4-P2		0.99	02/06/10					
O3A-P -1		30.78	11/06/10			10.12	28.26	28/09/2010
O3A-P -2		36.59	11/06/10			4.47	33.95	28/09/2010
BH01						10.55	28.85	27/09/2010
BH03						1.93	33.16672	28/09/2010
BH04						12.49	45.72	28/09/2010
BH05						1.12	33.8404	28/09/2010
BH06						1.34	32.92656	28/09/2010
BH07						1.44	30.822	28/09/2010
BH08						4.53	29.39	28/09/2010
BH09						5.89	28.2456	28/09/2010
BH10						11.7	35.28	28/09/2010
BH11						2.78	27.1246	28/09/2010
BH12						24.72	40.0456	28/09/2010
BH13						1.18	27.5344	28/09/2010
BH14						1.73	37.15	28/09/2010
GW01				0	09/09/10			
BH02						17.665	30.635	27/09/2010
BW01	19.72	14.91	08/07/10	23.39	09/09/10	2.88	31.75	28/09/2010
BW02				0.47	09/09/10	0.46	31.0796	27/09/2010
BW03	0	>34.73	08/07/10	0	09/09/10	0	>34.73	27/09/2010
DW01								
DW02								
DW03								
DW04						0.03	28.5596	27/09/2010
DW06								
DW07								
DW08								
DW09								
DW11								
DW12								
DW13								
DW14								
DW15								
DW16						1.6	29.83	28/09/2010
DW17								
DW18								
DW19								
DW20								
DW21						1.44	35.0644	28/09/2010
DW22								
DW23								
DW24								
DW25						3	34.54352	28/09/2010
MHPW2								
OW01						13.205	39.015	27/09/2010
OW02						12.19	38.79	27/09/2010
OW04								
OW05						20.31	40.31	27/09/2010
OW06						0	>41.83	27/09/2010
TW01								
TW02								
TW03								
TW04								
TW06								
TW07								
TW08								
TW09						16.24	48.94	27/09/2010
TW11						0	>33.99	27/09/2010
TW12				0	09/09/10	0	>31.43	27/09/2010
TW14						7.86	28.98	27/09/2010
TW14A								
TW15								
TW16								

Table A1.2 Water Quality Data for Kingscourt Trial Wells and
Gypsum Limited Monitoring Wells
Data From KTC and WYG 1995 to 2003, and Minerex 2003 to 2010

Borehole ID	Date	Data Source	Comment	PARAMETERS	Calcium	Magnesium	Potassium	Sodium	Total Ammonia	Chloride	Nitrate	Nitrite	Sulphate	Alkalinity	meq Cat	meq An	Ionic Balance	IB Fail?	Hardness	Conductivity	Aluminium	Iron	Manganese
				UNIT	Ca mg/l	Mg mg/l	K mg/l	Na mg/l	NH4 mg/l	Cl mg/l	NO3 mg/l	NO2 mg/l	SO4 mg/l	CaCO3 mg/l	meq/l	meq/l	%		CaCO3 mg/l	µS/cm	Al mg/l	Fe mg/l	Mn mg/l
				EPA Threshold				150	0.23	24	37.5	0.375	187.5							800	0.15		
				DWS				200	0.3	250	50	0.5	250							2500	0.2	0.2	0.05
TW02	11/01/1995	KTC			33	14	2.1	11	<0.05	16	<0.5	<0.01	35	122	3.35	3.626309524	-3.98		140	320	<0.05	3.1	0.3
TW03	10/03/1995	KTC			75	32	4.4	17	0.1	18	<0.5	<0.01	69	252	7.27	6.991785714	1.98		319	575	<0.05	3.5	0.32
BW01	02/06/1995	KTC	TW05		42	11	2.8	11	<0.05	17	<0.5	<0.01	9.2	150	3.57	3.677380952	-1.53		150	290	<0.05	0.11	0.54
BW01	06/06/1995	KTC	TW05		42	11	2.8	11	<0.05	18	<0.5	<0.01	9.2	150	3.57	3.71	-1.91		150	280	<0.05	0.11	0.54
BW01	09/06/1995	KTC	TW05		41	11	2.4	12	0.05	15	<0.5	<0.01	8.6	143	3.55	3.47	1.21		148	280	<0.05	0.13	0.53
BW01	28/02/2003	WYG	PW5		42	10							8						146	285		0.19	0.56
BW01	04/03/2003	WYG	PW5		40	5.1							8						151			<0.01	0.55
BW01	11/03/2003	WYG	PW5		45	11	2.8	9.1	<0.1	14	<0.5	<0.01	8	140	3.63	3.37	3.73		158	285	<0.05	0.02	0.6
BW01	19/03/2003	WYG	PW5		39	9.6							8						137	285		0.04	0.51
BW01	25/03/2003	WYG	PW5		39	9.9	2.7	8.5	<0.05	14	<0.5	<0.01	8	142	3.21	3.42	-3.04		138	285	<0.05	0.09	0.53
BW01	01/04/2003	WYG	PW5; Filtered Sample		39	10							8						138	285		0.02	<0.01
BW01	03/04/2003	WYG	PW5		40	11	2	10	0.02	14	<1	<0.01	10		3.40				142	270	<0.008	0.09	0.5
BW01	04/04/2003	WYG	PW5		40	11	2	10	0.02	14	<1	<0.01	10	168	3.40	3.97	-7.66	Fail	142.5	270	<0.008	0.091	0.5
BW01	07/04/2009	CavCoCo	BW01					11	<0.01	15	0.8	<0.01	8							286	<0.01	<0.02	<0.099
BW01 C35/3c	05/03/1980	NERDO			34.8	10.8	3.5	11.2		12	0.18		4.5	146	3.22	3.36	-2.17		132	3		0.78	0.53
BW01 C35/3c	25/03/1980	NERDO			40.8	6.72	2.94	10.3		13	0.22		7.3	152	3.12	3.57	-6.63	Fail	130	335		1.04	0.43
BW01 C35/3c	26/03/1980	NERDO	**10am**		39.2	11.52				11	0.18		7.4	148		3.43			146	330			
BW01 C35/3c	26/03/1980	NERDO	**4pm**		40	11.04	2.83	10.2		12	0.27		6.5	150	3.44	3.48	-0.67		146	310		0.596	0.44
BW01 C35/3c	27/03/1980	NERDO			40	11.52	2.51	9.95					6.4	146	3.46				148	330		0.25	0.47
TW07	25/08/1995	KTC			57	23	3.5	25	0.13	30	<0.5	<0.01	38	219	5.95	6.03	-0.65		237	485	<0.05	0.83	0.08
TW08	21/02/1996	KTC			100	19	3.5	20	<0.05	14	<0.5	<0.01	113	242	7.54	7.59	-0.34		328	619	<0.05	0.38	0.01
TW08	16/04/2002	WYG			106	20	3.9	18	0.09	12	<0.5	<0.01	150	234	7.85	8.15	-1.83		347	670	<0.05	<0.01	0.01
TW08	22/04/2002	WYG			116	22	4	20	0.11	15	<1	<0.01	158	285	8.61	9.42	-4.48		372	639	0.05	0.392	0.017
TW09	02/03/1996	KTC			34	27	3.4	26	0.09	23	<0.5	<0.01	33	259	5.17	6.52	-11.56	Fail	271	533	0.08	1.1	0.09
TW09	16/04/2002	WYG			54	23	3	16	0.1	23	<0.5	<0.06	78	172	5.39	5.72	-2.94		230	475	15	0.02	0.2
TW09	22/04/2002	WYG			58	25	19	3	0.09	20	<1	<0.01	60	224	5.61	6.30	-5.84	Fail	245	474	0.015	4.73	0.204
BW03	07/03/1996	KTC	TW10		51	16	1.2	9.2	0.05	15	<0.5	<0.01	16	176	4.32	4.28	0.41		193	349	0.07	0.11	0.23
BW03	28/02/2003	WYG	TW10		53	15							15						194	350		0.01	0.22
BW03	04/03/2003	WYG	TW10		49	7.1							13						152			<0.01	0.22
BW03	11/03/2003	WYG	TW10		55	15	1.7	8.4	<0.1	15	<0.5	0.01	15	175	4.41	4.24	1.94		199	350	<0.05	<0.01	0.23
BW03	19/03/2003	WYG	TW10		49	14							15						180	350		<0.01	0.21
BW03	25/03/2003	WYG	TW10		49	14	1.7	8.1	0.08	15	<0.5	0.06	15	176	4.02	4.26	-2.95		180	350	<0.05	0.01	0.2
BW03	01/04/2003	WYG	TW10; Filtered Sample		50	15							15						187	350		<0.01	<0.01
BW03	03/04/2003	WYG	TW10		50	15	1	9	0.09	15	<1	<0.01	16		4.17				195	337	<0.025	0.02	0.2
BW03	04/04/2003	WYG	TW10		50	15	1	9	0.09	15	<1	<0.01	16	208	4.17	4.92	-8.25	Fail	195	337	0.025	0.02	0.208
TW11	05/02/1998	KTC			50	12	1.4	11	<0.05	14	1	<0.01	27	147	4.01	3.92	1.20		174	328	0.06	0.68	0.2
TW11	16/04/2002	WYG			53	13	1.3	8.4	0.05	16	<0.01	<0.01	21	170	4.13	4.29	-1.90		186	365	0.28	<0.01	0.28
TW11	22/04/2002	WYG			57	14	1	10	0.06	15	<1	<0.01	23	204	4.48	4.99	-5.36	Fail	192	362	0.02	0.045	0.278
TW12	12/02/1998	KTC			45	17	1.3	9.7	<0.05	12	<0.5	<0.01	16	173	4.12	4.14	-0.17		182	350	<0.05	0.02	0.07
BW02	12/02/1998	KTC	TW13		50	16	1.4	9.8	<0.05	13	<0.5	<0.01	17	176	4.30	4.25	0.58		191	355	<0.05	0.09	0.15
BW02	28/02/2003	WYG	TW13		56	17							16						210	365		0.13	0.2
BW02	04/03/2003	WYG	TW13		53	8							14						165			<0.01	0.2
BW02	11/03/2003	WYG	TW13		60	17	1.8	9	<0.1	15	<0.5	0.02	17	192	4.85	4.62	2.44		195	375	<0.05	0.02	0.21
BW02	19/03/2003	WYG	TW13		52	16							18						196	385		0.07	0.19
BW02	25/03/2003	WYG	TW13		55	16	1.8	8.6	<0.05	15	<0.01	<0.05	18	200	4.50	4.80	-3.23		203	390	0.2	0.1	0.2
BW02	01/04/2003	WYG	TW13; Filtered Sample		57	18							18						216	390		0.01	<0.01
BW02	03/04/2003	WYG	TW13		56	18	1	10	0.05	15	<1	<0.01	20		4.76				212	375	0.009	0.14	0.2
BW02	04/04/2003	WYG	TW13		56	18	1	10		15	<1	<0.01	20	239	4.76	5.63	-8.33	Fail	212.5	375	0.009	0.139	0.202
TW14	25/02/1999	KTC			90	20	2.1	18	18	<0.05	<0.5	<0.01	82	250	8.00	6.71	8.80	Fail	307	575	0.05	0.4	0.18
TW14A	16/04/2002	WYG			172	35	3.9	49.0	0.07	26	<0.5	<0.01	496	200	13.75	15.08	-4.60		574	1120	<0.05	0.01	0.38
TW14A	22/04/2002	WYG			198	39	3.0	58.0	0.10	30	<1	<0.01	509	224	15.75	15.94	-0.59		634	1160	<0.01	1.358	0.36
TW15	16/04/2002	WYG			360	30	6.4	25.0	0.05	15	<0.5	0.12	950	186	21.75	23.94	-4.78		1022	1620	<0.05	0.02	0.06
TW15	22/04/2002	WYG			394	31	5.0	24.0	0.09	17	<1	<0.01	863	225	23.46	22.96	1.07		1074	1504	<0.01	0.162	0.031
TW16	16/04/2002	WYG			45	20	1.9	18.0	0.06	29	<0.5	<0.01	89	123	4.75	5.14	-3.96		420	420	<0.05	0.16	0.17
TW16	22/04/2002	WYG			46	20	2.0	22.0	0.05	27	<1	<0.01	68	149	4.98	5.17	-1.88		190	397	<0.01	2.29	0.02
BH05	24/04/2007	Dunnes/EuroEnv	Hagwell Construction Cabra Borehole 1						0.21			<0.003							155	369	0.478	0.821	
BH05	26/04/2007	Dunnes/EuroEnv	Hagwell Construction Cabra Borehole 1						<0.09			<0.003							151	366	0.134	0.1	
03A-P1	Nov-03	Minerex	Upper Mudst. (Should be NamSSTSH??)		479.6	53.82	18.6	212		65	<0.3		1431	NDP	38.16					2721			
03A-P1	May-05	Minerex			559	109	0.4	544	0.54	378	<0.08		929	20	60.73	30.55	33.05	n/a		3169			
03A-P1	Nov-05	Minerex			683.5	166.8	22.4	692.7	0.35	198	0.367		3632	120	78.79	83.73	-3.04	n/a		5483.3			
03A-P1	Jun-06	Minerex			432.9	95.9	13.8	504.1	0.29	319.9	0.17		4027.7	100	51.92	95.05	-29.34	n/a		4120			
03A-P1	Oct-06	Minerex			408.9	80.63	15.33	442	0.27	301	<0.125		2666	100	46.79	66.14	-17.14	n/a		3950			
03A-P1	May-07	Minerex			475.8	103.3	18.3	510.1	0.31	257.2	<0.125		4288.4	144	55.06	99.57	-28.78	n/a		4170			
M101P	Nov-03	Minerex	Upper Mudst. (Should be NamSSTSH??)		264.1	43.67	4.4	77		12	<0.3		772	70	20.30	17.83	6.50	n/a		1536			
M101P	May-05	Minerex			523	63	0.1	45	0.15	13.8	<0.08		729	10	33.37	15.78	35.78	n/a		2227			
M101P	Nov-05	Minerex			563	69.2	3.5	50.7	0.03	13.5	0.117		2803	62	36.21	60.02	-24.74	n/a		2201			
M101P	Jun-06	Minerex			524.3	60.2	3.5	46.8	0.03	13.7	<0.054		2454.5	90	33.36	53.33	-23.04	n/a		2320			
M101P	Oct-06	Minerex			462	52.58	4.39	46.58	0.08	10.6	<0.125		1331	68	29.62	29.39	0.39	n/a		2170			
M101P	May-07	Minerex			494	5.5	9.5	45.5	0.43	9.242	<0.125		825.2	694	27.40	31.34	-6.69	n/a		3650			
MW3-P1	Nov-03	Minerex	Namurian/ Westphalian		412.6	39.98	5.8	67		19	<0.3		1586	130	27.02	36.18	-14.49	n/a		2264			
MW3-P1	May-05	Minerex			864	284	0.7	82	0.21	30.7	<0.05		818	62	70.46	19.16	57.24	n/a		2342			
MW3-P1	Nov-05	Minerex			605.5	95.9	7.4	96	0.10	163.6	0.415		2533	112	42.64	59.69	-16.67	n/a		2410			
MW3-P1	Jun-06	Minerex			437.6	72.5	6	123.7	0.15	28.7	0.055		2415.8	120	33.46	53.55	-23.09	n/a		2441			
MW3-P1	Oct-06	Minerex			837	46.36	5.03	22.19	<0.011	6.59	0.403		837	126	46.81	20.15	39.81	n/a		2080			
MW3-P1	May-07	Minerex			472	64.5	7	51.8	0.13	14.278	<0.125		2282.8	90	31.41	49.77	-22.61	n/a		3055			
MW3-P1	Apr-08	Minerex			642.5	64.6	69	56		14.6			825	100	41.71	19.60	36.05	n/a		3186			
MW3-P1	Sep-08	Minerex			802.7	80.7	12.1	168.1		25.7				538	54.48	11.49	65.15	n/a		2587			
MW3-P1	Apr-10	Minerex			527	62.9	7.45	50	<0.26	17.9	<0.3			105	33.96	2.61	85.72	n/a		2044			

Table A1.2 Water Quality Data for Kingscourt Trial Wells and
Gypsum Limited Monitoring Wells
Data From KTC and WYG 1995 to 2003, and Minerex 2003 to 2010

Borehole ID	Date	Total Coliforms	Fecal Coliforms	Total Barium	Total Boron	Total Cadmium	Total Chromium	Copper	Fluoride	Total Lead	Total Mercury	Total Nickel	Total Inorg P	Total Selenium	Total Silver	Total Zinc	Total Antimony	Total Arsenic	K/Na Ratio (using meq)	Dissolved Oxygen (% Sat)
		No./100ml	No./100ml	ug/l Ba	ug/l B	ug/l Cd	ug/l Cr	ug/l Cu	ug/l F	ug/l Pb	ug/l Hg	ug/l Ni	ug/l	ug/l Se	ug/l Ag	ug/l Zn	ug/lsb	ug/l As	[-]	%
					750	3.75		1500		18.75			35					7.5	0.4	
		0	0		1000	5		2000	1500	25				10			5	1		
TW02	11/01/1995	0	0					<10												
TW03	10/03/1995	0	0					<10												
BW01	02/06/1995							<10												
BW01	06/06/1995	0	0					<10												
BW01	09/06/1995	0	0					<10												
BW01	28/02/2003																			
BW01	04/03/2003																			
BW01	11/03/2003	0	0					<10												
BW01	19/03/2003																			
BW01	25/03/2003	0	0					<1												
BW01	01/04/2003																			
BW01	03/04/2003	0	0					<2												
BW01	04/04/2003	0	0	98	<12	<0.4	<1	<2	<88	<1	<0.1	<2	36	<1	<0.3	63	<1	<1		
BW01	07/04/2009	0	0		30	<0.02	10	1.4	<100	0.8	<0.05	2		0.8			<1	0.7		
BW01 C35/3c	05/03/1980																			
BW01 C35/3c	25/03/1980																			
BW01 C35/3c	26/03/1980																			
BW01 C35/3c	26/03/1980																			
BW01 C35/3c	27/03/1980																			
TW07	25/08/1995	0	0					<10												
TW08	21/02/1996	0	0					<10												
TW08	16/04/2002	Nil	Nil					<10												
TW08	22/04/2002	Nil	Nil	14	113.00	<0.5	<1	<5	160	<1	0.1	<5	<30	<1	<0.3	66	<1	<1		
TW09	02/03/1996	0	0					<10												
TW09	16/04/2002	Nil	Nil					<10												
TW09	22/04/2002	Nil	9	70	29.00	<0.5	<1	<5	142	<1	0.1	11	207	<1	<0.3	91	<1	<1		
BW03	07/03/1996	0	0					<10												
BW03	28/02/2003																			
BW03	04/03/2003																			
BW03	11/03/2003	0	0				<0.01													
BW03	19/03/2003																			
BW03	25/03/2003	0	0				<0.01													
BW03	01/04/2003																			
BW03	03/04/2003	0	0				<0.002													
BW03	04/04/2003	0	0	20	15		<1	<2	<88	2	<0.1	<2	<24	<1	<0.3			<1		
TW11	05/02/1998	0	0					<10												
TW11	16/04/2002	Nil	Nil					<10												
TW11	22/04/2002	Nil	1	50	<20	<0.5	<1	<5	129	<1	0.1	<5	<30	<1	<0.3	80	<1	<1		
TW12	12/02/1998	0	0					<10												
BW02	12/02/1998	0	0					<10												
BW02	28/02/2003																			
BW02	04/03/2003																			
BW02	11/03/2003	0	0				<0.01													
BW02	19/03/2003																			
BW02	25/03/2003	0	0				<0.1													
BW02	01/04/2003																			
BW02	03/04/2003	0	0				<0.002													
BW02	04/04/2003	0	0	33	14	<0.4	<1	<2	<88	<1	<0.1	<2	<24	<1	<0.3	6	<1	1		
TW14	25/02/1999	0	0					<10												
TW14A	16/04/2002	Nil	Nil					<10												
TW14A	22/04/2002	Nil	Nil	48	126	<0.5	<1	<5	124	<1	0.1	<5	<30	<1	<0.3	36	<1	<1		
TW15	16/04/2002	Nil	Nil					<10												
TW15	22/04/2002	Nil	1	12	162	<0.5	<1	<5	200	<1	0.1	<5	<30	<1	<0.3	34	<1	<1		
TW16	16/04/2002	Nil	Nil					<10												
TW16	22/04/2002	Nil	Nil	18	24	<0.5	<1	<5	116	<1	0.1	<5	38	<1	<0.3	297	<1	<1		
BH05	24/04/2007	0	0																	
BH05	26/04/2007	0	0																	
03A-P1	Nov-03																			
03A-P1	May-05																			
03A-P1	Nov-05																			
03A-P1	Jun-06																			
03A-P1	Oct-06																			
03A-P1	May-07																			
M101P	Nov-03																			
M101P	May-05																			
M101P	Nov-05																			
M101P	Jun-06																			
M101P	Oct-06																			
M101P	May-07																			
MW3-P1	Nov-03																			
MW3-P1	May-05																			
MW3-P1	Nov-05																			
MW3-P1	Jun-06																			
MW3-P1	Oct-06																			
MW3-P1	May-07																			
MW3-P1	Apr-08																			
MW3-P1	Sep-08																			
MW3-P1	Apr-10																			

Table A1.2 Water Quality Data for Kingscourt Trial Wells and
Gypsum Limited Monitoring Wells
Data From KTC and WYG 1995 to 2003, and Minerex 2003 to 2010

Borehole ID	Date	pH	Temp	Total Organic Carbon	Non-Carbonate Hardness	Non-Purg Org. Carb.	Colour	Turbidity	Fee CN	Total CN	Oxidisability	Dissolved Solids	Suspended Solids	Calcium Hardness
		units	deg C	mg/l as C	CaCO3 mg/l	C mg/l	Hazen	FTU	ug/l	ug/l CN	mg/l	mg/l	mg/l	mg/l CaCO3
		>6.5 & < 9.5												
TW02	11/01/1995	6.7		0.6			5	5						
TW03	10/03/1995	7		1.9			<5	50						
BW01	02/06/1995	7.6		<0.5			5	0.5						
BW01	06/06/1995	7.6		<0.5			5	0.4						
BW01	09/06/1995	7.5		0.6			<5	0.25						
BW01	28/02/2003	7.5												
BW01	04/03/2003												<10	
BW01	11/03/2003	7.7			18	<0.5	<5	0.5						
BW01	19/03/2003													
BW01	25/03/2003	7.5				<0.5	<5	0.15						
BW01	01/04/2003	7.7												
BW01	03/04/2003	7.5					<2	0.6						
BW01	04/04/2003	7.5		0.5			<2	0.6	0.4		1.2	294		
BW01	07/04/2009	7.7					<1	1		<30	<3			
BW01 C35/3c	05/03/1980	8.2										175		87
BW01 C35/3c	25/03/1980	7.6										109		102
BW01 C35/3c	26/03/1980	8.2										124		98
BW01 C35/3c	26/03/1980	7.7										169		100
BW01 C35/3c	27/03/1980	7.7										135		100
TW07	25/08/1995	7.1		0.9			<5	11						
TW08	21/02/1996	7.6		1			<5	3.4						
TW08	16/04/2002	7.6			113	<0.5								
TW08	22/04/2002	7.69		1.2			<1	5.6	<0.5	<0.5	0.7	488		
TW09	02/03/1996	7.2		1.1			<5	8.8						
TW09	16/04/2002	7.4			58	1.6								
TW09	22/04/2002	6.86		2			<1	>20	<0.5	<0.5	1.6	314		
BW03	07/03/1996	7.9		0.69			<5	2.4						
BW03	28/02/2003	7.6												
BW03	04/03/2003												<10	
BW03	11/03/2003	7.7			22	<0.5	<5	0.1						
BW03	19/03/2003													
BW03	25/03/2003	7.6			4	<0.5	<5	<0.1						
BW03	01/04/2003	7.8												
BW03	03/04/2003	7.52					<2	0.4						
BW03	04/04/2003	7.52		0.5			<2	0.4	<0.4		1.2	368		
TW11	05/02/1998	7.3		0.6			<5	5.2						
TW11	16/04/2002	7.6			16	<0.5								
TW11	22/04/2002	7.34		0.8			<1	0.4	<0.5	<0.5	1	236		
TW12	12/02/1998	8.2		<0.5			<5							
BW02	12/02/1998	8.1		<0.5			<5	6.4						
BW02	28/02/2003	7.8												
BW02	04/03/2003												<10	
BW02	11/03/2003	7.7			3	<0.5	<5	0.3						
BW02	19/03/2003													
BW02	25/03/2003	7.8			3	<0.5	<5	<0.1						
BW02	01/04/2003	7.8												
BW02	03/04/2003	7.58					<2	0.6						
BW02	04/04/2003	7.58		0.9			<2	0.6	0.4		1.4	374		
TW14	25/02/1999	<5		1			6.5	7.4						
TW14A	16/04/2002	7.9			374	<0.5								
TW14A	22/04/2002	7.38		1.2			<1	18.9	1.3	1.3	1.1	994		
TW15	16/04/2002	7.7			836	0.7								
TW15	22/04/2002	6.97		1.2			<1	1.2	<0.5	<0.5	0.7	1600		
TW16	16/04/2002	7.4			72	0.9								
TW16	22/04/2002	7.41		1.5			<1	10	0.5	0.5	1.7	218		
BH05	24/04/2007	8.2					31	23.54						
BH05	26/04/2007	8.1					5	1.79						
03A-P1	Nov-03	7.3										2285		
03A-P1	May-05	7.69												
03A-P1	Nov-05	6.72												
03A-P1	Jun-06	6.58												
03A-P1	Oct-06	7.9												
03A-P1	May-07	6.84												
M101P	Nov-03	7.41										1189		
M101P	May-05	8.61												
M101P	Nov-05	8.45												
M101P	Jun-06	8.42												
M101P	Oct-06	7.7												
M101P	May-07	11.9												
MW3-P1	Nov-03	6.83										1299		
MW3-P1	May-05	7.52												
MW3-P1	Nov-05	7.54												
MW3-P1	Jun-06	7.58												
MW3-P1	Oct-06	7.5												
MW3-P1	May-07	6.58												
MW3-P1	Apr-08													
MW3-P1	Sep-08	7.7												
MW3-P1	Apr-10	7.83												

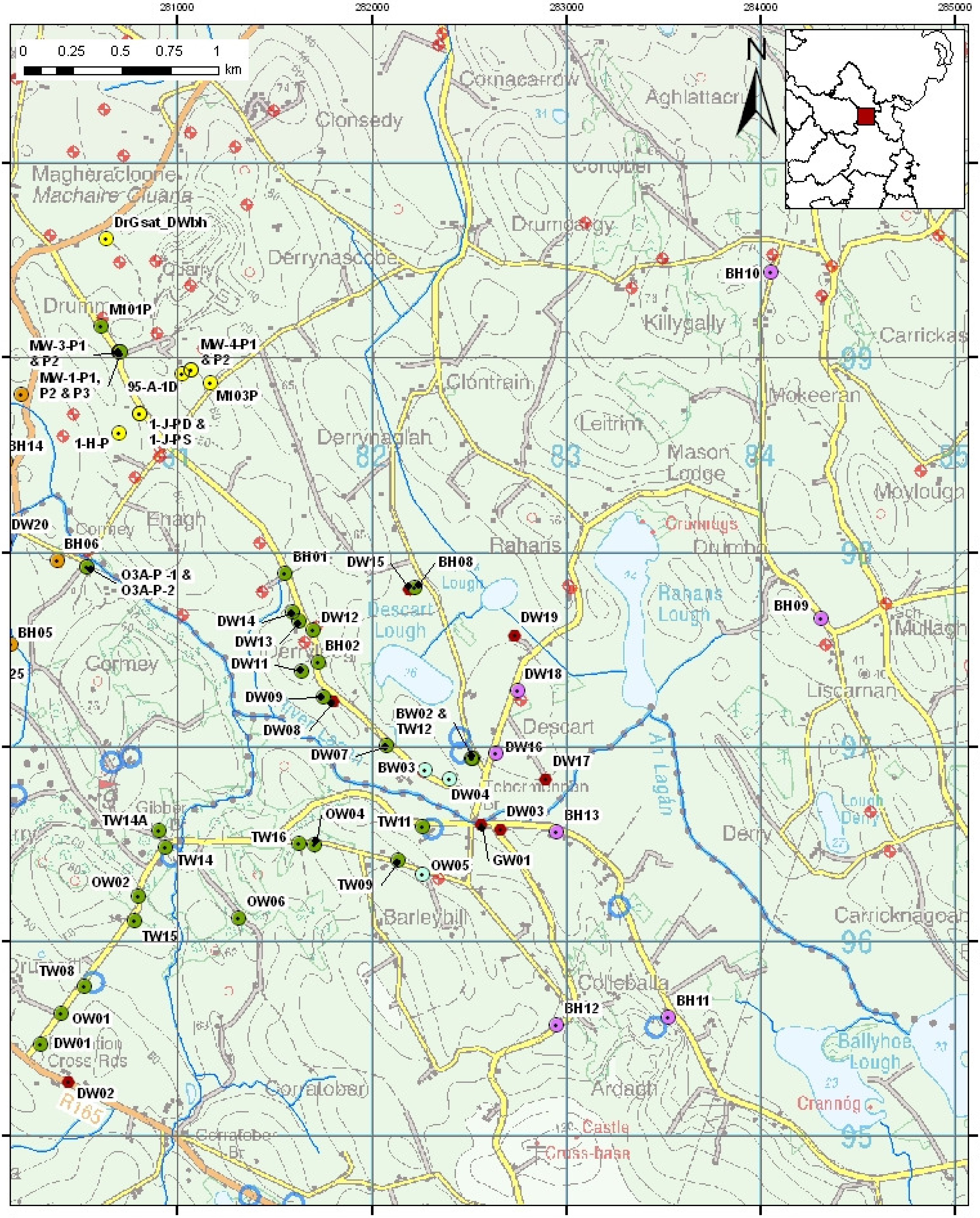

Figure A1.1 Data Points in the Vicinity of Descart PWS Site

- Bedrock Groundwater Borehole
- Dug Well / Spring
- Stream
- GSI Well Database (50 m accuracy)
- GSI Well Database (50 to 100 m accuracy)

Borehole - Aquifer Key

- PT Sandstone
- Kingscourt Gypsum Formation
- Namurian Sandstone & Shale
- Namurian Sandstone & Shale / Dinantian Limestones
- Dinantian Limestones