Cavan County Council

Establishment of Groundwater Source Protection Zones

Kingscourt Water Supply Scheme

Mullantra Borehole

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RevC

Prepared by:
Peter Conroy
On behalf of the Geological Survey of Ireland

With contributions from:
Ms. Jenny Deakin & Dr. Robert Meehan

And with assistance from:
Cavan County Council

Geological Survey of Ireland
Suirbhéireacht Gheolaíochta Éireann

Project description

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

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 Kingscourt source protection zones for the Mullantra source borehole.

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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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 Mullantra source borehole (BW01) is located in the townland of Mullantra, Co. Cavan, which lies approximately 2.5 km north-northeast of Kingscourt town centre.

Kingscourt is currently supplied by BW01 (500 m^3/day) and by Ervey Lough (500 m^3/day). Cavan County Council plans to phase out the abstraction from Ervey Lough by 2013 and replace it with two additional borehole groundwater sources. These are boreholes BW02 and BW03 located at Descart, Carrickmacross Co. Monaghan, 4 km east-northeast of Kingscourt town centre. Source protection zones have also been delineated for the Descart sources and are described in a separate report.

The objectives of the study were:

- To outline the principal hydrogeological characteristics of the Mullantra area.
- To delineate source protection zones for the borehole.
- 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

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

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

Borehole BW01 is located just west of the R179 road inside an enclosed compound, 275 m south-southwest of the River Lagan and the Cavan – Monaghan county boundary. The site location is shown in Figure 1.

The borehole, rising main and flow meter are housed within a raised cast-concrete chamber located in the centre of the site which is fenced and locked (see Photograph 1). The chamber is accessed *via* bolted, hinged steel roof plates. The chamber roof allows rainfall to leak inside, and pond in the base of the structure; this is removed by a sump pump. The mouth of the borehole is formed by concentric 300 mm and 200 mm steel casings, which are covered by a 350 mm diameter steel plate (Photograph 2). The borehole log records that during the construction of the borehole, a grout seal was installed in the borehole annulus between the 200 mm and 300 mm diameter steel casings, between 0 m and 70 m below ground level. There is no untreated-water sampling tap at the borehole.

Photo1: Borehole BW01 Chamber

Photo2: Borehole BW01

Borehole BW01 was drilled by Dunnes Water Services Ltd. with KT Cullen & Co Ltd. as hydrogeological consultants in May 1995.

4 Summary of well details

The well details (Table 4-1) are derived from various KT Cullen & Co Ltd. and WYG hydrogeological investigation reports and accompanying borehole logs prepared between 1996 and 2003. The borehole log for borehole BW01 together with tables summarising key data extracted from the reports (Tables A1.1 to A1.4) is provided in Appendix 1.

The borehole was commissioned in 2009 and Cavan County Council advises that it began supplying water to the scheme in January 2010.

The source installation is specified to provide the sustainable yield of 500 m^3/day by pumping at 6.91 l/s for 20 hours per day. Abstraction records from September 2010 indicate that the borehole currently pumps for approximately 14.5 hours per day at an average of 26 m^3/hour (7.2 l/s), giving a typical daily abstraction of 375 m^3/d. The water level in the borehole is monitored by a pressure transducer linked to Cavan County Council telemetry for continuous measurement and logging. Data collected prior to September 2010 were routinely being deleted on a rolling 7-day basis but are now being collated for longer term analyses.

Pumping test data are summarised in Table 4-1. Further details of pumping tests carried out on the borehole are recorded in Table A1.1 in Appendix 1.

5 Topography, surface hydrology, landuse

The 60 m high Kingscourt half-rift valley scarp is located immediately west of the borehole. The ground elevation at borehole BW01 in the base of the rift valley is 34.63 mAOD.

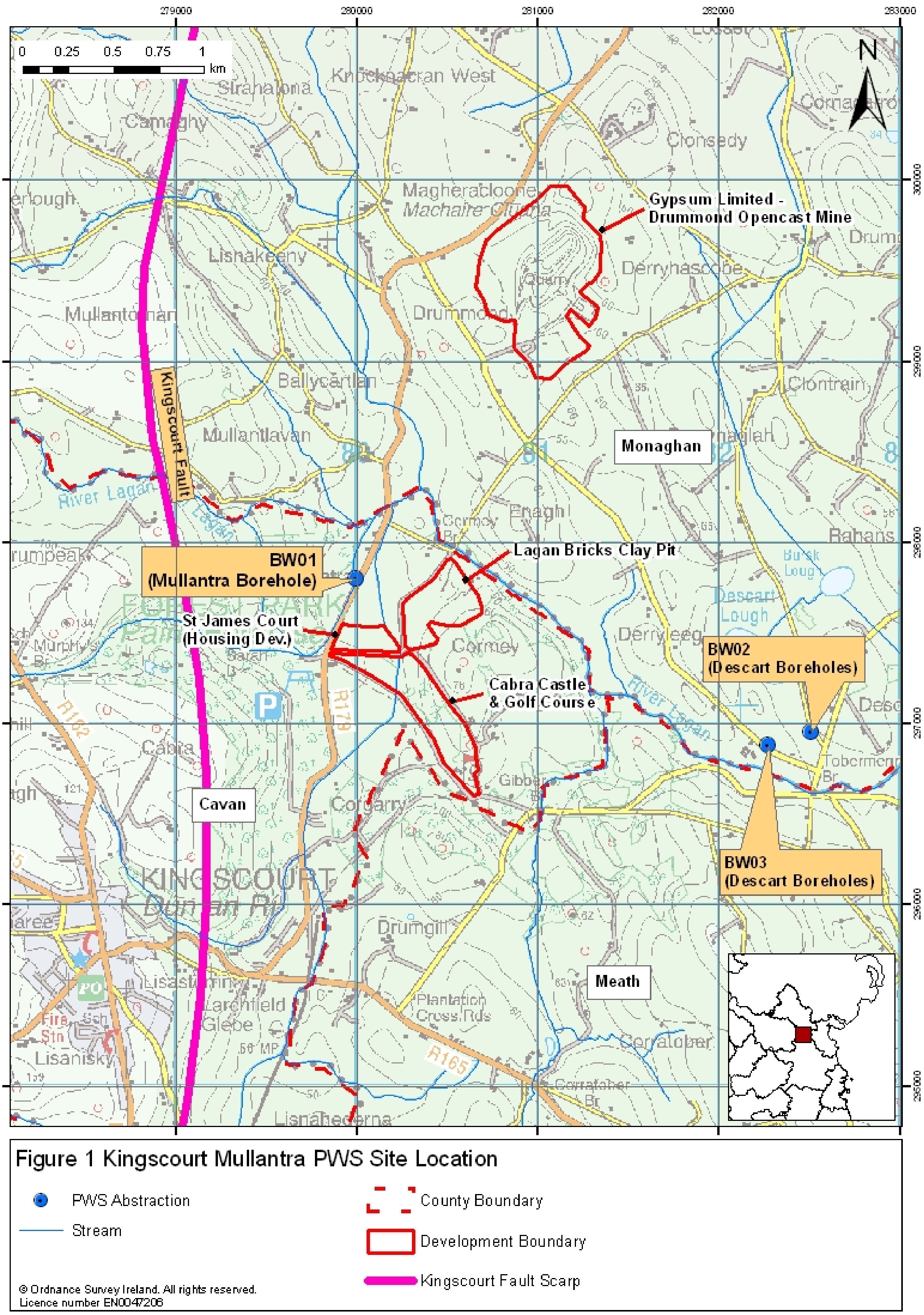

Figure 1 Kingscourt Mullantra PWS Site Location

Table 4-1: Well Details

	BW01
Grid ref. (GPS)	X: 280006 Y: 297801
GSI Well Database Reference No.	2629SEW503
Townland	Mullantra
Source type	Borehole
Drilled	1995 (Commissioned in January 2010)
Owner	Cavan County Council
Elevation (Ground Level)	34.63 mAOD
Depth (m)	120
Depth of casing	300 mm steel casing at 0 m to 70 mbgl 200 mm steel casing at 0 m to 70 mbgl and 113 m to 120 mbgl, as part of casing/well screen string. 200 mm galvanised well screen, 0.4 mm slot aperture, at 71 m to 113 mbgl, as part of casing/well screen string.
Grout Seal	Cement grout seal installed between the 200 mm and 300 mm diameter steel casings from 0 m to 70 mbgl
Diameter	200 mm
Depth to rock	38 m
Static water level	0.35 mbRef(1) (24/02/2003; 34.28 mAOD), (WYG, 2003)
Pumping water level	Min PWL varied between 21.91 mbRef and 23.34 mbRef between 03 & 10/09/2010(2) (12.72 mAOD to 11.29 mAOD respectively)
Consumption (Co. Co. records)	375 m^3/d
Pumping test summary: (i) abstraction rate m^3/d	635 m^3/d & 735 m^3/d
(ii) specific capacity	14.8 m^3/d/m @ 635 m^3/day (1995, 10 day test after drilling) 18.3 m^3/d/m @ 735 m^3/day (2003, 6 week test)
(iii) transmissivity	21 m^2/d (based on 1995 data)
(iv) storativity	0.00017 (based on 1995 data)

Note 1: Level at start of WYG pumping test on 24/02/2003. Ref point not recorded. Assume = top of 200 mm steel casing.
Note 2: Ref = top of 200 mm diameter Steel Casing = 34.63 mAOD (i.e. same as Ground Level).

East of the borehole, the topography is dominated by drumlins with crests up to 80 mAOD. The regional topographic gradient from the fault scarp across the drumlin field is to the east.

The half-rift scarp is dissected by numerous, west to east flowing surface water courses. Drainage density is high and presence of rushes suggests poorly drained soils. The main surface water feature in the vicinity of the borehole is the River Lagan, approximately 190 m north of borehole BW01, which flows in an east-southeasterly direction with a gradient of 0.0029. Two unnamed tributaries of the Lagan flow east from the scarp and divert northwards towards the Lagan, to flow to the west (Mullantra Stream) and east of the source (Cormey Stream). The Mullantra stream forms the western boundary of the source site while the Cormey stream passes approximately 100 m east of the site. The land immediately surrounding borehole BW01 is part of an alluvial flat on the half-rift valley floor between, and to either side of, the Mullantra and Cormey streams (see Figure 1).

Landuse in the vicinity of the borehole is varied but predominantly comprises wet grassland and forestry. The Lagan Bricks clay pit is located 275 m east at Cormey bridge and the Cabra Castle golf course lies 400 m to the southeast. To the north of the site and the river Lagan, the landuse is predominantly agricultural; however the Gypsum Industries opencast gypsum mine is located 1.5 km north-northeast of the borehole. One-off housing is common in the area and the St James Court housing development is located 300 m south of the borehole. There is no mains water supply or sewerage in the area. As such the St James Court development and other residences in the area are serviced by private boreholes and wells and by on-site waste water treatment systems.

6 Hydrometeorology

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

Annual rainfall: 1013 mm. The closest meteorological station to borehole BW01 is Kingscourt Garda Station, located 2.3 km southwest in Kingscourt town centre. The annual average rainfall from 1961 to 1990 is 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). 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)
- Borehole logs of trial wells and production wells from Dunnes Water Services Ltd and KT Cullen LTD / WYG, 1995 to 2002
- Geology of Meath. Bedrock Geology 1:100,000 Scale Map, Sheet 13. Geological Survey of Ireland (McConnell, B *et al*. 2001)
- 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. The distribution of the various bedrock units is shown in Figure 2.

Table 7-1: Bedrock Descriptions

Bedrock Formation	Generalised Rock Unit Classification	Geological Description	Max thickness (m)[1]
Kingscourt Sandstone Formation (KS)	Permo-Triassic Sandstones (PTS)	Siltstone unit 80 to 100 m thick overlain by up to 300 m of thickly bedded, cross-laminated sandstones.	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
Castlerahan Formation (RA)	Silurian Metasediments and Volcanics (SMV)	Dark, quartz, greywacke conglomerate	unknown

The geology at the source borehole is recorded in the borehole log for BW01 (Appendix 1). This records a geological succession comprising 38 m of till overburden underlain by 4 m of hard grey-green sandstone, over 78 m of soft red mudstone which gradually becomes red sandstone. A trial well (NERDO borehole C35/3c, now destroyed) was drilled to 104 mbgl in the Kingscourt Sandstone in 1979, approximately 13 m from borehole BW01, and encountered Triassic Marl at 48 m below overburden, followed by fine grained red sandstone from 55 m to 104 mbgl, with a further, thin marl bed encountered at approximately 87 m to 90 mbgl (Appendix 1).

The Kingscourt Sandstone bedrock hosting borehole BW01 is bounded to the west by the north-south trending Kingscourt Fault. This fault has a maximum downthrow to the east of approximately 2100 m (McConnell *et al*, 2001). The fault juxtaposes the sandstones against Silurian Metasediments and has a surface scarp expression up to 60 m high (Gardiner and McArdle, 1992). The bedrock strata dip westwards towards the fault at approximately 10 degrees, producing a half-graben structure (Gardiner and McArdle, 1992).

Further faults to the east of and parallel to the Kingscourt fault, have throws of up to 150 m in the opposite direction. One fault passes 70 m west of borehole BW01, while another passes 275 m east of the borehole at the clay pit (called the BW01 and clay pit faults respectively in this report).

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

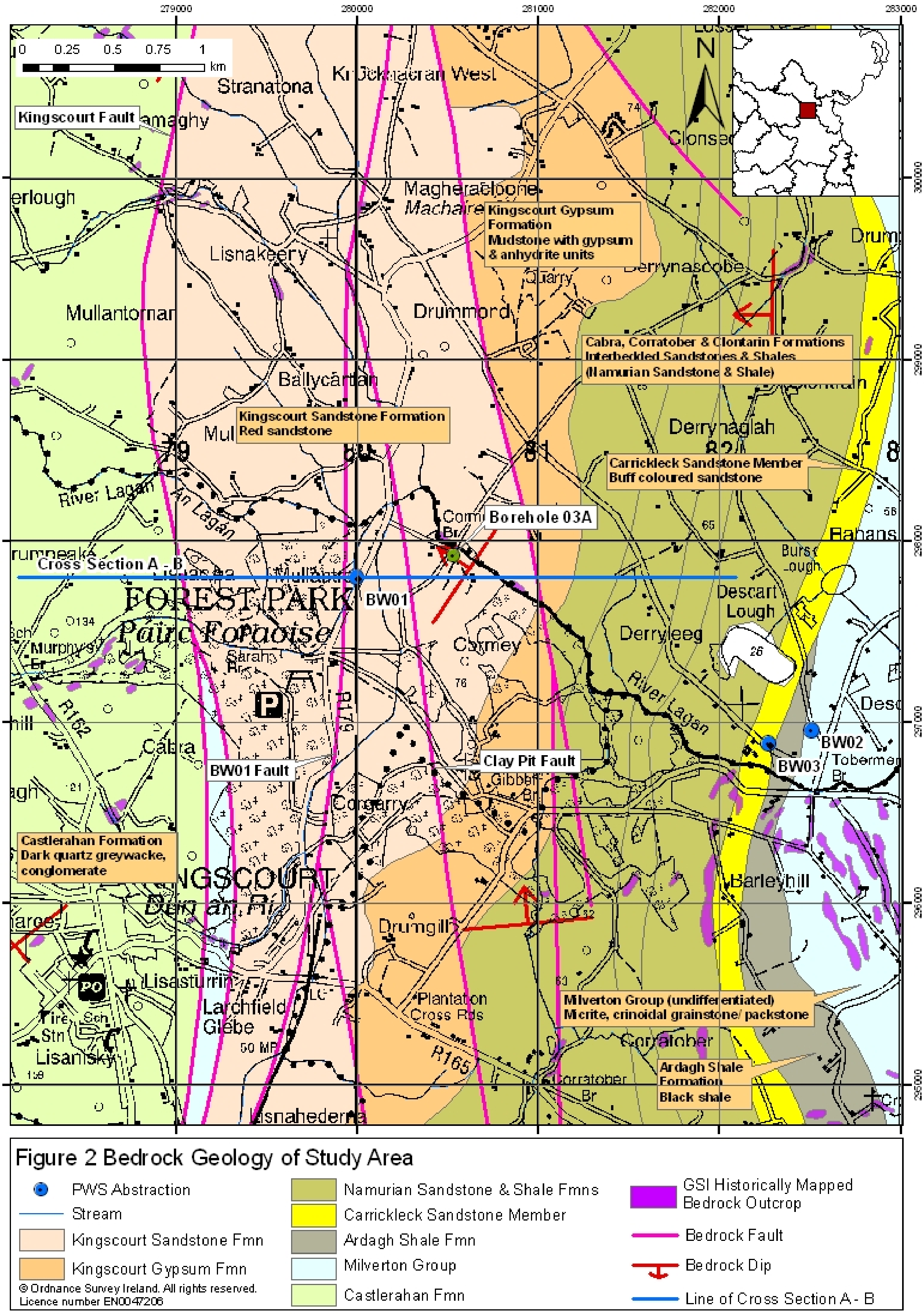

Figure 2 Bedrock Geology of the Study Area

The pattern of faulting results in a wedge shaped block of sandstone (NERDO, 1981).

Based on data from Gypsum Ltd. borehole 03A (at Cormey Bridge), faulting is likely to juxtapose Kingscourt Sandstone and Kingscourt Gypsum formations at depth to the east of borehole BW01. It is likely that these faults will have a low permeability “gouge” of fine grained, ground-up, marl bedrock fragments at gypsum horizons on the upthrow side of the fault (NERDO, 1981). The “clay pit” fault just west of borehole 03A would be an example of this condition. The clay pit at Cormey Bridge probably resides in an outcrop of the sandstone formation’s basal siltstone unit, which overlies the gypsum formation on the eastern side of the fault. In the southern part of the study area the sandstone formation bedrock is also dominated by siltstone/mudstone, e.g. at borehole TW06 (just east of Kingscourt) where mudstone was encountered from 1.5 m to 99 mbgl.

A cross-section of the geology of the study area is shown in Figure 12. The line of the cross-section in Figure 12 is shown in Figure 2.

Karstification can occur within the gypsum of the Kingscourt Gypsum Formation, as revealed by gypsum mining in the area (McConnell *et al,* 2001), although there is no mapped surface expression of it. The karstification does not occur in the sandstone or mudstone units.

7.3 Soil and subsoil geology

The soil and subsoil distributions are illustrated in Figures 3 and 4, respectively.

The EPA and GSI Web Mapping classify the soils surrounding the source as predominantly deep alluvial mineral soils derived mainly from non calcareous parent material. The soils surrounding the alluvial flat are generally deep and poorly drained. Well drained soils are mapped to the north of the River Lagan and to the southeast of the source in Corgarry (Teagasc, 2006).

The subsoils map suggests that the site is located within an area of alluvium among drumlins underlain by till derived from Lower Palaeozoic shales and sandstones (Meehan, 2008). The alluvium extends outwards in all directions from the site. The alluvial deposits are surrounded by till derived from Lower Palaeozoic shales and sandstones (TLPSsS). There is an area of till derived from Namurian sandstones and shales (TNSSs) in the south east of the study area. Glaciofluvial gravels, derived from shale and sandstone, flank the River Lagan 400 m to the north-northeast. Bedrock outcrop is mapped along the Mullantra stream where the stream crosses the scarp, at the Gypsum mine and at the Lagan Bricks clay pit. Further pockets of rock outcrop occur in places along the scarp. There are also small areas of cutover peat (Cut) and lacustrine deposits (L) to the east of the source. Built-up areas (Made) are mapped to the south west and east of the source at Kingscourt town, the Gypsum Ltd. mine and Cabra Castle Estate.

It is envisaged that, due to their predominantly shale parent material, both the alluvium and till in the area surrounding the source is of moderate to low permeability due to the relatively high clay and silt content (Meehan, 2008). Borehole logs from trial wells to the east and south of borehole BW01, and from Gypsum Industries boreholes to the north, show a predominantly clay subsoil where till and alluvial deposits are intersected. This supports a low permeability interpretation (see Table A1.3 in Appendix 1). There are no detailed descriptions of the alluvial deposits around the source. Where alluvial deposits are logged (boreholes BW01 and C35/3c) they are recorded to be underlain by significant thicknesses of boulder clay, which is likely to be the same till recorded in the surrounding area. The overall permeability of the subsoil column below the mapped areas of alluvium is therefore likely to be ‘low permeability’.

In areas on slopes where the soils are mapped as poorly drained, the areas are likely to be underlain by ‘low permeability’ till, *i.e*. tills in the townlands of Mullantra, Cormey, Cabra, Lisnaclea and Enagh.

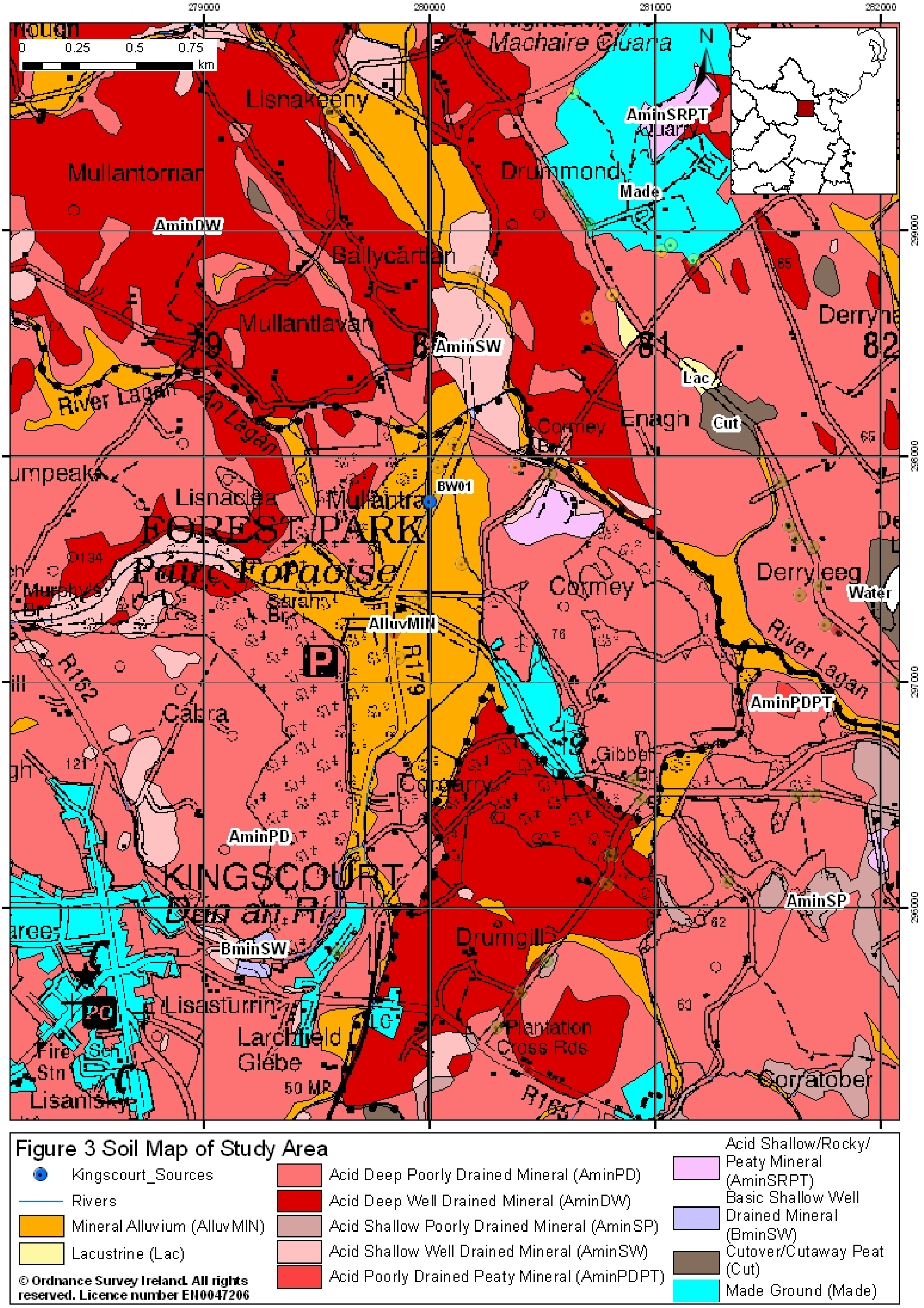

Figure 3 Soil Map of Study Area. The deep pink soils (AminPD) are poorly drained.

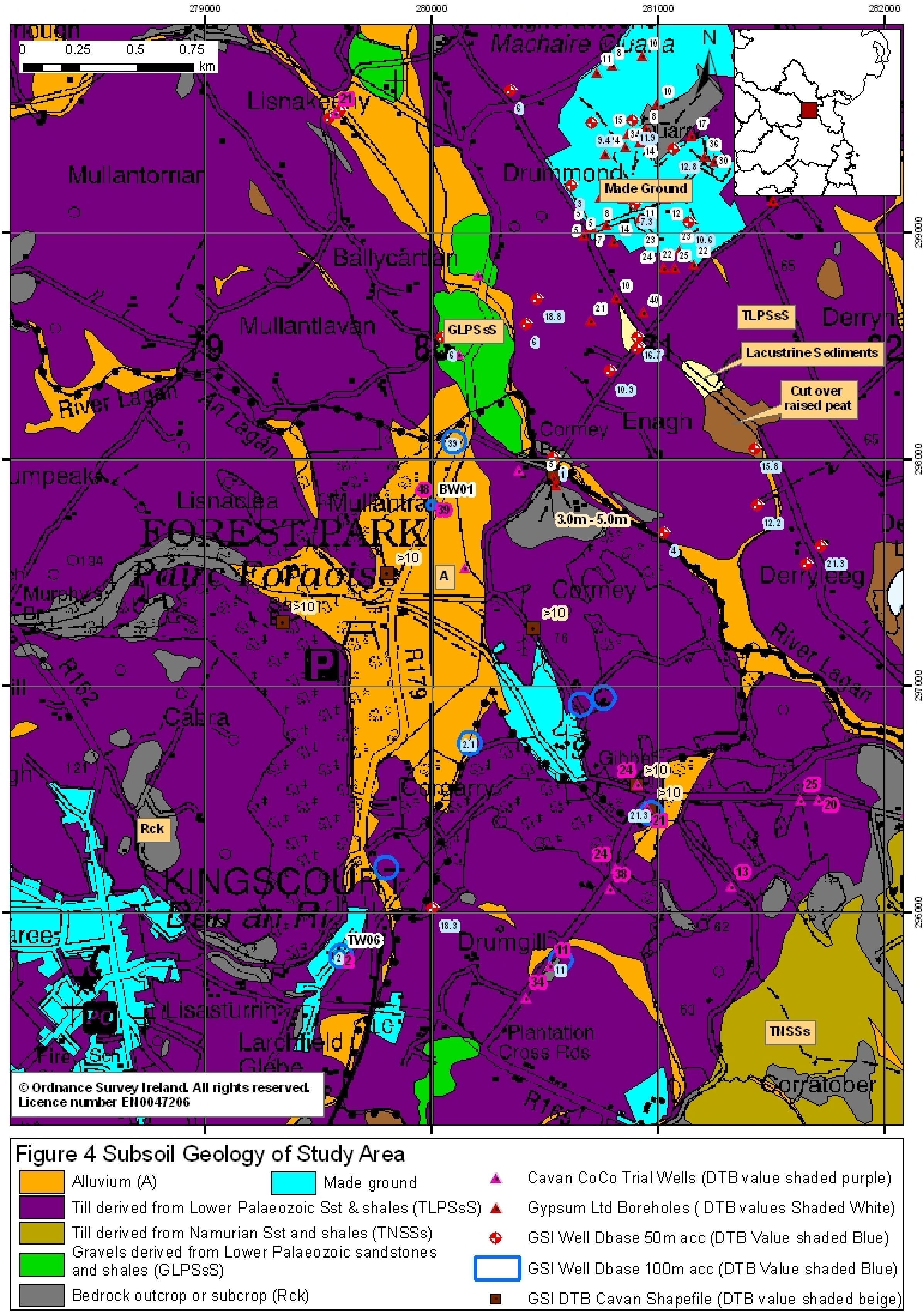

Figure 4 Subsoil Geology of Study Area

Where well drained soils occur, the drainage conditions suggest that the underlying subsoil is of 'moderate permeability', *i.e*. to the north of the Lagan River in the townlands of Mullantlavan, Ballycartlan and the western part of Enagh, and to the southeast of the source in the townland of Corgarry.

7.4 Depth to bedrock

The available depth to bedrock (DTB) data are shown on Figure 4. Areas of bedrock outcrop and rock close to surface (*i.e.* DTB <3 m) are shown on the GSI groundwater vulnerability map of the area (see Figure 5). Data points in the vicinity of borehole BW01 (including C35/3c, OW02, OW04, TW14, TW14A, TW15; see Figure A1.1 and Table A1.7 in Appendix 1) show that away from the outcrop locations noted above, DTB across this area generally exceeds 10 m and can be as much as 48 m. Further data from Gypsum Industries boreholes in Enagh and Drummond to the south and southeast of the mine, and at borehole BH03 in Lisnakeeny, suggest that DTB to the north of the Lagan, away from mapped outcrops, is also generally greater than 10 m. A single data point in the mapped glaciofluvial gravels to the north of the Lagan River suggests DTB in these deposits is between 5 m and 10 m.

8 Groundwater vulnerability

Groundwater vulnerability is dictated by the nature and thickness of the material overlying the uppermost groundwater 'target'. This means that in this area 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).

A small revision has been made to the local scale groundwater vulnerability map prepared for this report, compared to the national scale map. In the alluvial flat area surrounding borehole BW01, the groundwater vulnerability has been revised from *'moderate'* to *'low'*. This is to take account of site specific data collected during the desk study and field investigations which suggest *'low permeability'* subsoils (Section 7.3) and DTB greater than 10 m (Section 7.4) in this area. The resulting revised, local scale groundwater vulnerability map is shown in Figure 5.

The vulnerability of the area can be divided into the following zones:

- Borehole BW01 is surrounded by a large area of low vulnerability, which extends in all directions.
- To the west of the borehole at the Kingscourt Fault scarp, bedrock outcrops are mapped as extreme vulnerability grading outwards into high, moderate and low vulnerability moving away from the outcrop sites. Further areas of extreme vulnerability occur at outcrops in the Lagan Bricks clay pit, Drummond mine, along the Lagan River and to the southeast of the source at Barley Hill. An area of extreme (E) vulnerability extends along the north bank of the River Lagan in the townland of Mullantlavan, upstream of borehole BW01.
- To the north of the River Lagan, soils are generally well drained and the till subsoils are interpreted to be of moderate permeability, giving rise to high and moderate vulnerability areas, depending on the DTB. This situation also occurs to the southeast of the source in the Drumgill – Corgarry area.

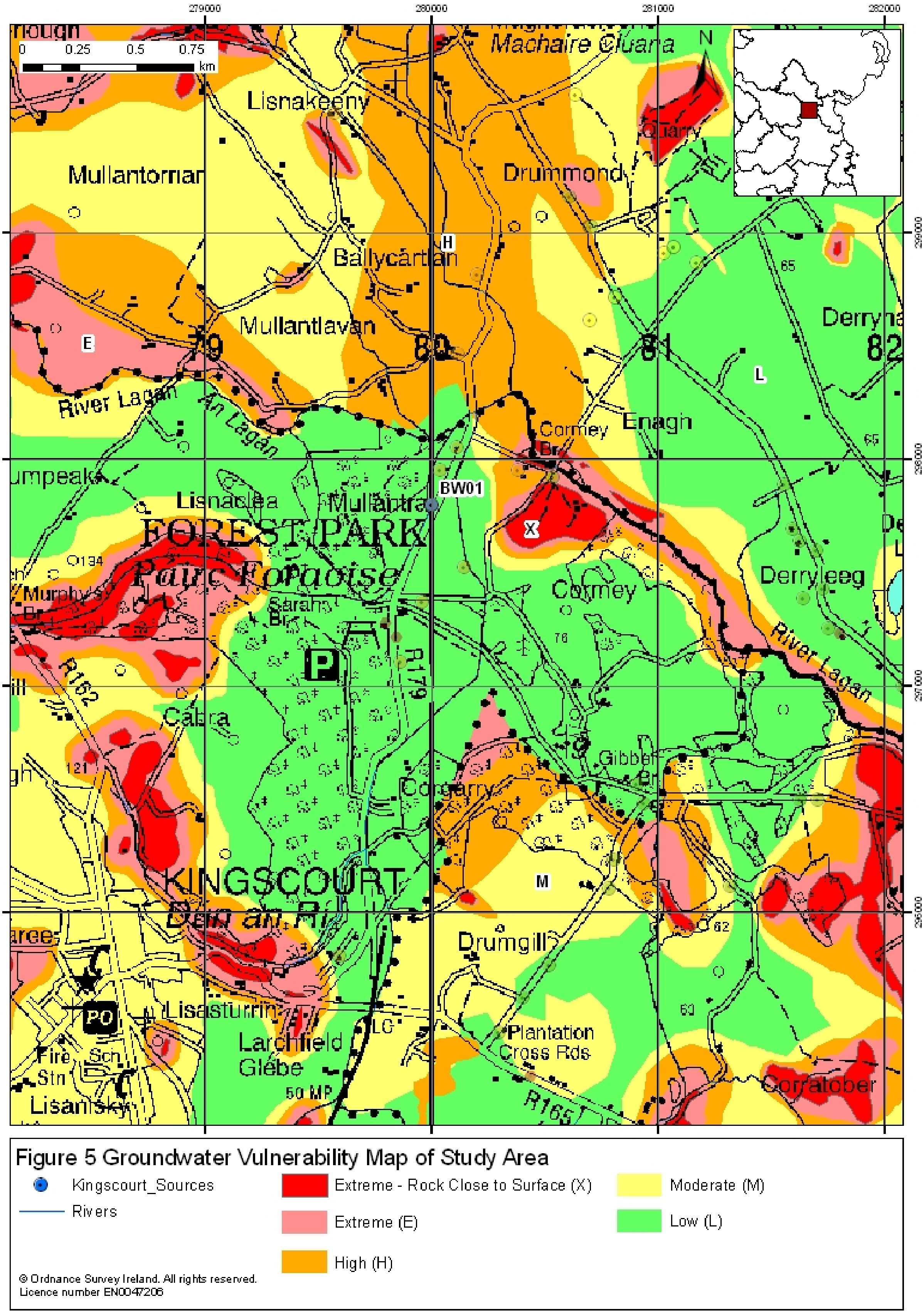

Figure 5 Groundwater Vulnerability Map of Study Area

9 Hydrogeology

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

- EPA and GSI Websites, and well and groundwater-monitoring databases (Sept. 2010)
- Staff from the Cavan, Meath and Monaghan County Councils, Lagan Bricks and Gypsum Limited.
- Reports on groundwater resources investigations for the Kingscourt Regional Water Supply Scheme between 1995 and 2005 (KT Cullen, White Young Green)
- Gypsum Limited borehole, groundwater level and groundwater quality data and Hydrogeological Reports between 2003 and 2010
- Report on Groundwater Resources in the N.E. (R.D.O.) Region (NERDO, 1981)
- Hydrogeological mapping by Peter Conroy and Robert Meehan (July and September 2010)

9.1 Groundwater body and status

The borehole is located in the Kingscourt (IE_NB_G_017) Groundwater Body, which has 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 during hydrogeological investigations at trial wells across the study area between 1995 and 2010 by KT Cullen and WYG. Groundwater monitoring has been conducted routinely at various depths within the stratified aquifers underlying the Gypsum Ltd site to the northwest of the source boreholes. The water level data from the various data sources have been collated and are presented in Tables A1.1 to A1.4 in Appendix 1. Table A1.4 and Figure A1.1 in Appendix 1 show the aquifer intersected by each monitoring point.

As part of the fieldwork conducted for this report, a groundwater level monitoring round was executed on 27 and 28 September 2010 measuring depth to groundwater in a wide network of monitoring points across the study area. The groundwater elevation in mAOD for each groundwater depth on those dates has been estimated (Table A1.4), and is shown in Figure 6. Interpreted contours of groundwater elevations in each aquifer for September 2010, derived from the point data are also shown. Data for the gypsum formation have not been contoured as only a single data point was available for that aquifer from the survey.

The groundwater elevation data and contours suggest that:

- Groundwater flow in the Kingscourt sandstone aquifer, which hosts the public supply, is in an easterly direction and has a natural gradient of 0.038.
- The natural, regional, vertical gradient is likely to be downwards from the sandstone aquifer into the gypsum.
- Pumping at the public supply, the clay pit and the mine creates cones of depression, commensurate with the pumping rate and aquifer transmissivity, which alter the natural lateral and vertical gradients in the areas around the abstractions. For example, the water level in the gypsum mine Drumgoosat De-watering Borehole (1.9 km north-northeast of borehole BW01) is approximately -41 mAOD creating induced lateral and vertical gradients towards the mine (Minerex, 2010).

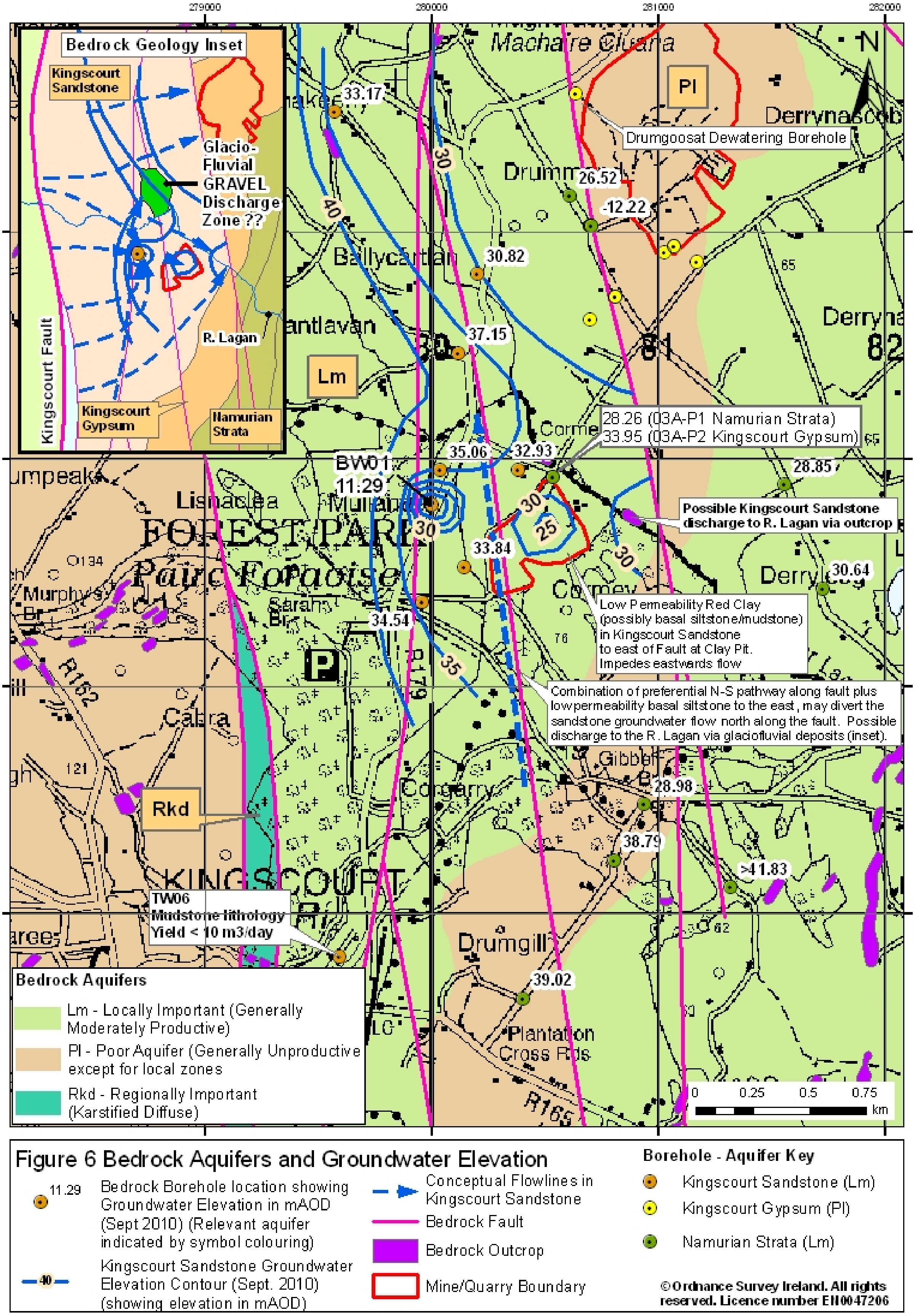

Figure 6 Bedrock Aquifers and Groundwater Elevation across Study Area

- Dewatering of the clay pit creates an upwards gradient and induces minor leakage through the basal siltstone (*via* an unsealed exploration borehole) from the Kingscourt gypsum aquifer into the clay pit. Drawdown at BW01 creates a similar upwards gradient, but here the upper mudstone of the gypsum formation and basal siltstone unit of the sandstone formation form an effective aquitard between the sandstone and the underlying gypsum (based on water quality evidence; Section 9.3). It also appears that BW01 drawdown does not induce any lateral inflow from the upthrown gypsum strata to the east (again based on water quality evidence). This is likely to be due to the low permeability "gouge" of marl along the gypsum reach of the clay pit fault boundary (Section 7.2).
- Several (unspecified) gypsum exploration holes met strong artesian flows (650 m^3/day) at depths of 244 mbgl (NERDO, 1981). This suggests that a significant component of recharge may penetrate deeply into the sandstone before rising to discharge zones.
- There is minimal groundwater flow in the southern part of the sandstone aquifer to the east of Kingscourt town. The mudstones encountered in trial borehole TW06 had low yields of less than 10 m^3/day and suggest negligible shallow and deep flow in the area.
- The River Lagan is the likely natural discharge boundary for the sandstone aquifer. Some localised discharge probably occurs *via* the extreme (E) vulnerability area on the north bank of the river in Mullantlavan, where it crosses the fault scarp.
- Elsewhere, particularly south of the river, the widespread thick, low and moderate permeability subsoil cover means there are few viable discharge points from the Kingscourt Sandstone into the river. The bedrock outcrops at Cormey Bridge, and downstream thereof, are likely discharge areas; however they are located in the area likely to be comprised of basal siltstone to the east of the clay pit fault. There is little flow in the vicinity of the clay pit, with the pit dewatering rate estimated at 38.6 m^3/day (Noel Duffy, pers comm., 2010). This suggests that this area may be a low transmissivity zone with low volumes of groundwater through-flow. As such, the magnitude of easterly groundwater flow from the sandstone across the clay pit fault, and onwards towards the river (through the basal siltstone) may be quite low. This suggests that additional natural discharge locations might be needed to service the full discharge from the sandstone aquifer.
- An additional discharge hypothesis under natural conditions is as follows. The north-south BW01 and clay pit faults may create preferential flow paths along the fault zones. This would allow the majority of the easterly flow in the sandstone south of the river to be diverted along preferential north-south flow paths at the faults. If this were the case, the logical flow direction would be north towards the river with the mapped glaciofluvial gravel deposits on the north bank of the river being a possible discharge pathway to the river (*i.e.* a conduit 'window' through the thick, low permeability tills; Figure 6 inset). There are no data to confirm a pathway from the sandstone to the river *via* the fault zones and gravels.
- Under the current pumping regimes affecting the aquifer, the majority of flow north of the river is diverted to the gypsum mine. South of the river, borehole BW01 intercepts flow from directly upgradient. It is also likely to capture preferential northwards flow in the BW01 fault zone, and possibly from the downgradient clay pit fault at depth. The latter fault zone is likely to dip west in keeping with the wedge shaped block of sandstone, bringing it closer to the borehole at depth. Intercepting preferential flowpaths would extend the borehole catchment southwards to take in areas that recharge the fault zones .

Hydrographs of water level data for borehole BW01 from June to September 2008 (GSI data; pre-commissioning *i.e.* no recorded pumping) and from 03/09/2010 to 10/09/2010 (Cavan County Council telemetry data; borehole commissioned *i.e.* PWS pumping), are presented in graphical format in Figure 7 and Figure 8 respectively. The hydrographs for borehole BW01 suggest that:

- The rest water levels vary by over 1 m from 0.35 to 1.41 m below the reference level at the top of the borehole. Under the current pumping regime, the borehole does not recover to the aquifer rest water level between pumping periods (Figure 8). Pumping test data for the borehole from March and April 2003 suggest that recovery to close to the rest water level can take up to 4 days following prolonged abstraction.
- Pumping water levels in the borehole vary with the abstraction rate and the abstraction period. Current minimum pumping water levels in the borehole vary between 21.91 mbRef and 23.34 mbRef (Figure 8). The latter value may be approaching the steady state drawdown value for a pumping rate of 542 m^3/day (after 2.5 days). Pumping test data (Table A1.1a in Appendix 1) for a higher pumping rate between 864 and 980 m^3/day resulted in a water level of 48.6 mbRef.

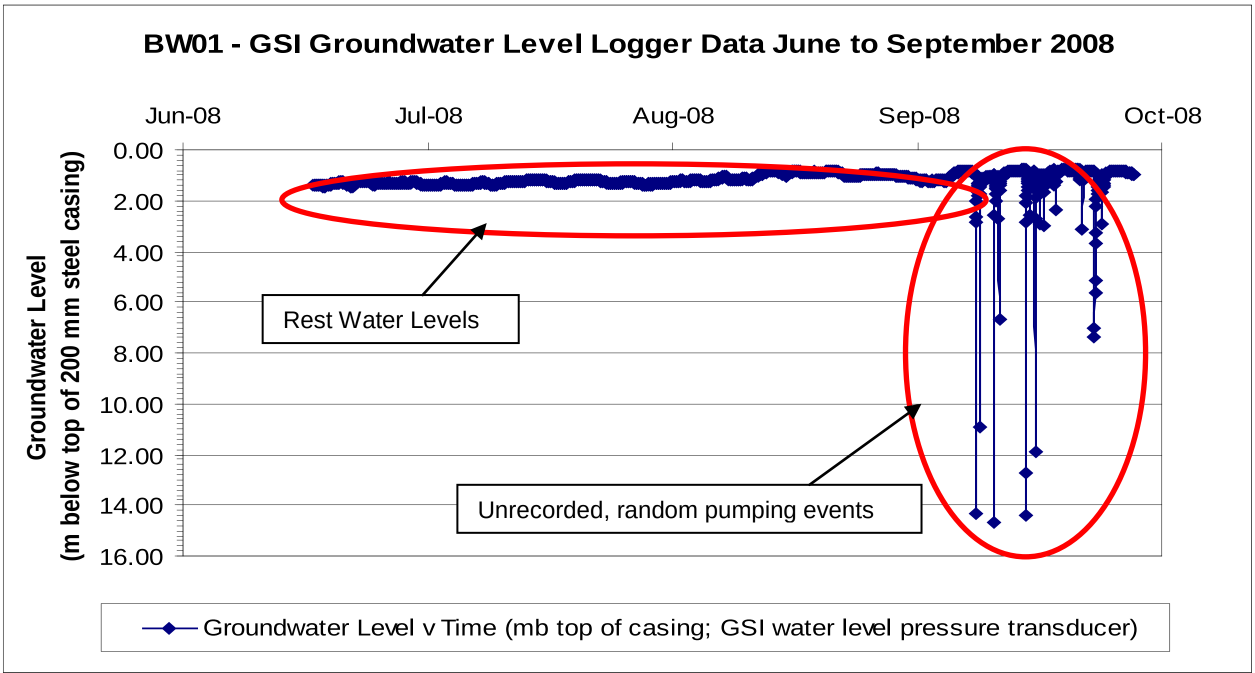

Figure 7 Borehole BW01 Hydrograph June to September 2008

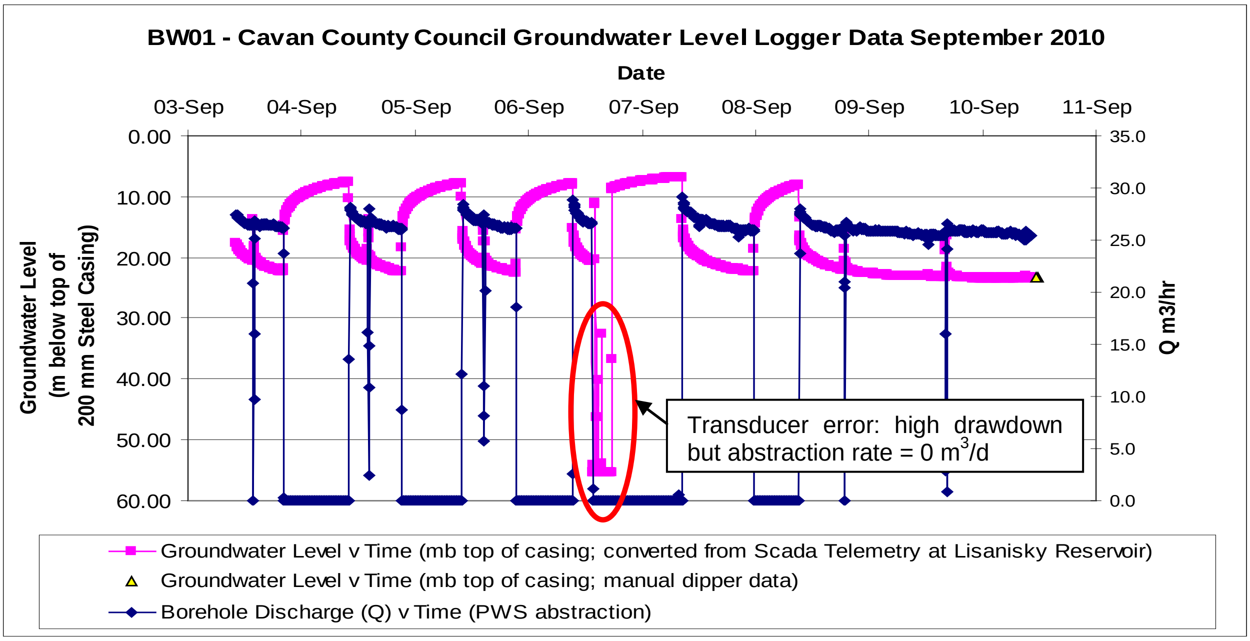

Figure 8 Borehole BW01 Hydrograph September 2010

9.3 Hydrochemistry and water quality

No routine groundwater quality monitoring data are currently available for borehole BW01. Three groundwater samples were collected and analysed from borehole BW01 during the 10 day pumping test in May–June 1995. A further eight samples were collected and analysed from the borehole during a 6 week pumping test between February and April 2003 A sample of partially treated water from borehole BW01 (subjected to chlorination and probably manganese removal), was collected at the Lisanisky reservoir site by Cavan County Council on 7th April 2009.

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 9 to 11 and the data interpretation is summarised below. The available data are tabulated in Table A1.6 in Appendix 1.

The hydrochemistry data suggest that:

- The source has a moderate level of mineralization as indicated by the electrical conductivity (average 282 µS/cm), alkalinity (average 148 mg/l as $CaCO_3$) and slight hardness (average 146 mg/l as $CaCO_3$). The water has a calcium bicarbonate hydrochemical signature with a significant magnesium component. There is no evidence of elevated sulphate concentrations at the borehole. This suggests there is no inflow from where the Kingscourt gypsum formation underlies the site or is laterally adjacent to the east.
- There were no total or faecal coliforms detected at the borehole.
- The ammonia concentrations are detectable but low. Ammonia is converted to nitrate under aerobic conditions and as such, its presence and the absence of nitrate at below the detection limits indicate reducing conditions in the aquifer. No exceedences of the ammonium drinking water standard or EPA threshold level have occurred.
- Average chloride concentrations measured 15 mg/l which is below the EPA threshold of 24 mg/l.

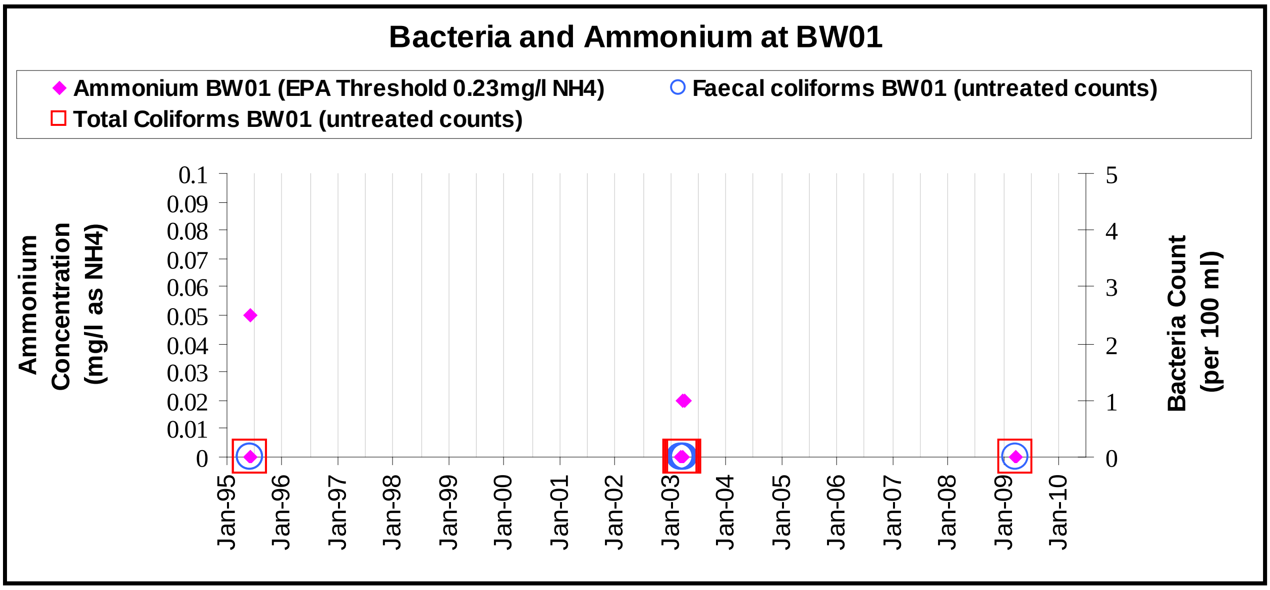

Figure 9 Key Indicators of Agri and Domestic Contamination (BW01): Bacteria and Ammonium

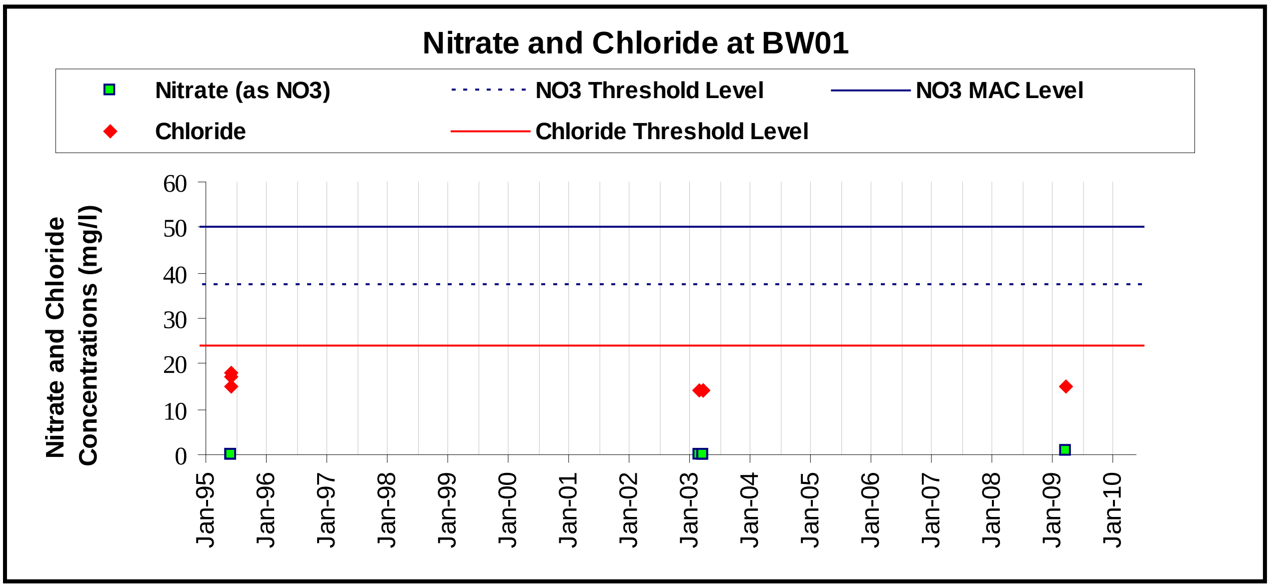

Figure 10 Key Indicators of Agri and Domestic Contamination (BW01): Nitrate and Chloride

- The sulphate, potassium, sodium, magnesium and calcium levels and the K:Na ratio are within normal ranges.
- Manganese exceeded the drinking water standard at borehole BW01 by approximately one order of magnitude in both 1995 and 2003. The high manganese concentrations are likely to be derived from natural sources as a result of the reducing conditions in the aquifer.

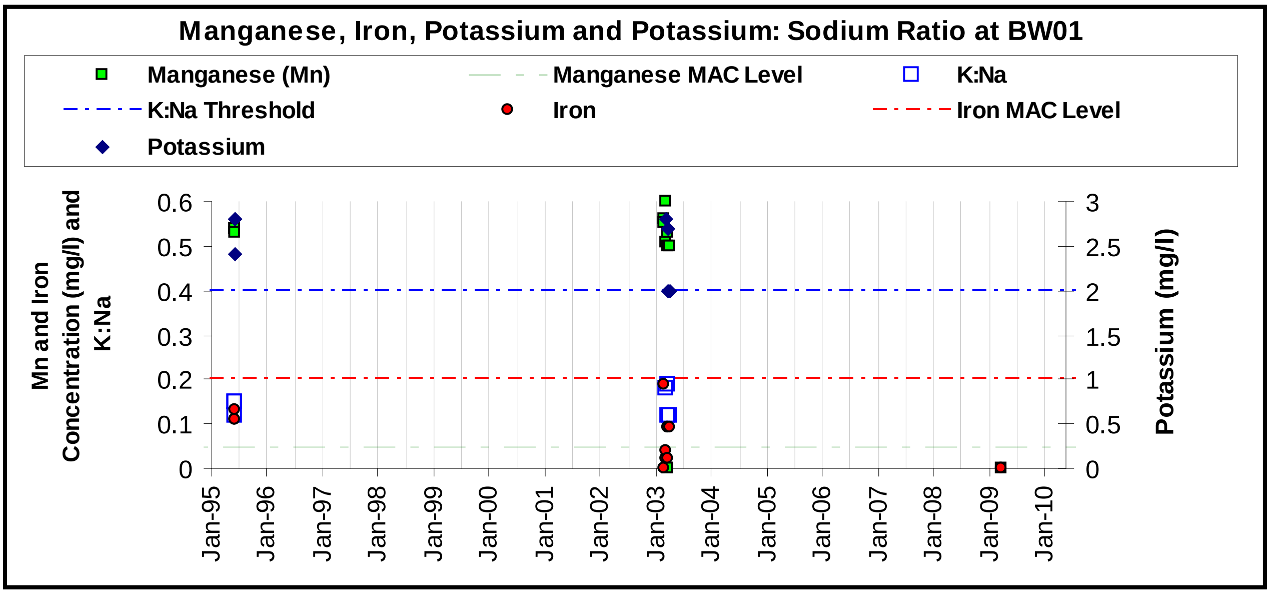

Figure 11 Key Indicators of Agri and Domestic Contamination (BW01): Mn, Fe, K and K:Na ratio

- 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.

The data suggest that the groundwater from borehole BW01 is unpolluted but is affected by elevated manganese concentrations resulting from confined, reducing aquifer conditions.

9.4 Aquifer characteristics

Borehole BW01 abstracts water from the Kingscourt Sandstone rock unit which is classified by the GSI as a *Locally Important Aquifer (Lm)* which is generally moderately productive. The underlying Kingscourt Gypsum rock unit, and the Silurian metasediments and volcanic rocks to the west, are classified as *Poor Aquifers (Pu)* (see Figure 6). Under the current abstraction regime, the pumping water level in the borehole remains above the top of the well screen (70 mbgl) and above the top of the bedrock aquifer (39 mbgl). Rest water level data at boreholes BW01, and the nearby boreholes C35/3c, BH05 and TW01, show that the bedrock aquifer piezometric level is generally above the base of the overlying low permeability overburden material, suggesting that the sandstone bedrock intersected by the boreholes is confined by the low permeability overburden.

The Kingscourt Sandstones are semi-porous and considered to have relatively high fissure permeability (GSI, 2004). Long flow paths (e.g. 2000 m) can be expected although they are likely to be shorter in discharge areas (100–300 m). The original borehole log[2] for borehole BW01 suggests that groundwater flow occurs throughout the bedrock in the borehole, with water strikes recorded at the top of the bedrock at 40 mbgl and between 74 m and 115 mbgl. At nearby borehole BH05, bedrock water strikes were recorded at 11 m and 40 mbgl. Deep flows also occur with artesian flows up to 650 m^3/day encountered at depths of 244 mbgl (NERDO, 1981). Only minor flow occurs in the mudstone dominated bedrock in the vicinity of borehole TW06.

There may be a limited quantity of leakage into the sandstone aquifer from the Pl aquifer to the west of the Kingscourt fault. Flow paths in the Pl aquifer are typically short, such that any such leakage is likely to derive from recharge occurring close to the fault.

Pumping tests on the sandstone aquifer were carried out at boreholes BW01, C35/3c and BH05. Analysis of data for borehole BW01 suggests an aquifer transmissivity of 21 m^2/day and a storativity of 0.00017 (KTC, 1996). Pumping tests on borehole C35/3c suggest a transmissivity of 48 m^2/day at the same site (NERDO, 1981), while analysis of data for borehole BH05 suggests a transmissivity of 14 to 18 m^2/day. The geometric mean transmissivity is 23 m^2/day. Transmissivity is much lower in the mudstone bedrock around borehole TW06 and east of Cormey Bridge.

The specific capacity of borehole BW01 ranged from 15 m^3/day/m in 1995 to 18 m^3/day/m in 2003. The latter value was for a higher pumping rate (see Table 3-1) and suggests that borehole efficiency improved between 1995 and 2003, possibly due to over-pumping for the first 19 hours of the 2003 test which may have served to further develop the borehole compared to 1995.

Based on the depths of water strikes and taking account of the depth to bedrock, the thickness of sandstone bedrock intersected at boreholes BW01, C35/3c and BH05 was 75, 66 and 51 m respectively (average 64 m)[3]. Bulk aquifer permeability (K) has been estimated from transmissivity by dividing by an aquifer thickness of 64 m. As the boreholes only partially penetrate the aquifer the transmissivity may be underestimated (underestimation not quantified).

The hydraulic gradient in the *Lm* aquifer is estimated at 0.038 (Section 9.2). The specific yield (approximately equal to the porosity) of the sandstone aquifer is estimated at 0.1 (NERDO, 1981).

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

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

[2] Water strikes for BW01 are shown on the original log for borehole BW01 (labelled Trial Well No. 5) and in Table A1.1.
[3] Borehole C35/3c was located in the same compound as and 13 m from BW01 (WYG, 2003). It is no longer there and seems to have been destroyed during the commissioning of BW01. There are no records of it precise location/coordinates. Borehole logs for C35/3c and BH05 are shown in Appendix 1.

The average groundwater velocity in the *Lm* aquifer is estimated as approximately 0.14 m/d. The aquifer parameters are summarized in Table 9-1.

Table 9-1: Indicative Aquifer Hydraulic Parameters

Parameters	Source of Data	*Lm* aquifer (BW01)
Transmissivity (m^2/d)	Calculated (based on pumping test data for BH01 and two adjacent boreholes)	23
Permeability (m/d)	Estimated from T value assuming saturated thickness is the average full depth of the boreholes (64 m)	0.36
Effective Porosity	From NERDO (1981)	0.1
Groundwater gradient	Assumed based on groundwater elevation measurements and interpreted contours	0.038
Velocity (m/d)	calculated based on above	0.14

10 Zone of Contribution

The Zone of Contribution (ZOC) is the complete hydrologic catchment area to the 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

Borehole BW01 abstracts water from the Kingscourt Sandstone *Lm* aquifer. The majority of the sandstone aquifer footprint is confined by the overlying, low and moderate permeability subsoil deposits. It is mainly recharged at areas of bedrock outcrop and extreme vulnerability along the Kingscourt fault scarp to the west of the borehole. These areas have a limited areal extent which in turn limits direct rainfall recharge. The direct recharge will be supplemented by runoff from the *Pl* aquifer to the west of the Kingscourt fault, i.e. from the catchment draining onto each outcrop/extreme vulnerability area. This additional component has not been quantified. There may also be a small component of leakage into the sandstone aquifer from the adjacent Silurian *Pl* aquifer, from the area immediately west of the fault. Recharge to the east of the scarp in the confined reaches of the aquifer is likely to be minimal due to the low permeability subsoils and the impedance resulting from the upwards pressure of the confined aquifer (drawdown may induce some limited additional recharge).

Interpreted contours of groundwater elevation suggest that groundwater flow is generally eastwards from the fault scarp towards the borehole with a lateral gradient of 0.038. The sandstone aquifer is semi-porous and highly fissured. Groundwater flow appears to occur throughout the depth of the aquifer with borehole inflows recorded at many depths between 11 and 244 mbgl. Borehole BW01 will capture groundwater flowing eastwards from the fault scarp. It is also likely to capture a component of any preferential northwards flow through possible preferential flowpaths along the strike of the BW01 and clay pit faults.

The sandstone aquifer appears to be hydraulically isolated from the gypsum aquifer by the low permeability basal layer of the sandstone and upper strata of the gypsum. Where the two aquifers are juxtaposed by faulting the gypsum appears to be sealed off by a low permeability "gouge" of marl.

Apart from PWS abstraction (south of the river) and mine/quarry dewatering (north of the river), the River Lagan is likely to be the main discharge boundary for flow in the sandstone aquifer; however the aquifer seems to be sealed off from much of the relevant river reach by thick low (to the south) and moderate (to the north) permeability subsoil. The sandstone aquifer groundwater elevation contours suggest that the natural discharge zone for the aquifer would be at the bedrock outcrop in the river bed at, and east of Cormey Bridge. These outcrops are situated in the area where low transmissivity basal siltstones of the sandstone aquifer form bedrock. The low transmissivity of the bedrock will limit the flow through this part of the bedrock aquifer and consequently the magnitude of the discharge to the river via this pathway. Groundwater flow volumes and aquifer transmissivity are also low in the south of the study area around borehole TW06.

It is assumed here that the BW01 and clay pit faults are transmissive along strike and that a large component of the eastwards flow reaching the faults gets diverted northwards along the strike. The northwards flow is then assumed to discharge to the river *via* a window through the thick till subsoils. The window is provided by the mapped glaciofluvial gravel deposits adjacent to the north bank of the River Lagan and which overlie the fault zones (BW01 fault passes slightly west of the gravels). As noted above, abstraction at borehole BW01 may capture a component of flow in the fault zones where they pass close to the borehole.

North of the river, the contours suggest that much of the flow in the sandstone is diverted north towards the gypsum mine by the mine dewatering. To date the groundwater has been unpolluted but has naturally elevated manganese levels.

The conceptual model for the study area is illustrated in the cross section in Figure 12.

10.2 Boundaries of the ZOC

The boundaries of the ZOC for the borehole are considered to be as follows (Figure 13):

The **eastern boundary** is the downgradient boundary of the ZOC. This is delineated along the western side of the clay pit fault to account for the possibility that the borehole might intercept northwards preferential flow along the strike of the fault. The surface separation between the borehole and the fault is 270 m. This is a large downgradient distance, which is three times the calculated Uniform Flow Equation (UFE) X_L Distance[4]. Nonetheless, the fault zone is considered to dip towards the borehole and as such may come in close proximity to the borehole at depth. The large downgradient distance of the ZOC takes account of this and conservatively includes the potential recharge area for the fault zone.

The **northern boundary** is a flow line delineated perpendicular to the interpreted groundwater elevation contours. Groundwater flow in the *Lm* aquifer on the north side of the Lagan River, is towards the Drummond mine, which creates a groundwater divide and prevents the northern boundary of the ZOC from extending further north than delineated. The northern margin of the ZOC passes beneath the Lagan River. It is considered unlikely that borehole BW01 will draw water from the river due to the generally thick, low permeability subsoils separating the borehole from the river upstream of Cormey Bridge and the glaciofluvial deposits.

The **western boundary** of the ZOC is considered to be the mapped Kingscourt Fault. A 100 m buffer zone is added to the ZOC on the western side to allow for potential leakage of groundwater from the adjacent Pl aquifer into the ZOC.

[4] UFE (Todd, 1980). $x_L = Q / (2\pi * T * i)$ where: Q is the pumping rate (design yield = 500 m^3/day);T is the *Lm* aquifer Transmissivity (taken from aquifer characteristics); and, i is gradient in the *Lm* aquifer.

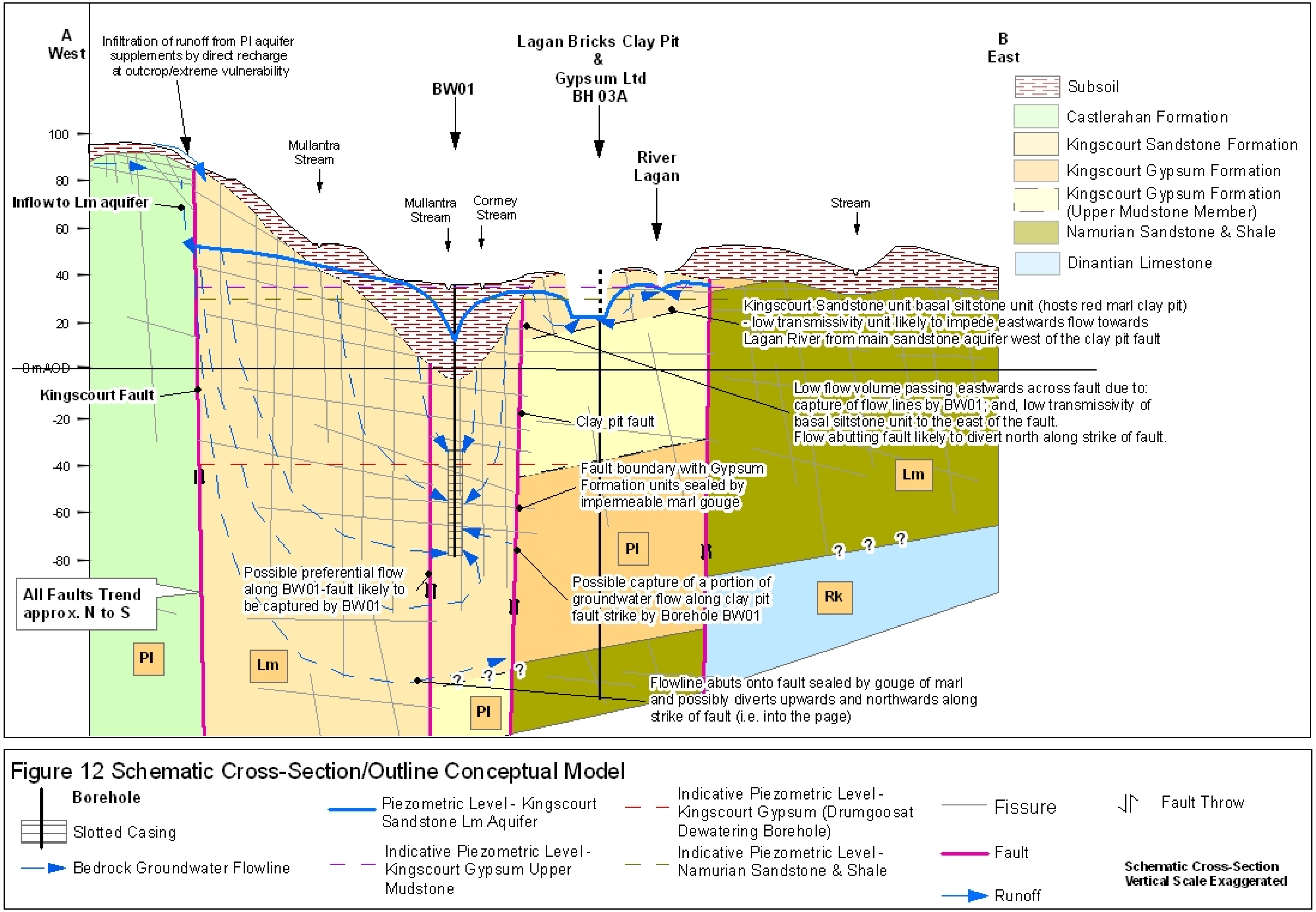

Figure 12 Schematic Cross Section / Outline Conceptual Model

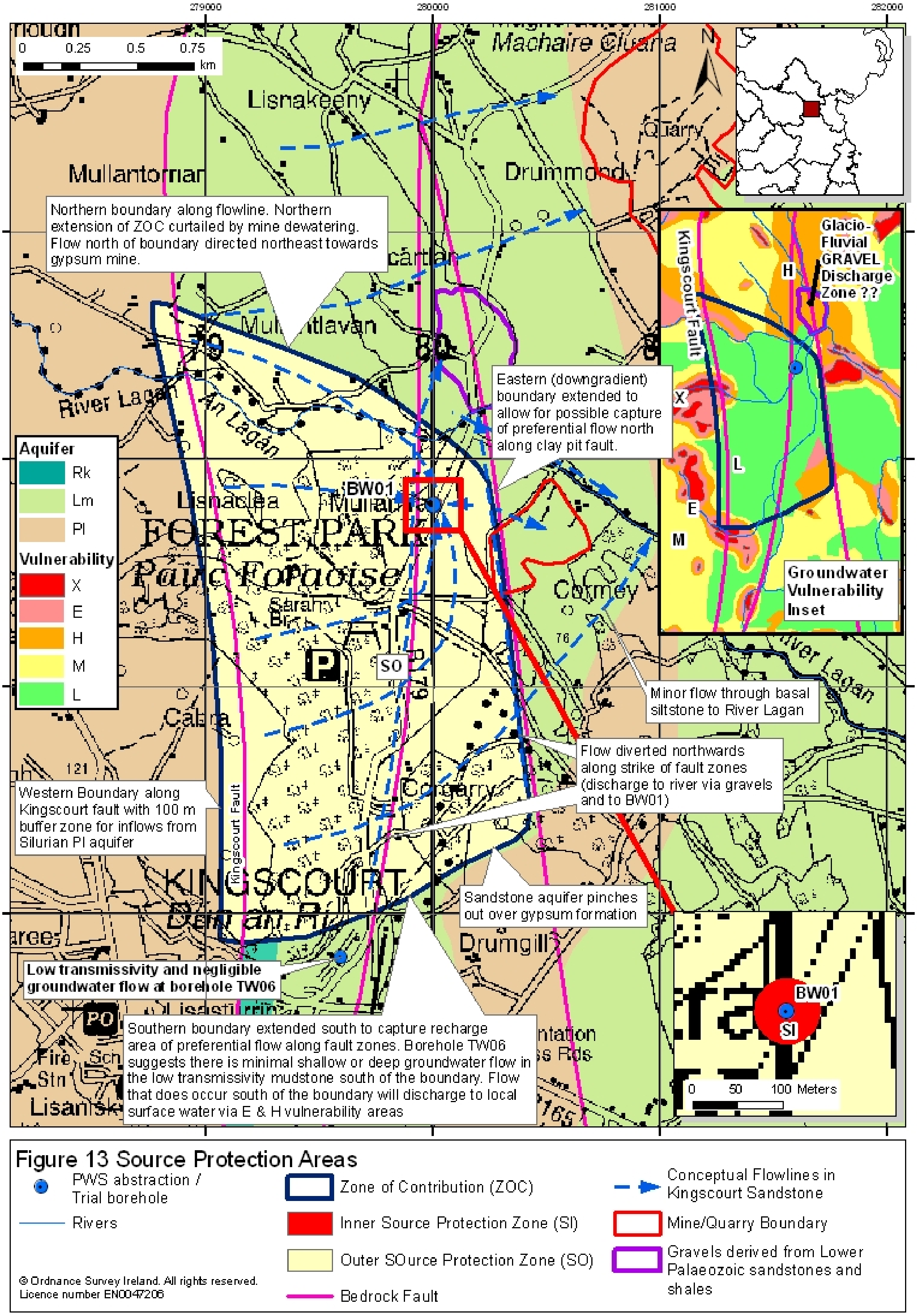

Figure 13 Source Protection Areas

The **southern boundary** is delineated at the likely southern extent of preferential northern flow along the BW01 and clay pit fault zones. At its eastern end the sandstone aquifer pinches out and inflow from the adjacent gypsum formation upper mudstone unit is likely to be negligible. The western end of the boundary borders the low transmissivity mudstones encountered at borehole TW06. Shallow and deep groundwater flow were negligible in this area, and any flow that occurs is likely to discharge to local surface water features via the thin, high to extreme vulnerability subsoils rather than migrate north to the borehole.

10.3 Recharge and water balance

The term 'recharge' refers to the amount of water replenishing the groundwater flow system. The recharge rate is generally estimated on an annual basis, and 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 diffuse recharge to the ZOC is estimated as follows. The calculations are summarized in Tables 10-1 and 10-2.

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

Actual (diffuse) recharge is estimated to be 63 mm/yr, which is 11% of potential recharge; this value is based on averaging of the recharge for the different settings outlined in Table 10-1.

Runoff losses: 534 mm (89% of potential recharge). Rejected potential recharge is assumed to runoff to surface water *via* surface and interflow.

Table 10-1 Recharge co-efficients for diffuse recharge across the study area

Vulnerability	Location in Study Area	Additional factors	% Area	Recharge Coefficient Guidance		Chosen Recharge Co-efficient
				Inner Range	Outer Range	
Low	Low permeability till subsoils around outcrop along the Kingscourt Fault scarp, along the River Lagan and under the alluvial flat of the Mullantra and Cormey streams	Steep slope at scarp but flat in alluvial areas. Confined bedrock aquifer. Drawdown may induce localised minor additional recharge	76.7	5 - 15%	2 - 20%	0.02
Moderate	Moderate permeability till subsoils around outcrop along the Kingscourt Fault scarp and along the River Lagan, with well drained soils	Steep slope	2.1	30 - 40%	25 - 60%	0.3
	Low permeability till and alluvial subsoils around outcrop along the Kingscourt Fault scarp and along the River Lagan, with poorly drained soils	Steep slope	2.6	10 - 20%	5 - 30%	0.1
High	Moderate permeability till subsoils around outcrop along the Kingscourt Fault scarp and along the River Lagan, with well drained soils	Steep slope	8.3	50 - 70%	35 - 80%	0.5
	Low permeability till and alluvial subsoils around outcrop along the Kingscourt Fault scarp and along the River Lagan, with poorly drained soils	Steep slope	3.6	23 - 30%	10 - 40%	0.23

Vulnerability	Location in Study Area	Additional factors	% Area	Recharge Coefficient Guidance		Chosen Recharge Co-efficient
				Inner Range	Outer Range	
Extreme (E)	Till subsoils around outcrop along the Kingscourt Fault scarp and along the River Lagan, with well drained soils	Steep slope	4.1	50 - 70%	45 - 80%	0.5
	Till and alluvial subsoils around outcrop along the Kingscourt Fault scarp and along the River Lagan, with poorly drained soils	Steep slope	1.7	25 – 40%	15 - 50%	0.25
Extreme (X)	Occasional bedrock outcrop along the Kingscourt Fault scarp	Steep slope	0.8	80 – 90%	60 – 100%	0.8

Table 10-2 Diffuse Bedrock Recharge Calculation Summary

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	(83%)	497 mm/yr
Bulk recharge coefficient	0.17	
Recharge		100 mm/yr

The water balance calculation states that the diffuse recharge over the area contributing to the source, should equal the discharge at the source. At a diffuse recharge rate of 63 mm/yr, an average yield of 500 m^3/day (i.e. design yield, 33% greater than current abstraction rate of 375 m^3/day) would require a recharge area of 2.9 km^2. The area of the ZOC described above is 3.1 km^2, which is slightly in excess of the water balance requirement, but captures all likely flow-paths to the source.

The delineated ZOC meets the source water balance requirements from diffuse recharge; however this will be supplemented by indirect recharge from *Pl* aquifer runoff onto extreme vulnerability areas at the Kingscourt fault scarp. This additional recharge has not been quantified; however following recharge it is expected to flow east to intersect the BW01 and Clay Pit preferential flow fault zones, and subsequently discharge to either borehole BW01 or the River Lagan. As such, the total groundwater resource available within the ZOC (from diffuse recharge plus runoff-recharge) is considered to exceed the PWS demand, with the excess discharging to the river Lagan. Nonetheless, given the potential for within-fault-zone mixing of water from different recharge locations the borehole could abstract water deriving from any part of the delineated ZOC.

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 overlay 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 0.14 m/d in both the *Lm* sandstone aquifer, and hence the 100-day TOT distance is 14 m. Using maximised aquifer parameter values (T = 48 m^2/d, i = 0.038, b = 51 m and n_e = 0.1) the velocity is calculated as 0.36, giving the 100-day TOT distance as 36 m. This maximum value is used in order to conservatively delineate the SI. The Inner Protection Area is illustrated in Figure 13. The remainder of the ZOC is classified as the Outer Source Protection Area (SO).

The groundwater Source Protection Zones are shown in Figure 14 and are listed in Table 11-1. They include SI/L, SO/L, SO/M, SO/H, SO/E and SO/X.

Table 11-1 Source Protection Zones

Source Protection Zone		% of Total Area	Area (km^2)
SI/L	Inner Source Protection area / Low vulnerability	0.004	0.1
SO/X	Outer Source Protection area / Extreme vulnerability, ≤1 m subsoil	0.03	0.8
SO/E	Outer Source Protection area / Extreme vulnerability, <3 m subsoil	0.18	5.8
SO/H	Outer Source Protection area / High vulnerability	0.37	11.9
SO/M	Outer Source Protection area / Moderate vulnerability	0.15	4.7
SO/L	Outer Source Protection area / Low vulnerability	2.40	76.6

12 Potential pollution sources

The borehole has a grout seal and good well head protection, though there is ponded water on the chamber floor. This may derive from rainfall leakage through the roof or leakage along service ducts. This water may be contaminated by animals and birds. The main potential contaminants from these sources are faecal bacteria, viruses and cryptosporidium.

The landuse within the ZOC is primarily agriculture and forestry with numerous residential farms, pastureland for grazing animals and conifer plantations. There is also a golf course and a housing estate with on-site waste water treatment. On-site wastewater treatment and 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 source boreholes are unpolluted. No coliform bacteria have been detected in the boreholes, though testing has been infrequent. This is in agreement with the low vulnerability across the majority of the ZOC. Nonetheless, poorly constructed private boreholes and abandoned County Council trial wells may provide localised preferential pathways through the protective subsoil cover, which could allow pollution to occur.

Microbial contaminant sources are only of concern within the SI area. In general sources of microbial contaminants are not present within the limited SI area, which is in agreement with the good microbial quality of the water. The ponded water within the source chamber is the main potential concern in this respect.

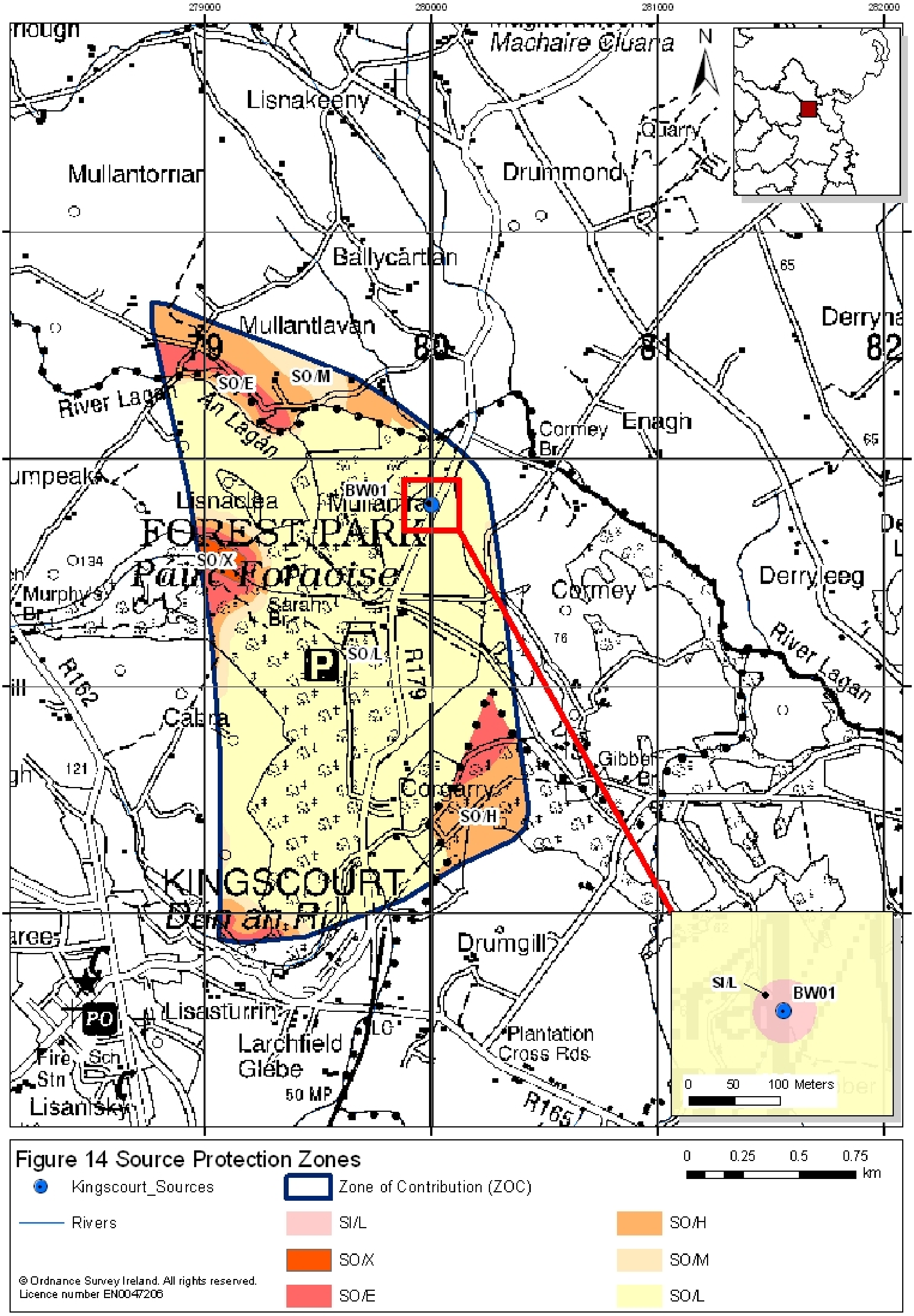

Figure 14 Source Protection Zones for Mullantra borehole

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 indicates that the risk of such contamination is low.

13 Conclusions

Borehole BW01 abstracts 375 m^3 /day from the Kingscourt Sandstone *Lm* aquifer. This yield has been sustained since commissioning of the borehole in January 2010. The long term sustainable yield for the source is considered to be 500 m^3/day (WYG, 2003). The ZOC for the source boreholes has been delineated on the basis of a demand of 500 m^3/day.

An SI zone of 36 m diameter has been delineated around the source borehole and it has low groundwater vulnerability. The remainder of the ZOC (SO zone) is also predominantly low vulnerability although there are places where there is Extreme vulnerability with rock at, or very close to, the surface.

The untreated groundwater is currently unpolluted due in large part to the good wellhead protection and the low vulnerability across most of the ZOC, and especially within the inner source protection zone. Potential contaminants such as nitrate appear to be removed naturally by denitrification in the confined bedrock aquifer and low chloride suggests that the nitrate loading at the ground surface may be low in any case. Elevated manganese concentrations are likely to derive from natural sources within the bedrock activated by the anaerobic, reducing conditions in the confined aquifer.

The ZOC encompasses an area of 3.1 km^2 which supports the long term, sustainable yield of the borehole of 500 m^3/day. The Source Protection Zones are based on the current understanding of the groundwater conditions and the available data. Additional data obtained in the future may require amendments to the protection zone boundaries.

14 Recommendations

The well chamber roof should be sealed to prevent water entry and the chamber floor should be maintained free of ponded water by regular use of the installed sump pump.

Maintaining a long term record of groundwater level within borehole BW01 will help in determining the long term sustainability of the abstraction. To assist in developing this record, critical water level interpretation parameters (*i.e.* the bullet points below) for the borehole water level monitoring system should be determined and recorded for reference. The following measures should be carried out:

- Accurate determination of the depth of the borehole BW01 pressure transducer below the top of the 200 mm diameter steel casing at the well-head.
- The borehole water level should be dipped monthly and the time of dipping plus the depth to water level below the top of the 200 mm diameter steel casing should be recorded. These measurements should be compared to the Scada water level and abstraction rate telemetry system at the borehole to confirm the Scada system is operating correctly.
- Synchronization of the Scada systems at the BW01 compound and the Lisanisky reservoir,
- Programming of the telemetry system to record groundwater level and borehole abstraction rate at, for example,.10 minute intervals should be carried out. The database of values stored

on site should be extended to the longest possible time period. The data should be downloaded periodically (*e.g.* every 6 months), processed and stored for reference.

All trial boreholes completed during the hydrogeological investigations phases of the water supply scheme development should be located and provided with secure well head protection. The trial wells should be converted into observation wells. The water level in the boreholes should be dipped seasonally and the data used to develop seasonal groundwater elevation contour maps in order to monitor drawdown in the aquifer due to the abstraction and confirm the sustainability of the supply.

Monitoring of groundwater levels in the layered bedrock aquifers should be carried out to determine seasonal fluctuations in the lateral and vertical hydraulic gradient and to monitor the Kingscourt Sandstone Aquifer particularly in case of dewatering of the aquifer.

Groundwater quality at the borehole should be monitored closely for a full annual cycle to confirm the unpolluted condition of the groundwater.

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APPENDIX 1

- Borehole Logs – BW01 (old & new logs), C35/3c and BH05
- 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 A6 –Water Quality Data For boreholes PWSBH01 & BH09
- Table A1.7 – Subsoil data from Trial and Production Well Drilling in Vicinity of Borehole BW01
- Figure A1.1 – Data Points in the Vicinity of Mullantra PWS Site
- List of abbreviations used in Appendix tables

Well Log

Well No. PW5 = BW01 | **Grid Reference** 279800 297400

Project No. 1903 | **Client** Cavan Co. Co. | **Drill Date** May 1995

Well Type Trial Well | **Location** Kingscourt | **Geologist** Kieran O Dwyer

SUBSURFACE PROFILE

Description | **Depth (m)** | **Symbol**

Ground Surface

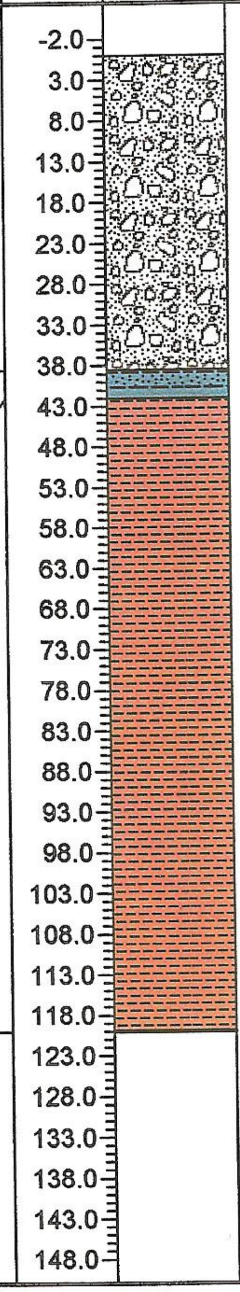
OVERBURDEN

Brown BOULDER-CLAY

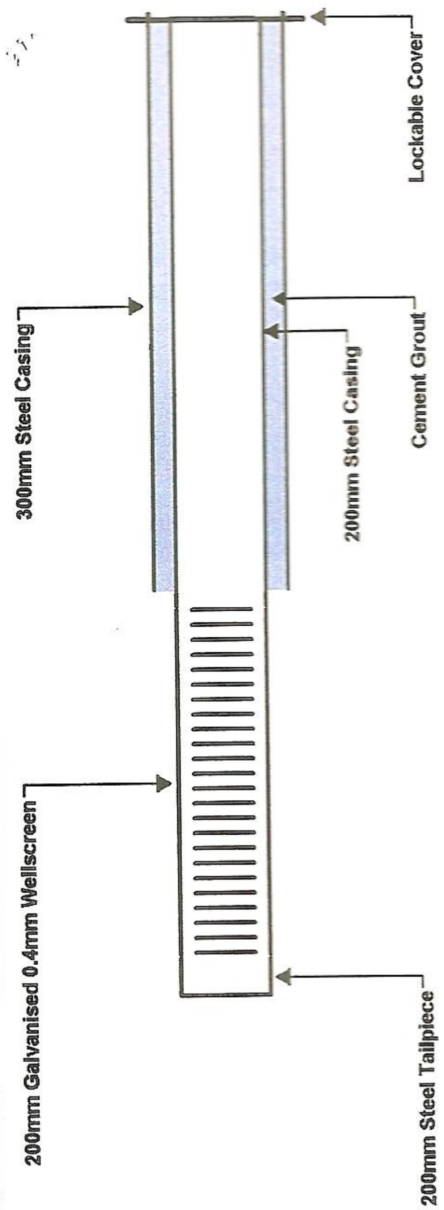
ROCK

Hard Grey-Green SANDSTONE

Soft Red MUDSTONE gradually becoming Red SANDSTONE



Well Construction



White Young Green

Drill Method Air Rotary | **Hole Size (mm)** 200

Casing Length (m) 120 | **TOC (mOD)**

Driller Dunne's | **Static Water Level (bgl)**

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

Name	Source	Other Names	X	Y	Drill Date	Driller	Casing	Screen / OH	Final Diameter	Water Strikes
									mm	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 Fieldwc	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

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								

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		

Table A1.1e GSI Well Database Records within the Study Area

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 A1.2 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												

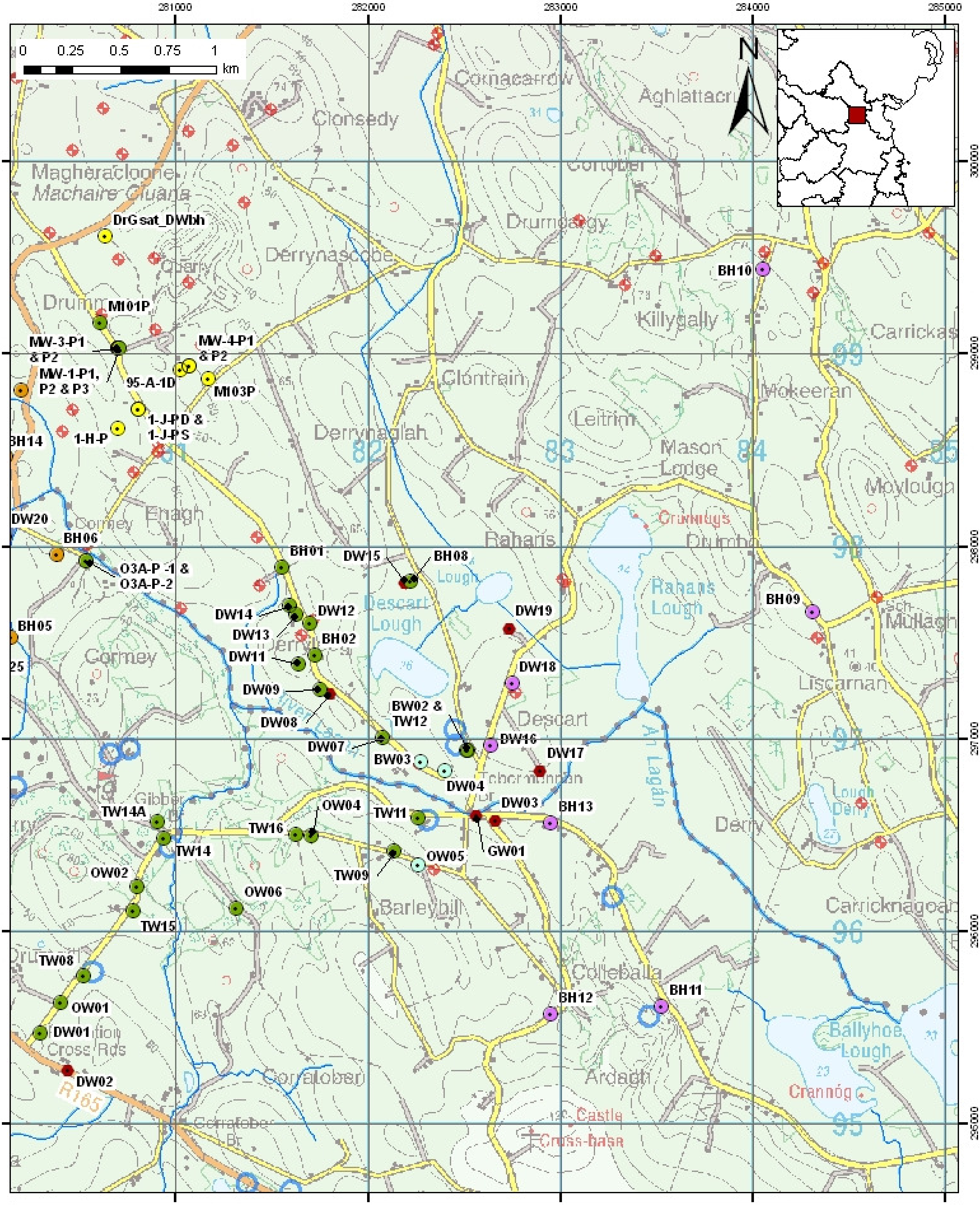


Figure A1.1 Data Points in the Vicinity of Descart PWS Site

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