Kilkea Public Water Supply

Extracted from:
County Kildare Groundwater Protection Scheme,
Volume II: Source Protection Zones

County Kildare
Groundwater Protection Scheme

Volume II: Source Protection Zones

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12.1 Introduction

The objectives of the report are as follows:

- To delineate source protection zones for the borehole.
- To outline the principal hydrogeological characteristics of the Kilkea area.
- To assist Kildare County Council in protecting the water supply from contamination.

The protection zones are delineated to help prioritise certain areas around the source in terms of pollution risk to the well. This prioritisation is intended to provide a guide in the planning and regulation of development and human activities. The implications of these protection zones are further outlined in 'Groundwater Protection Schemes' (DELG/EPA/GSI, 1999).

The report forms part of the groundwater protection scheme for the county. The maps produced for the scheme are based largely on mapping techniques which use inferences and judgements based on experience at other sites. As such, the maps cannot claim to be definitively accurate across the whole county covered, and should not be used as the sole basis for site-specific decisions, which will usually require the collection of additional site-specific data.

12.2 Borehole Location & Site Description

The source is located on the main Athy - Castledermot road (R418) approximately 600 m north of Kilkea. The source comprises a single borehole that pumps water directly into the distribution system. The system provides water for about 200 people. A manhole cover sits over the borehole which is located next to a small pump house that houses the treatment system and a surge tank. Both the pump house and borehole are located at the roadside. The top of the borehole is below road level (0.48 m). However, the caretaker reports that flooding has never been an issue at the borehole, and that this is due to the location of the manhole cover at the top of small rise in the land surface. In addition, the manhole chamber is lined preventing water from entering the top of the borehole. The risk of runoff from the River Greese is low.

12.3 Summary of Borehole Details

GSI No.	2617NWW267
Grid reference	S ^{2}7419 ^{1}8964
Townland	Kilkea Lodge Farm
Owner	Kildare County Council
Well Type	Borehole
Depth	48.8
Elevation (ground level)	76.9 m OD (Malin Head). Top of borehole is 48 cm lower (76.43 m OD) (measured by GSI staff on 10/5/2002).
Static water level	10.22 m (measured by GSI staff on 13/5/2002)
Normal consumption/abstraction	~45 m^3d^{-1}. (Caretaker's figures 2002)
Hours Pumping	5-10 hours per day
Yield	163 m^3d^{-1} (1500 gallons per hour) from 72 hour initial test pump test
Depth-to-rock	~10 m
Diameter	6 inch
Treatment	Chlorine. raw water tap available
System	Live to mains / No reservoir / submersible pump

12.4 Methodology

12.4.1 Desk Study

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

12.4.2 Site visits and fieldwork

This included the following;

- Water sampling on July 2002.
- Interview with the caretaker 13/5/02.
- Levelling in the borehole 13/5/02.
- Drilling of depth to bedrock holes during May 2002.
- Field mapping walkovers to further investigate the subsoil geology, the hydrogeology and vulnerability to contamination.

12.4.3 Assessment

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

12.5 Topography, Surface Hydrology and Land Use

The topography in the vicinity of the source is flat or undulating with an altitude lying between 70 and 80 m O.D. The general lie of the landscape is a gentle dip toward the River Barrow. There are small hillocks within a few hundred metres to the west in Kilkea Lodge Farm but the highest point near the source is Mullaghreelan which stands at 140 m O.D. It is about 3 km to the south east of the borehole. The lowest point in the area is the Barrow river which is about 4 km to the west at an elevation of approximately 51 m OD. Overall topographic gradients are in the order of 0.005 to the south west.

There are three main surface water features in the area, namely the River Barrow and its tributaries the River Greese and the Glasna Stream. The land appears to free draining with few field drains or ditches. The Greese is located 500 m due east of the borehole flowing south toward the Barrow. The Glasna stream is located about 1 km to the west of the borehole flowing southwest toward the Barrow. The Barrow flows in a southerly direction.

Land use around the source is generally tillage with corn being the principal crop grown. Large fields occupy the land in the area and the frequency of drainage ditches appears to be low. To the south of Kilkea the land use is pasture with cattle and sheep. There are also several sand/gravel pits in the locality (some disused).

12.6 Geology

12.6.1 Introduction

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

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

- Bedrock Geology 1:100,000 Map Series, Sheet 16, Kildare-Wicklow. Geological Survey of Ireland. (Mc Connell *et al*, 1994)
- Information from geological mapping in the nineteenth century (on record at the GSI).

- Glanville (1997) The quaternary geology of Co. Kildare, map descriptions for relevant 1:25,000 sheets. GSI report.

12.6.2 Bedrock Geology

The Feighcullen Limestone Formation occupies the area around the source (refer to Map 1). The borehole sits approximately 300 m east of the geological boundary with the Ballysteen Formation. Both rock types are largely similar. They primarily comprise fine grained, muddy, fossiliferous limestones. Both these formations do show evidence of dolomitisation but the extent of this is unclear. A borehole drilled into the Ballysteen Formation by KT Cullen 300 m west of the site (GSI well number 2617NWW252) indicates 17.5 m of grey fine-grained dolomite in the upper part of the log. However, three other boreholes drilled into the Feighcullen Formation in the vicinity of the source (GSI well numbers: 2617NWW250, 2617NWW251 and 2617NWW253) do not show evidence of dolomite. This indicates the unpredictability of dolomitisation and also indicates the difficulty in pinpointing dolomitised zones.

12.6.3 Subsoil (Quaternary) Geology

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

- 'Till' or 'Boulder clay' is an unsorted mixture of coarse and fine materials laid down by ice. The mapped till bodies around the source appear to be intermixed with sand/gravel. This is indicated by the subsoils map and borehole logs. A mixture of till and sand/gravel is reported in the majority of the boreholes around the source. Till is generally found to be overlying the sand/gravel component. There are two sand/gravel pits mapped within the till areas. The two closest boreholes to the source report 18 m (2617NWW253) of sand/gravelly SILT and 9 m (2617NWW252) of sand/gravel.
- Sand/gravel is widespread in south Kildare. Several quarries (some disused) are mapped in the vicinity of the source. Several eskers are also mapped nearby to the source. All the borehole logs in the vicinity of the source indicate sand/gravel present. Generally the sand/gravel is located beneath the till where there is till present. It appears from the logs to increase in thickness further south toward Kilkea. Wells 2617NWW251 and 2617NWW250 which are about 650 m to the south of the source have 27 m and 24 m of sand/gravel described in the borehole logs. A sand/gravel aquifer is mapped in this area just to the south of the source.
- Alluvium is mapped along the path of the River Greese. It can be seen along the banks of the river and is approximately one metre thick.
- A depth to bedrock drilling programme was carried out to ascertain the subsoil thicknesses. The thicknesses vary considerably from 0 m at Mullaghreelan hill (rock outcrop) to >20 m in the vicinity to the source in Kilkea Lodge Farm. Two boreholes drilled within 300 m of the source (GSI well numbers 2617NWW252 and 2617NWW253) have recorded depth to bedrock of 9 m and 18 m respectively. Generally, depth to bedrock is >10 m.

12.7 Groundwater Vulnerability

Groundwater vulnerability is dictated by the nature and thickness of the material overlying the uppermost groundwater 'target'.

Areas where the bedrock aquifer is the uppermost target: These areas occur to the north and east of the Kilkea source. Considerations of groundwater vulnerability in this area concern the permeability of the whole subsoil profile and the depth to bedrock. The subsoils are thought to be moderate-highly permeable (refer to Section 5 of Volume I) and are generally greater than 10 m in thickness. Thus the vulnerability is classed as generally 'moderate' (refer to Maps 6 and 8).

Areas where a sand/gravel aquifer is mapped: A small sand/gravel aquifer has been delineated toward Kilkea Demesne. The till covering this aquifer is less than a few metres in thickness and considerations of groundwater vulnerability in this area therefore concern the thickness of the unsaturated zone. The water levels in nearby wells are greater than 3 m and are typically in the order of 4m to 5m below ground. The vulnerability is therefore mapped as being generally 'high'.

The vulnerability mapping provided will not be able to anticipate all the natural variation that occurs in an area. The mapping is intended only as a guide to land use planning and hazard surveys, and is not a substitute for site investigation for specific developments. Classifications may change as a result of investigations such as trial hole assessments for on-site domestic wastewater treatment systems. The potential for discrepancies between large scale vulnerability mapping and site-specific data has been anticipated and addressed in the development of groundwater protection responses (site suitability guidelines) for specific hazards. More detail can be found in 'Groundwater Protection Schemes' (DELG/EPA/GSI, 1999).

12.8 Hydrogeology

12.8.1 Introduction

This section presents our current understanding of groundwater flow in the area of the source.

Hydrogeological and hydrochemical information for this study was obtained from the following sources:

- GSI files and archival Kildare County Council data.
- Kildare County Council drinking water returns.
- Hydrogeological mapping carried out by GSI.
- A drilling programme carried out by GSI to ascertain depth to bedrock and subsoil permeability.
- Logs provided by K.T. Cullen & Co.

12.8.2 Rainfall, Evaporation and Recharge

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

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

Gauging Stations	**Grid reference**	**Elevation OD (m)**	**Approximate distance & direction from source**	**Annual ppt 1961-1990**
Athy (Voc.Sh)	S656933	61	7.5 km north west	746 mm
Castledermot G.S.	S775848	82	6 km south	752 mm

  The contour maps of precipitation presented in the "Agroclimatic Atlas of Ireland" (Collins and Cummins, 1996) and the Monthly and annual averages of rainfall for Ireland (Fitzgerald, D., Forrestal., F., 1996) indicate that the precipitation is about 750 mm annually.

- *Annual evapotranspiration losses:* 400 mm. Potential evapotranspiration (P.E.) is estimated to be 425 mm $yr.^{-1}$ (based on data from Met Éireann). Actual evapotranspiration (A.E.) is then estimated as 95 % of P.E., to allow for seasonal soil moisture deficits. This figure ('actual evapotranspiration') was calculated using an adaptation of the country-wide potential evapotranspiration data presented in the "Agroclimatic Atlas of Ireland" (Collins and Cummins, 1996). More local measurements of evapotranspiration are not available.

- *Potential recharge:* 350 mm $yr.^{-1}$. This figure is based on subtracting estimated evapotranspiration losses from average annual rainfall. It represents an estimation of the excess soil moisture available for either vertical downward flow to groundwater or runoff and is commonly referred to as "Effective Rainfall" (E.R.).

- *Annual runoff losses:* ~35 mm. The slopes and the nature of the deposits around the source need to be considered in order to give a representative value for the runoff during rainfall events. The subsoils are a mixture of till and sand/gravel and are generally moderate to high permeability. Due to the free draining, flat nature of the land, a representative value for the proportion of runoff is estimated to be in the order to 10%.

These calculations are summarised as follows:

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

12.8.3 Groundwater levels, Flow Directions and Gradients

Data is available from work done by KT Cullen hydrogeological consultants and from a GSI well survey in the 1960's and 1970's. Additional water level information for the streams & rivers is available on the original GSI archive 1:10560 scale maps. The hydrogeological data shows that the water levels are generally 4-5 m below ground level. The data suggests that the regional groundwater flow direction is to the south west. This would support an assumption that the regional flow patterns were south westerly toward the River Barrow. Groundwater gradients are estimated to in the region of 0.003-0.007.

Due to the predominance of coarse-grained material along the course of the River Greese, the river is assumed to be in hydraulic connection with groundwater. The River Greese is a tributary of the River Barrow. It is also assumed that the Glasna Stream is in hydraulic connection with the groundwater table. No water level data are available in close proximity to the Greese and Glasna, but it is likely that shallow groundwaters within a few hundred metres of these rivers will discharge into them. Thus, there is thought to be a difference between regional and local shallow groundwater flow directions. As a consequence of this difference, a minor watershed is thought to occur between the Kilkea source and the Greese River. To the east of this watershed, shallow groundwater flows will probably occur towards the Greese, while shallow flows to the west will occur towards the Kilkea source and the Glasna and Barrow Rivers.

It is also likely that river flows in the Greese and Glasna Rivers can be induced to recharge shallow groundwater at times of low water levels or in localities where abstraction has had an influence on groundwater levels close to the rivers.

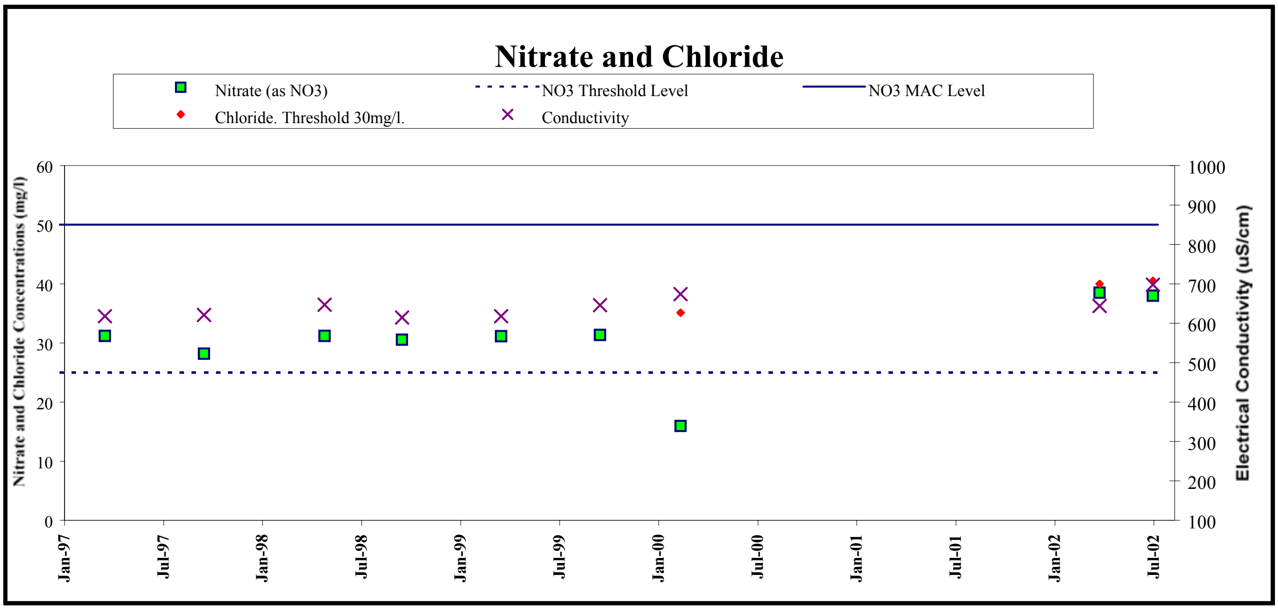
12.8.4 Hydrochemistry and Water Quality

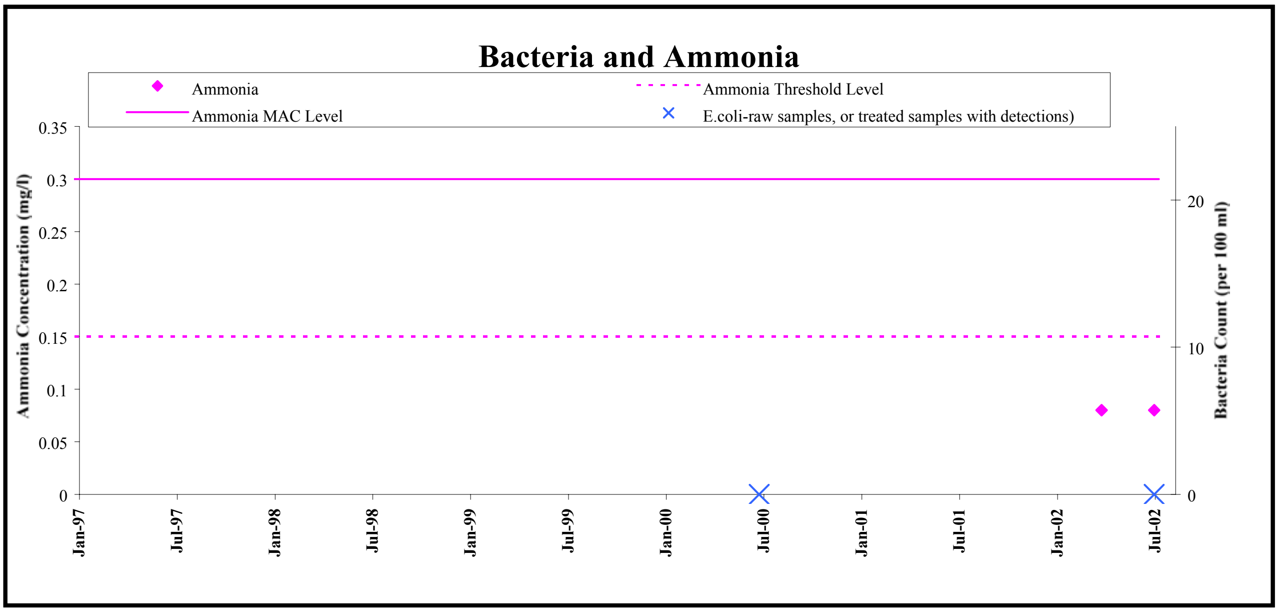
The available data is summarised in Figure 12-1 and the following key points are identified:

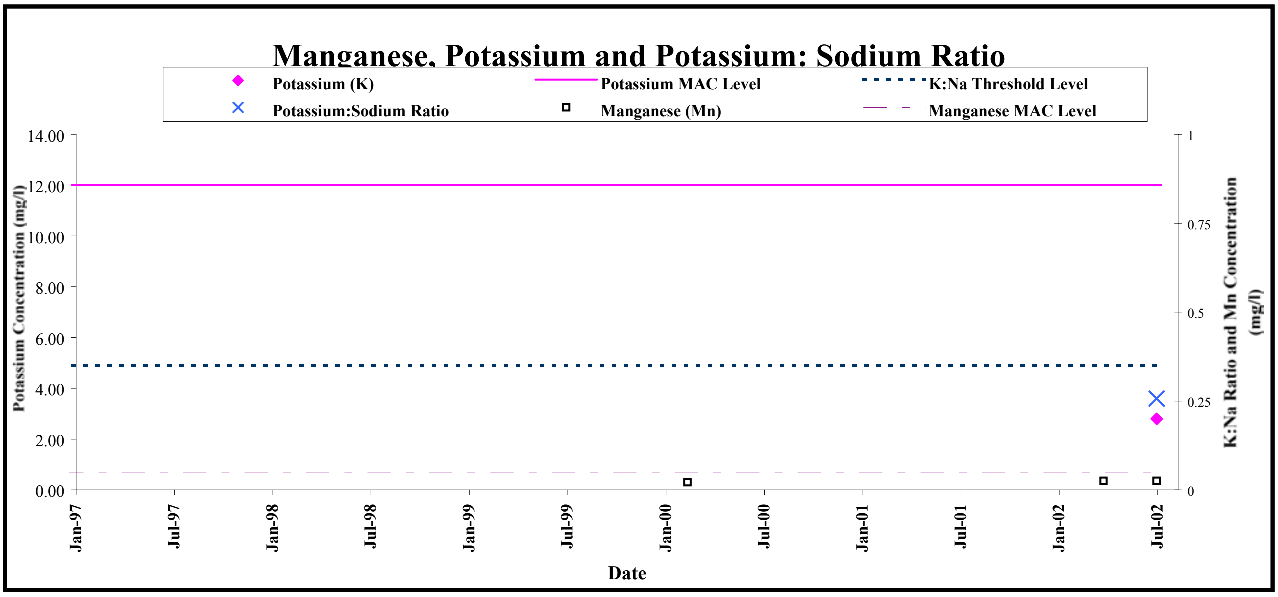
- The hydrochemical analyses suggest that the water is very hard, with a total hardness value of 370 mg l^{-1} (as $CaCO_3$) and electrical conductivity values of 608-674 µS cm^{-1}.
- Nitrate concentrations from the nine available analyses over the last five years are typically 30-40 mg l^{-1}. There is some evidence of a slight increase in concentrations.
- Chloride levels from three available analyses are also elevated (30-40 mg l^{-1}). Council staff have indicated that no salt softener is used at Kilkea.
- There are only two raw water analyses of *E.coli* available to GSI. No detections were recorded in either sample.

- The elevated nitrates and chlorides data suggest that organic and possibly inorganic wastes are influencing water quality at the source. Given that no areas of extreme vulnerability are mapped near the source, and given that no significant detections of faecal coliforms and ammonia are apparent, considerations of water quality and groundwater vulnerability cannot be used to distinguish point from diffuse hazards at this source. However, given the obviously intensive agriculture which is practiced in the area, it is likely that diffuse hazards (e.g. tillage practices) are influencing (at least partially) the reported nitrate levels.

Figure 12-1Kilkea - Key indicators of agricultural and domestic contamination at Kilkea PWS







12.8.5 Aquifer Characteristics

The bedrock and the sand/gravel deposits are the main aquifers supplying the borehole. The bedrock is classed as a **locally important** aquifer which is **moderately productive** only in **local zones** (**Ll**). Table 12 provides estimates for the aquifer parameters. The sand/gravel is classed as a locally important sand/gravel aquifer (Lg). It is likely that flows to the borehole occur in bedrock but that the sand/gravel provide extra storage capacity (particularly in summer), with vertical infiltration from sand/gravel into the bedrock. As flow to the well is primarily through the rock, the parameters for bedrock are of more concern in delineating the source protection zones. Flow in the rock is likely to occur in an upper shallow weathered zone and in faults, fractures and joints.

Table 12 Estimated Aquifer parameters for the rock units in Kilkea.

Parameter	*Source of data*	*Feighcullen*
Transmissivity (m^2 $d^{-1)}$	Local	5-15
Permeability (m d^{-1})	Local	0.5-2
Porosity	Assumed	0.01

The permeability of the bedrock has been estimated, from the transmissivity data and from estimates of the thickness of the weathered bedrock, to be in the order of 0.5-2 m d^{-1}. Porosity is assumed to be in the order of 1%.

12.9 Conceptual Model

- The Kilkea Public Water Supply borehole is fed by the Feighcullen Limestone Formation which is classed as a **locally important aquifer** which is **moderately productive** only in **local zones** (**Ll**). Small sand/gravel bodies are common in the area and these are likely to provide additional groundwater storage for the bedrock aquifer.
- The transmissivity in this aquifer is generally low but can increase in local zones depending on dolomitisation, the development of faults, fissures and fractures. Groundwater flow is probably confined to fractures, fissures, joints, bedding planes and the uppermost part of the bedrock as indicated by a series of inflows in the borehole logs.
- The bedrock aquifer is unconfined as it is overlain by moderately permeable till and highly permeable sand/gravel.
- There are few artificial drains and the subsoils are thought to be moderately to highly permeable, depending on the location of sand/gravel pockets.
- The River Greese and Glasna Stream are thought to be in close hydraulic connection with the groundwater. The Greese and Glasna Rivers are thought to form a local groundwater discharge zone. It is expected that shallow groundwater within a few hundred metres of these rivers will discharge into the rivers. Regionally, however, most groundwater will flow to the west and south west and discharge to the River Barrow. As a consequence of the difference between the local and regional flow directions, a minor watershed is thought to occur between the Kilkea source and the Greese River. To the east of this watershed, shallow groundwater flows will probably occur towards the Greese, while shallow flows to the west will occur towards the Kilkea source and the Glasna and Barrow Rivers. It is also likely that river flows in the Greese and Glasna Rivers can be induced to recharge shallow groundwater at times of low water levels or in localities where abstraction has had an influence on groundwater levels close to the rivers.
- Diffuse recharge occurs over most of the land surface through the sands & sand/gravel and the permeable till. Estimates are in the order of 315 mm yr^{-1}.

12.10 Delineation of Source Protection Areas

12.10.1 Introduction

This section delineates the areas around the source that are believed to contribute groundwater to it, and that therefore require protection. The areas are delineated based on the conceptualisation of the groundwater flow pattern, and are presented in Map 8.

Two source protection areas are delineated:

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

12.10.2 Outer Protection Area

The Outer Protection Area (SO) is bounded by the complete catchment area to the source, i.e. **the zone of contribution (ZOC)**, which is defined as the area required to support an abstraction from long-term recharge. The ZOC is controlled primarily by (a) the pumping rate, (b) the groundwater flow direction and gradient, (c) the subsoil and rock permeability and (d) the recharge in the area. The ZOC is delineated using both analytical modelling and the results of hydrogeological mapping and conceptualisation. Given the limited amount of calibration data available, a full groundwater numerical model was not undertaken. The resulting boundaries are presented in Map 8 and are described as follows:

The **western boundary** is defined by the downgradient limit of the well. This is calculated from semi-analytical equations and is about 100 m. This estimate means that it is anticipated that the well can pull water into the well from up to 100 m downgradient of the well.

The **eastern boundary** is delimited by the Greese River. Under normal conditions, it is expected that most shallow groundwater near the river will not flow towards the well, but will discharge into the river (refer to Section 12.8.3). However, it is possible that, during periods of low water levels, flow directions will change and recharge will be induced from the river to the well. Consequently, the eastern boundary of the ZOC has been extended to meet the Greese River.

The **northern and southern boundaries** are more difficult to establish as there are no obvious topographical or hydrological controls. They have been estimated by varying the main groundwater flow direction between the eastern boundary and the well by +/-20º to form a wedge shape that is at no point any less than 100m from the well.

Note that the total area required to provide sufficient diffuse recharge to meet the demands of abstraction at the Kilkea source is approximately 0.08 km^2. This area is less than that delineated by the above boundaries and was derived using the recharge estimates from Section 12.8.2, and the abstraction figures from Section 12.3. The abstraction rate was increased by a safety factor of 50% to allow for daily variations in abstraction and also to allow for an expansion of the ZOC during dry weather.

12.10.3 Inner Protection Area

According to "Groundwater Protection Schemes" (DELG/EPA/GSI, 1999), delineation of an Inner Protection Area is required to protect the source from microbial and viral contamination and it is based on the 100-day time of travel (ToT) to the supply. Estimations of the extent of this area cannot be made by hydrogeological mapping and conceptualisation methods alone. Analytical modelling was therefore used to estimate the extent of this zone upgradient of the well.

Bedrock Aquifer: Using Darcy's Law, a permeability value of 2 m d^{-1}, porosity of 0.01 and gradients of 0.005, the 100 day ToT is estimated be approximately 100 m.

12.11 Groundwater Protection Zones

The groundwater protection zones are obtained by integrating the two elements of land surface zoning (source protection areas and vulnerability categories) – a possible total of 8 source protection zones. In practice, the source protection zones are obtained by superimposing the vulnerability map on the source protection area map. Each zone is represented by a code e.g. **SI/H**, which represents an Inner Protection area where the groundwater is highly vulnerable to contamination. The final groundwater protection zones are shown in Map 8 and are presented in Table 13.

Table 13 Matrix of Source Protection Zones at Kilkea PWS.

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

12.12 Potential Pollution Sources

Land use in the area is described in Section 12.5. The land around the source is grassland dominated, used for cattle and sheep. Agricultural activities and septic tanks are the principal hazards to the water quality in the area. The main potential sources of pollution within the ZOC are landspreading of organic and inorganic fertilisers, roadway spillages and accidents near the source, farmyards, and septic tank systems.

Note that the source is beside a road, and the well head lies below road level within a manhole chamber. Though the manhole chamber is reported to be sealed, there may be some potential for the direct inundation of contaminants; particularly in relation to accidents close to the source involving tankers. There may also be an issue in relation to herbicides if they are used to maintain the road verges.

12.13 Conclusions and Recommendations

- The source is a relatively small production borehole abstracting about 45 m^3 d^{-1}. It is located in a locally important limestone aquifer which is moderately productive only in local zones (Ll). Yields are thought to be supported by vertical flows from a locally important sand/gravel aquifer (Lg).

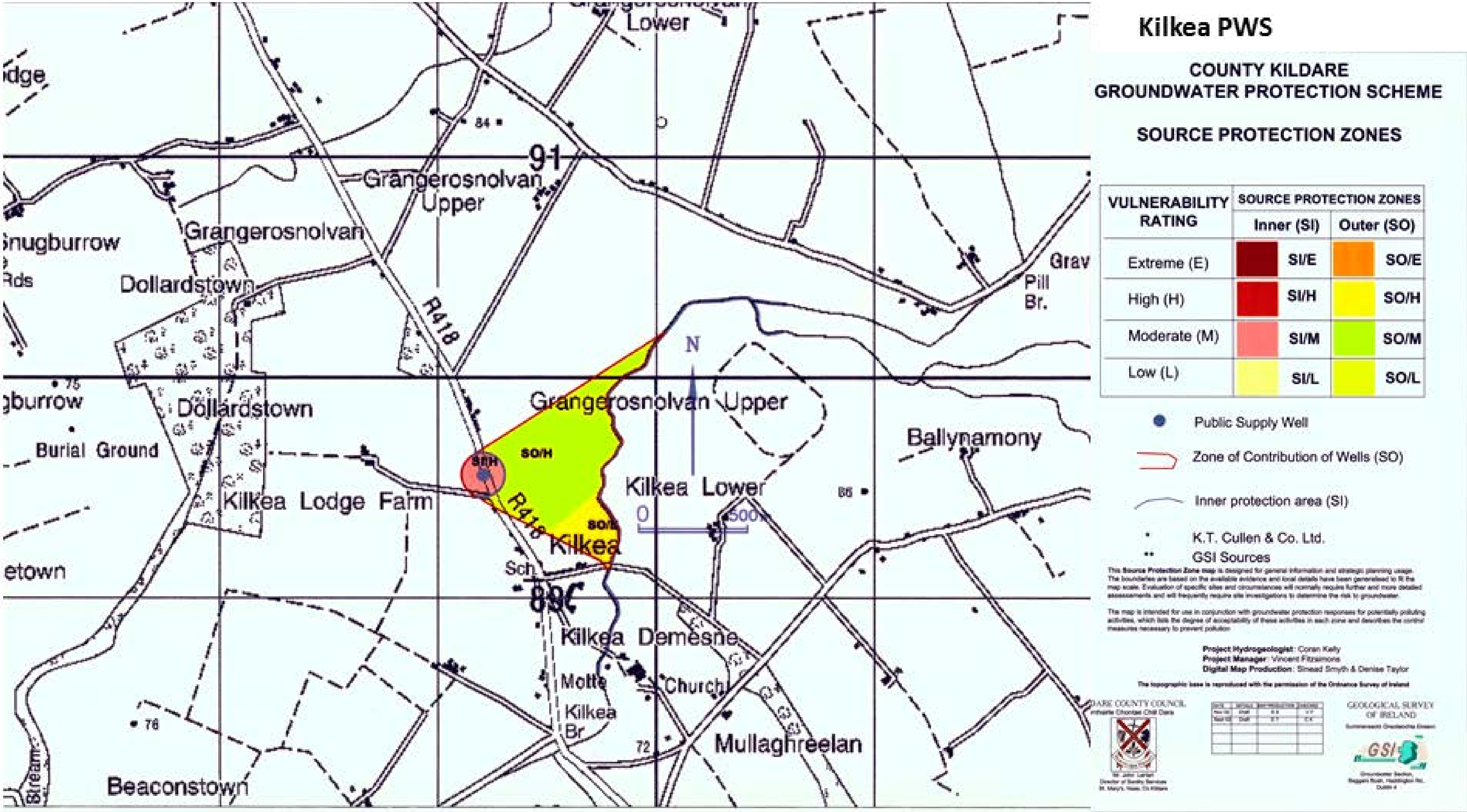
- Groundwaters supplying the source are thought to be moderately to highly vulnerable to contamination.

- Landspreading of organic and inorganic wastes are the main potential hazards in the area, along with road spillages and accidents near the source, farmyards and septic tank systems.

- The protection zones delineated in the report are based on our current understanding of groundwater conditions and on the available data. Additional data obtained in the future may indicate that amendments to the boundaries are necessary.

- It is recommended that:
  1. A full scale pumping test be carried out to estimate the yield of the well and to improve the hydrogeological understanding of the area.
  2. A full chemical and bacteriological analysis of the **raw** water is carried out on a regular basis. The normal range of parameters might be expanded to incorporate contaminants associated with roadway spillages and roadway maintenance (e.g. herbicides and hydrocarbons).

3. Particular care should be taken when assessing the location of any activities or developments which might cause contamination at the well, particularly in relation to nitrates.
4. The potential hazards in the ZOC should be located and assessed.



Map 8 Kilkea Source Protection Zones

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Appendix IV: Discussion Of the Key Indicators of Domestic and Agricultural Contamination of Groundwater

A.1 Introduction

This appendix is adapted from Daly, 1996.

There has been a tendency in analysing groundwater samples to test for a limited number of constituents. A "full" or "complete" analysis, which includes all the major anions and cations, is generally recommended for routine monitoring and for assessing pollution incidents. This enables (i) a check on the reliability of the analysis (by doing an ionic balance), (ii) a proper assessment of the water chemistry and quality and (iii) a possible indication of the source of contamination. A listing of recommended and optional parameters are given in Table A1. It is also important that the water samples taken for analysis have not been chlorinated - this is a difficulty in some local authority areas where water take-off points prior to chlorination have not been installed.

The following parameters are good contamination indicators: E.coli, nitrate, ammonia, potassium, chloride, iron, manganese and trace organics.

TABLE A1

Recommended Parameters		
Appearance	Calcium (Ca)	Nitrate ($N0_3$)*
Sediment	Magnesium (Mg)	Ammonia ($NH_4$and NH_3)*
pH (lab)	Sodium (Na)	Iron (Fe)*
Electrical Conductivity (EC)*	Potassium (K)*	Manganese (Mn)*
Total Hardness	Chloride Cl)*	
General coliform	Sulphate ($S0_4$)*	
E. coli *	Alkalinity	
Optional Parameters (depending on local circumstances or reasons for sampling)		
Fluoride (F)	Fatty acids *	Zinc (Zn)
Orthophosphate	Trace organics *	Copper (Cu)
Nitrite ($N0_2$)*	TOC *	Lead (Pb)
B.O.D.*	Boron (B) *	Other metals
Dissolved Oxygen *	Cadmium (Cd)	
*** good indicators of contamination**		

A.2 Faecal Bacteria and Viruses

E. coli is the parameter tested as an indicator of the presence of faecal bacteria and perhaps viruses; constituents which pose a significant risk to human health. The most common health problem arising from the presence of faecal bacteria in groundwater is diarrhoea, but typhoid fever, infectious hepatitis and gastrointestinal infections can also occur. Although E. coli bacteria are an excellent indicator of pollution, they can come from different sources - septic tank effluent, farmyard waste, landfill sites, birds. The faecal coliform : faecal streptococci ratio has been suggested as a tentative indicator to distinguish between animal and human waste sources (Henry *et al*., 1987). However, researchers in Virginia Tech (Reneau, 1996) cautioned against the use of this technique.

Viruses are a particular cause for concern as they survive longer in groundwater than indicator bacteria (Gerba and Bitton, 1984).

The published data on elimination of bacteria and viruses in groundwater has been compiled by Pekdeger and Matthess (1983), who show that in different investigations 99.9% elimination of *E. coli* occurred after 10-15 days. The mean of the evaluated investigations was 25 days. They show that 99.9% elimination of various viruses occurred after 16-120 days, with a mean of 35 days for Polio-, Hepatitis, and Enteroviruses. According to Armon and Kott (1994), pathogenic bacteria can survive for more than ten days under adverse conditions and up to 100 days under favourable conditions; entertoviruses can survive from about 25 days up to 170 days in soils.

Bacteria can move considerable distances in the subsurface, given the right conditions. In a sand and gravel aquifer, coliform bacteria were isolated 100 ft from the source 35 hours after the sewage was introduced (as reported in Hagedorn et al., 1981). They can travel several kilometres in karstic aquifers. In Ireland, research at Sligo RTC involved examining in detail the impact of septic tank systems at three locations with different site conditions (Henry, 1990; summarised in Daly, Thorn and Henry, 1993). Piezometers were installed down-gradient; the distances of the furthest piezometers were 8 m,10 m and 9.5 m, respectively. Unsurprisingly, high faecal bacteria counts were obtained in the piezometers at the two sites with soakage pits, one with limestone bedrock at a shallow depth where the highest count (max. 14 000 cfu's per 1000 ml) and the second where sand/gravel over limestone was present (max 3 000 cfu's per 100 ml). At the third site, a percolation area was installed at 1.0 m b.g.l; the subsoils between the percolation pipes and the fractured bedrock consisted of 1.5 m sandy loam over 3.5 m of poorly sorted gravel; the water table was 3.5 b.g.l. (So this site would satisfy the water table and depth to rock requirements of S.R.6:1991, and most likely the percolation test requirement.) Yet, the maximum faecal coliform bacteria count was 300 cfus per 100 ml. Faecal streptocci were present in all three piezometers. It is highly likely that wells located 30 m down gradient of the drainage fields would be polluted by faecal bacteria.

As viruses are smaller than bacteria, they are not readily filtered out as effluent moves through the ground. The main means of attenuation is by adsorption on clay particles. Viruses can travel considerable distances underground, depths as great as 67 m and horizontal migrations as far as 400 m have been reported (as reported in US EPA, 1987). The possible presence of viruses in groundwater as a result of pollution by septic tank systems is a matter of concern because of their mobility and the fact that indicator bacteria such faecal coliforms have been found not to correlate with the presence of viruses in groundwater samples (US EPA, 1987).

The natural environment, in particular the soils and subsoils, can be effective in removing bacteria and viruses by predation, filtration and absorption. There are two high risk situations: (i) where permeable sands and gravels with a shallow water table are present; and (ii) where fractured rock, particularly limestone, is present close to the ground surface. The presence of clayey gravels, tills, and peat will, in many instances, hinder the vertical migration of microbes, although preferential flow paths, such as cracks in clayey materials, can allow rapid movement and bypassing of the subsoil.

A.3 Nitrate

Nitrate is one of the most common contaminants identified in groundwater and increasing concentrations have been recorded in many developed countries. The consumption of nitrate rich water by young children may give rise to a condition known as methaemoglobinaemia (blue baby syndrome). The formation of carcinogenic nitrosamines is also a possible health hazard and epidemiological studies have indicated a positive correlation between nitrate consumption in drinking water and the incidence of gastric cancer. However, the correlation is not proven according to some experts (Wild and Cameron, 1980). The EC MAC for drinking water is 50mg/l.

The nitrate ion is not adsorbed on clay or organic matter. It is highly mobile and under wet conditions is easily leached out of the rooting zone and through soil and permeable subsoil. As the normal concentrations in uncontaminated groundwater is low (less than 5 mg/l), nitrate can be a good indicator of contamination by fertilisers and waste organic matter.

In the past there has been a tendency in Ireland to assume that the presence of high nitrates in well water indicated an impact by inorganic fertilisers. This assumption has frequently been wrong, as examination of other constituents in the water showed that organic wastes - usually farmyard waste, probably soiled water - were the source. The nitrate concentrations in wells with a low abstraction rate - domestic and farm wells - can readily be influenced by soiled water seeping underground in the vicinity of the farmyard or from the spraying of soiled water on adjoining land. Even septic tank effluent can raise the nitrate levels; if a septic tank system is in the zone of contribution of a well, a four-fold dilution of the nitrogen in the effluent is needed to bring the concentration of nitrate below the EU MAC (as the EU limit is 50 mg/l as NO_3 or 11.3 mg/l as N and assuming that the N concentration in septic tank effluent is 45 mg/l).

The recently produced draft county reports by the EPA on nitrate in groundwater show high levels of nitrate in a significant number of public and group scheme supplies, particularly in south and southern counties and in counties with intensive agriculture, such as Carlow and Louth. This suggest that diffuse sources – landspreading of fertilisers – is having an impact on groundwater.

In assessing regional groundwater quality and, in particular the nitrate levels in groundwater, it is important that:

(i) conclusions should not be drawn using data only from private wells, which are frequently located near potential point pollution sources and from which only a small quantity of groundwater is abstracted;

(ii) account should be taken of the complete chemistry of the sample and not just nitrate, as well as the presence of *E. coli.*;

(iii) account should be taken of not only the land-use in the area but also the location of point pollution sources;

(iv) account should be taken of the regional hydrogeology and the relationship of this to the well itself. For instance, shallow wells generally show higher nitrate concentrations than deeper wells, low permeability sediments can cause denitrification, knowledge on the groundwater flow direction is needed to assess the influence of land-use.

A.4 Ammonia

Ammonia has a low mobility in soil and subsoil and its presence at concentrations greater than 0.1 mg/l in groundwater indicates a nearby waste source and/or vulnerable conditions. The EU MAC is 0.3 mg/l.

A.5 Potassium

Potassium (K) is relatively immobile in soil and subsoil. Consequently the spreading of manure, slurry and inorganic fertilisers is unlikely to significantly increase the potassium concentrations in groundwater. In most areas in Ireland, the background potassium levels in groundwater are less than 3.0 mg/l. Higher concentrations are found occasionally where the rock contains potassium e.g. certain granites and sandstones. The background potassium:sodium ratio in most Irish groundwaters is less than 0.4 and often 0.3. The K:Na ratio of soiled water and other wastes derived from plant organic matter is considerably greater than 0.4, whereas the ratio in septic tank effluent is less than 0.2. Consequently a K:Na ratio greater than 0.4 can be used to indicate contamination by plant organic matter - usually in farmyards, occasionally landfill sites (from the breakdown of paper). However, a K:Na ratio lower than 0.4 does not indicate that farmyard wastes are **not** the source of contamination (or that a septic tank is the cause), as K is less mobile than Na. (Phosphorus is increasingly a significant pollutant and cause of eutrophication in surface water. It is not a problem in groundwater as it usually is not mobile in soil and subsoil).

A.6 Chloride

The principle source of chloride in uncontaminated groundwater is rainfall and so in any region, depending on the distance from the sea and evapotranspiration, chloride levels in groundwater will be fairly constant. Chloride, like nitrate, is a mobile cation. Also, it is a constituent of organic wastes. Consequently, levels appreciably above background levels (12-15 mg/l in Co. Offaly, for instance) have been taken to indicate contamination by organic wastes such as septic tank systems. While this is probably broadly correct, Sherwood (1991) has pointed out that chloride can also be derived from potassium fertilisers.

A.7 Iron and manganese

Although they are present under natural conditions in groundwater in some areas, they can also be good indicators of contamination by organic wastes. Effluent from the wastes cause deoxygenation in the ground which results in dissolution of iron (Fe) and manganese (Mn) from the soil, subsoil and bedrock into groundwater. With reoxygenation in the well or water supply system the Fe and Mn precipitate. High Mn concentrations can be a good indicator of pollution by silage effluent. However, it can also be caused by other high BOD wastes such as milk, landfill leachate and perhaps soiled water and septic tank effluent.

Box A1 Warning/trigger Levels for Certain Contaminants
As human activities have had some impact on a high proportion of the groundwater in Ireland, there are few areas where the groundwater is in a pristine, completely natural condition. Consequently, most groundwater is contaminated to some degree although it is usually not polluted. In the view of the GSI, assessments of the degree of contamination of groundwater can be beneficial as an addition to examining whether the water is polluted or not. This type of assessment can indicate where appreciable impacts are occurring. It can act as a warning that either the situation could worsen and so needs regular monitoring and careful land-use planning, or that there may be periods when the source is polluted and poses a risk to human health and as a consequence needs regular monitoring. Consequently, thresholds for certain parameters can be used to help indicate situations where additional monitoring and/or source protection studies and/or hazard surveys may be appropriate to identify or prevent more significant water quality problems.

Parameter	**Threshold** mg/l	**EU MAC** mg/l
Nitrate	25	50
Potassium	4	12
Chloride	30 (except near sea)	250
Ammonia	0.15	0.3
K/Na ratio	0.3-0.4	
Faecal bacteria	0	0

Box A2 Summary : Assessing a Problem Area

Let us assume that you are examining an area with potential groundwater contamination problems and that you have taken samples in nearby wells. How can the analyses be assessed?

E. coli present ⇨ organic waste source nearby (except in karst areas), usually either a septic tank system or farmyard.
E. coli absent ⇨ either not polluted by organic waste or bacteria have not survived due to attenuation or time of travel to well greater than 100 days.
Nitrate > 25 mg/l ⇨ either inorganic fertiliser or organic waste source; check other parameters.
Ammonia > 0.15 mg/l ⇨ source is nearby organic waste; fertiliser is not an issue.
Potassium (K) > 5.0 mg/l ⇨ source is probably organic waste.
K/Na ratio > 0.4 (0.3, in many areas) ⇨ Farmyard waste rather than septic tank effluent is the source. If < 0.3, no conclusion is possible.
Chloride > 30 mg/l ⇨ organic waste source. However this does not apply in the vicinity of the coast (within 20 km at least).

In conclusion, faecal bacteria, nitrate, ammonia, high K/Na ratio and chloride indicate contamination by organic waste. However, only the high K/Na helps distinguish between septic tank effluent and farmyard wastes. So in many instances, while the analyses can show potential problems, other information is needed to complete the assessment.

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APPENDIX V: Laboratory analytical results

Location	County	Plot_no	location	Scheme	details	NGR	Easting	Northing	type	LAB	LAB_REF	date	pH	pH_field	Temp(O c)	Temp_Field (O c	Odour	Dslvd oxgen %sat	DO_field (mg/l)	DO_field (%sat)	BOD(mg/l O2)	Conduct (us/cm)	conduct_field_u	Location	Ammonia (mg/l N)	O-Phosphate (mg)	TON (mg/l N)	Nitrate (mg/l N	Nitrate (mg/l NO)	Nitrite (mg/l N	alkalinity(mg/l	Chloride (mg/lCl)	Flouride (mg/lF)	TOTL_HARD(mg/l)	Faecal_ Coliform	lab2_bact	Sulphate (mg/l S)	Sulphide (mg/l S)	Sodium (mg/l Na)	Potassium (mg/l)	Magnesium (mg/l)	Copper (mg/l Cu)	Calcium (mg/l Ca)	Iron (mg/l Fe)	Manganese (mg/l
Castledermot WS	KID	6	Castledermot WS	Castledermot @ Plunketstown		S805860	280527	186017	Bore	DUB	3718	11/21/95	7.29		nda		nda	nda			nda	718		Castledermot WS	<0.005	0.015	6.704	7.34	32.50152	nda	318	17.38	nda	nda	nda		16.2	nda	7.67	1.93	13.84	nda	110.53	0.0113	0.0025
Castledermot WS	KID	6	Castledermot WS	Castledermot @ Plunketstown		S805860	280527	186017	Bore	DUB	2988	08/21/96	7.12		nda		nda	nda			nda	683		Castledermot WS	<0.01	0.012	7.621	nda	33.74*	nda	302	17.87	nda	nda	nda		12.7	nda	8.04	1.68	13.1	nda	113.54	0.236	<0.0005
Castledermot WS	KID	6	Castledermot WS	Castledermot @ Plunketstown		S805860	280527	186017	Bore	DUB	4095	11/20/96	7.36		nda		nda	nda			nda	712		Castledermot WS	<0.01	0.0215	8.609	nda	38.13*	nda	316	18.1	nda	nda	nda		14.12	nda	7.09	2.17	9.2	nda	120.6	0.0633	0.002
Castledermot WS	KID	6	Castledermot WS	Castledermot @ Plunketstown		S805860	280527	186017	Bore	DUB	4342	11/05/97	7.24		nda		nda	nda			nda	652		Castledermot WS	0.018	0.018	8.107	nda	35.91*	nda	314	18.429	nda	nda	nda		16.089	nda	7.739	0.496	14.016	nda	127.451	0.067	0.007
Castledermot WS	KID	6	Castledermot WS	Castledermot @ Plunketstown		S805860	280527	186017	Bore	DUB	666	02/11/98	7.32		nda		nda	nda			nda	583		Castledermot WS	<0.01	0.00929	8.195	nda	36.31*	nda	289	17	nda	nda	nda		11.9	nda	9.5	1.4	15.2	nda	117	0.0165	<0.0005
Castledermot WS	KID	6	Castledermot WS	Castledermot @ Plunketstown		S805860	280527	186017	Bore	DUB	3184	09/10/98	7.51		nda		nda	nda			nda	599		Castledermot WS	2.589	0.0901	9.329	nda	41.31*	nda	273	18.9	nda	nda	nda		13.2	nda	10.4	11.7	13.8	nda	101.8	0.0513	0.009
Castledermot WS	KID	6	Castledermot WS			S805860	280527	186017	Bore	DUB	116	01/14/99	7.4	nda	9.3	9.3	nda	nda		9.48	85.3	nda	609	nda	Castledermot WS	<0.01	0.01127	9.49	nda	42.02*	nda	296	nda	nda	nda	nda		nda	nda	nda	nda	nda	nda	nda	0.0281	<0.0005
Castledermot WS	KID	6	Castledermot WS			S805860	280527	186017	Bore	DUB	3211	10/12/99	7.89	nda	10.1	10.1	nda	nda	nda			nda	356	430	Castledermot WS	0.016	1.32639	2.74	nda	12.13*	nda	156	13.8	nda	nda	nda		10.18	nda	13.67	2.81	6.39	nda	62.6	0.0535	0.0105
Kilberry Area WS	KID	9	Kilberry Area WS			N662000	266200	200000	Bore	DUB	3014	08/22/96	7.39		nda		nda	nda			nda	799		Kilberry Area WS	<0.01	0.009	10.559	nda	46.76*	nda	308	38.63	nda	nda	nda		38.28	nda	12.19	1.61	12.23	nda	135.54	0.128	0.0058
Kilberry Area WS	KID	9	Kilberry Area WS			N662000	266200	200000	Bore	DUB	4079	11/19/96	7.54		nda		nda	nda			nda	820		Kilberry Area WS	<0.01	0.009	9.934	nda	43.97*	nda	310	35.86	nda	nda	nda		40.56	nda	12.37	2.51	9.72	nda	147	0.182	0.0058
Kilberry Area WS	KID	9	Kilberry Area WS			N662000	266200	200000	Bore	DUB	4329	11/04/97	7.21		nda		nda	nda			nda	700		Kilberry Area WS	<0.01	0.008	10.756	nda	47.64*	nda	294	54.646	nda	nda	nda		42.341	nda	20.458	3.92	15.154	nda	146.189	<0.001	0.0028
Kilberry Area WS	KID	9	Kilberry Area WS			N662000	266200	200000	Bore	DUB	695	02/12/98	7.25		nda		nda	nda			nda	750		Kilberry Area WS	<0.01	0.007	14.407	nda	63.81*	nda	308	42.8	nda	nda	nda		30.7	nda	13.1	1.7	14.7	nda	148.1	0.0067	0.0014
Kilberry Area WS	KID	9	Kilberry Area WS			N662000	266200	200000	Bore	DUB	3152	09/08/98	7.12		nda		nda	nda			nda	742		Kilberry Area WS	<0.01	0.0096	10.84	nda	48.0*	nda	311	35.1	nda	nda	nda		33.8	nda	14.8	1.8	14.7	nda	140.4	<0.01	0.0021
Kilberry Area WS	KID	9	Kilberry Area WS			N662000	266200	200000	Bore	DUB	57	01/12/99	7.29	nda	10.9	10.9	nda	nda		6.97	64	nda	742	nda	Kilberry Area WS	<0.01	0.009	12.294	nda	54.42*	nda	303	54.8	nda	nda	nda		37.5	nda	15.8	2.3	16.8	nda	171.2	0.0115	0.0025
Kilberry Area WS	KID	9	Kilberry Area WS			N662000	266200	200000	Bore	DUB	2775	09/20/99	7.13	nda	12.4	12.4	nda	nda		6.1		nda	749	936	Kilberry Area WS	<0.01	0.006	9.174	nda	40.60*	nda	314	35	nda	nda	nda		37.1	nda	15.4	2.07	15.03	nda	144.1	0.0081	0.0037
Kilberry area WS	KID	9	Kilberry area WS			N662000	266200	200000	Bore	DUB	726	02/09/00	7.25	nda	10.4	10.4	nda	nda		8.45		nda	751	849	Kilberry area WS	<0.01	0.01	9.44	nda	41.80*	nda	276	33.6	nda	nda	nda		30.4	nda	14.62	1.61	14.24	nda	140.4	<0.02	0.0042
Kilberry area WS	KID	9	Kilberry area WS			N662000	266200	200000	Bore	DUB	5809	11/21/00	7.443	nda	11.7	11.7	nda	6.24	6.24		nda	833	862	Kilberry area WS	0.02	0.005558	6.745	nda	29.87*	nda	241	34.4	nda	nda	<1	DCORP	31.7	nda	11.6	<1	14.5	nda	126.5	<0.05	0.0024
Kilberry area WS	KID	9	Kilberry area WS			N662000	266200	200000	Bore	DUB	1467	04/04/01	7.161	nda	9	9	nda	7.11	7.11		nda	856	893	Kilberry area WS	<0.01	0.023987	10.801	nda	47.83*	nda	305	43.1	nda	nda	<1	DCORP	31	nda	14.87	0.55	13.86	nda	136.6	<0.05	0.0024
Monasterevin WS(spring@Hybla)	KID	14	Monasterevin WS(spring@Hybla)			N642125	264230	212502	Spring	DUB	3167	09/09/98	7.38		nda		nda	nda			nda	611		Monasterevin WS(spring@Hybla)	<0.01	0.009	3.247	nda	14.38*	nda	303	13.4	nda	nda	nda		18.7	nda	8.9	1.3	26.4	nda	103.3	0.0149	<0.0005
Monasterevin WS(spring@Hybla)	KID	14	Monasterevin WS(spring@Hybla)			N642125	264230	212502	Spring	DUB	92	01/13/99	7.54	nda	9.5	11.2	nda	nda		2.42	23	nda	597	nda	Monasterevin WS(spring@Hybla)	<0.01	0.011	3.134	nda	13.88*	nda	315	18.3	nda	nda	nda		25.3	nda	10.2	1.4	31.2	nda	131.4	0.0458	0.0025
Monasterevin WS(spring@Hybla)	KID	14	Monasterevin WS(spring@Hybla)			N642125	264230	212502	Spring	DUB	3202	10/11/99	7.45	nda	11.2	11.2	nda	nda	nda			nda	614	758	Monasterevin WS(spring@Hybla)	<0.01	0.006	3.42	nda	15.14*	nda	334	16.34	nda	nda	nda		19.7	nda	8.47	1.19	27.6	nda	111.2	0.0097	0.0025
Monasterevin WS(spring@Hybla)	KID	14	Monasterevin WS(spring@Hybla)			N642125	264230	212502	Spring	DUB	724	02/09/00	7.36	nda	9.9	9.9	nda	nda		5.35		nda	651	728	Monasterevin WS(spring@Hybla)	<0.01	<0.005	3.11	nda	13.77*	nda	299	17.4	nda	nda	nda		20.5	nda	8.84	1.18	26.8	nda	109.8	0.0201	0.0032
Monasterevin WS(spring@Hybla)	KID	14	Monasterevin WS(spring@Hybla)			N642125	264230	212502	Spring	DUB	5811	11/21/00	7.467	nda	9.9	9.9	nda	4.15	4.15		nda	693	717	Monasterevin WS(spring@Hybla)	<0.01	<0.005	2.226	nda	9.86*	nda	240	13.9	nda	nda	<1	DCORP	19.5	nda	6.9	<1	26.2	nda	96.5	<0.05	0.0046
Monasterevin WS(spring@Hybla)	KID	14	Monasterevin WS(spring@Hybla)			N642125	264230	212502	Spring	DUB	1469	04/04/01	7.33	nda	9.3	9.3	nda	4.92	4.92		nda	695	723	Monasterevin WS(spring@Hybla)	0.04	0.018274	3.27	nda	14.48*	nda	310	11.08	nda	nda	<1	DCORP	20.2	nda	9.3	0.2	28.8	nda	103.1	0.0698	0.0019
Monastrevin WS (BH No.1(Ballykelly))	KID	15	Monastrevin WS (BH No.1(Ballykelly))	Ballykelly		N642125	264354	203229	Bore	DUB	3716	11/21/95	7.25		nda		nda	nda			nda	804		Monastrevin WS (BH No.1(Ballykelly))	<0.005	0.009	6.012	6.27	27.76356	nda	320	19.52	nda	nda	nda		57.66	nda	9.36	2.14	31.88	nda	109.29	0.0066	0.0494
Monastrevin WS (BH No.1(Ballykelly))	KID	15	Monastrevin WS (BH No.1(Ballykelly))	Ballykelly		N642125	264230	212502	Bore	DUB	3012	08/22/96	7.2		nda		nda	nda			nda	837		Monastrevin WS (BH No.1(Ballykelly))	<0.01	0.006	8.175	nda	36.22*	nda	348	21.28	nda	nda	nda		61.05	nda	7.88	1.71	30.18	nda	127.13	0.0926	0.0149
Monastrevin WS (BH No.1(Ballykelly))	KID	15	Monastrevin WS (BH No.1(Ballykelly))	Ballykelly		N642125	264230	212502	Bore	DUB	4081	11/19/96	7.2		nda		nda	nda			nda	857		Monastrevin WS (BH No.1(Ballykelly))	<0.01	0.007	8.154	nda	36.09*	nda	356	21.24	nda	nda	nda		64.18	nda	8.59	1.96	32.55	nda	143.8	0.0081	0.0143
Monastrevin WS (BH No.1(Ballykelly))	KID	15	Monastrevin WS (BH No.1(Ballykelly))	Ballykelly		S642125	264230	212502	Bore	DUB	3166	09/09/98	7.19		nda		nda	nda			nda	759		Monastrevin WS (BH No.1(Ballykelly))	<0.01	0.009	8.437	nda	37.37*	nda	341	20.9	nda	nda	nda		61.7	nda	10.4	2.3	31.3	nda	130.1	0.0142	0.0173
Monastrevin WS (BH No.1(Ballykelly))	KID	15	Monastrevin WS (BH No.1(Ballykelly))	Ballykelly		S642125	264230	212502	Bore	DUB	91	01/13/99	7.28	nda	11.2	10.8	nda	nda		7.28	67.7	nda	753	nda	Monastrevin WS (BH No.1(Ballykelly))	<0.01	0.009	7.779	nda	34.45*	nda	337	24.8	nda	nda	nda		77.6	nda	11.4	2.9	35.8	nda	162	0.0063	0.0225
Monastrevin WS (BH No.1(Ballykelly))	KID	15	Monastrevin WS (BH No.1(Ballykelly))	Ballykelly		S642125	264230	212502	Bore	DUB	5812	11/21/00	7.319	nda	10.8	10.8	nda	nda	nda			nda	880	911	Monastrevin WS (BH No.1(Ballykelly))	0.059	<0.005	4.077	nda	18.05*	nda	257	19.2	nda	nda	<1	DCORP	74.3	nda	8.2	1.4	31.4	nda	130.2	<0.05	0.0629
Monastrevin WS (BH No.1(Ballykelly))	KID	15	Monastrevin WS (BH No.1(Ballykelly))	Ballykelly		S642125	264230	212502	Bore	DUB	1470	04/04/01	7.202	nda	10.7	10.7	nda	5.36	5.36		nda	871	911	Monastrevin WS (BH No.1(Ballykelly))	<0.01	0.014014	6.722	nda	29.77*	nda	350	14.12	nda	nda	<1	DCORP	59.9	nda	10.03	1.86	33.9	nda	126	<0.05	0.0231
Churchtown WS	KID	18	Churchtown WS	Churchtown		S640955	264000	195500	Bore	DUB	3015	08/22/96	7.3		nda		nda	nda			nda	728		Churchtown WS	<0.01	0.016	12.548	nda	55.57*	nda	276	33.22	nda	nda	nda		24.2	nda	10.55	1.95	12.4	nda	118.36	0.287	<0.0005
Churchtown WS	KID	18	Churchtown WS	Churchtown		S640955	264000	195500	Bore	DUB	4078	11/19/96	7.34		nda		nda	nda			nda	696		Churchtown WS	<0.01	0.014	9.784	nda	43.31*	nda	288	29.13	nda	nda	nda		21.55	nda	10.57	1.32	13.04	nda	116	0.185	<0.0005
Churchtown WS	KID	18	Churchtown WS	Churchtown		S640955	264000	195500	Bore	DUB	4328	11/04/97	7.32		nda		nda	nda			nda	647		Churchtown WS	<0.01	0.016	12.147	nda	53.80*	nda	272	37.466	nda	nda	nda		21.072	nda	11.4	0.731	13.834	nda	124.626	0.021	<0.0005
Churchtown WS	KID	18	Churchtown WS	Churchtown		S640955	264000	195500	Bore	DUB	4714	12/09/97	7.46		nda		nda	nda			nda	666		Churchtown WS	0.014	0.016	12.76	nda	56.50*	nda	274	nda	nda	nda	nda		nda	nda	nda	nda	nda	nda	nda	0.015	0.0017
Churchtown WS	KID	18	Churchtown WS	Churchtown		S640955	264000	195500	Bore	DUB	696	02/12/98	7.37		nda		nda	nda			nda	607		Churchtown WS	<0.01	0.013	13.136	nda	58.18*	nda	268	33	nda	nda	nda		21.6	nda	11.3	1.6	13.3	nda	127.1	0.003	<0.0005
Churchtown WS	KID	18	Churchtown WS	Churchtown		S640955	264000	195500	Bore	DUB	3153	09/08/98	7.44		nda		nda	nda			nda	667		Churchtown WS	<0.01	0.0143	13.008	nda	57.61*	nda	262	31.9	nda	nda	nda		22.8	nda	14.6	2	14.5	nda	119.1	<0.01	<0.0005
Churchtown WS	KID	18	Churchtown WS	Churchtown		S640955	264000	195500	Bore	DUB	58	01/12/99	7.36	nda	10.4	10.4	nda	nda		8.73	80.6	nda	637	nda	Churchtown WS	<0.01	0.014	10.982	nda	48.62*	nda	267	37.2	nda	nda	nda		26	nda	14.3	2.1	16.1	nda	144.7	<0.0005	0.0006
Churchtown WS	KID	18	Churchtown WS	Churchtown		S640955	264000	195500	Bore	DUB	2774	09/20/99	7.25	nda	10.8	10.6	nda	nda		7.8		nda	637	767	Churchtown WS	<0.01	0.013	10	nda	44.28*	nda	270	29	nda	nda	nda		20.9	nda	11.79	1.53	16.87	nda	115.8	<0.02	<0.0005
Churchtown WS	KID	18	Churchtown WS	Churchtown		S640955	264000	195500	Bore	DUB	727	02/09/00	7.33	nda	10.8	10.8	nda	nda		8.85		nda	693	775	Churchtown WS	<0.01	0.011	9.99	nda	44.24*	nda	325	28.4	nda	nda	nda		21.4	nda	12.7	1.69	14.6	nda	126.2	<0.02	<0.0005
Churchtown WS	KID	18	Churchtown WS	Churchtown		S640955	264000	195500	Bore	DUB	5808	11/21/00	7.395	nda	10	10	nda	8.1	8.1		nda	735	759	Churchtown WS	<0.01	0.006101	10.554	nda	46.73*	nda	263	30.6	nda	nda	<1	DCORP	21.4	nda	10.5	<1	15.5	nda	112.6	<0.05	<0.001
Churchtown WS	KID	18	Churchtown WS	Churchtown		S640955	264000	195500	Bore	DUB	1466	04/04/01	7.242	nda	10.8	10.8	nda	8.63	8.63		nda	734	753	Churchtown WS	<0.01	0.026112	10.057	nda	44.53*	nda	275	20.83	nda	nda	<1	DCORP	24.9	nda	13.49	1.78	14.18	nda	107	<0.05	<0.001
Monasterevin WS (Lughill)	KID	20	Monasterevin WS (Lughill)			N635064	263507	206482	3 No. Sp	DUB	3717	11/21/95	7.27		nda		nda	nda			nda	725		Monasterevin WS (Lughill)	<0.005	0.016	6.243	6.67	29.53476	nda	273.798	23.45	nda	nda	nda		25.94	nda	11.45	1.89	14.66	nda	108.28	0.0389	0.0051
Monasterevin WS (Lughill)	KID	20	Monasterevin WS (Lughill)			N635064	263507	206482	3 No. Sp	DUB	3013	08/22/96	7.18		nda		nda	nda			nda	732		Monasterevin WS (Lughill)	<0.01	0.01	7.736	nda	34.27*	nda	316	25.85	nda	nda	nda		25.73	nda	10.44	1.83	12.94	nda	123.76	0.5	0.0051
Monasterevin WS (Lughill)	KID	20	Monasterevin WS (Lughill)			N635064	263507	206482	3 No. Sp	DUB	4080	11/19/96	7.18		nda		nda	nda			nda	747		Monasterevin WS (Lughill)	<0.01	0.009	8.132	nda	36.0*	nda	318	25.8	nda	nda	nda		25.35	nda	10.57	1.86	9.17	nda	134.9	0.0194	<0.0005
Monasterevin WS (Lughill)	KID	20	Monasterevin WS (Lughill)			N635064	263507	206482	3 No. Sp	DUB	4330	11/04/97	7.17		nda		nda	nda			nda	665		Monasterevin WS (Lughill)	<0.01	0.009	7.72	nda	34.18*	nda	318	25.731	nda	nda	nda		20.232	nda	10.109	0.775	11.337	nda	136.664	0.076	0.0006
Monasterevin WS (Lughill)	KID	20	Monasterevin WS (Lughill)			N635064	263507	206482	3 No. Sp	DUB	652	02/11/98	7.21		nda		nda	nda			nda	653		Monasterevin WS (Lughill)	<0.01	0.009	8.327	nda	36.89*	nda	318	32.523	nda	nda	nda		22.805	nda	10.965	1.812	12.085	nda	132.3	0.0248	<0.0005
Monasterevin WS (Lughill)	KID	20	Monasterevin WS (Lughill)			N635064	263507	206482	3 No. Sp	DUB	3165	09/09/98	7.23		nda		nda	nda			nda	644		Monasterevin WS (Lughill)	<0.01	0.011	8.332	nda	36.89*	nda	302	23.4	nda	nda	nda		23.5	nda	13.9	1.7	14.3	nda	123.3	0.0526	0.0031
Monasterevin WS (Lughill)	KID	20	Monasterevin WS (Lughill)			N635064	263507	206482	3 No. Sp	DUB	90	01/13/99	7.17		10.8		nda	nda			nda	663		Monasterevin WS (Lughill)	<0.01	0.011	9.154	nda	40.52*	nda	308	24.8	nda	nda	nda		21.8	nda	12.7	2.3	12.2	nda	161.7	<0.0005	0.001
Monasterevin WS (Lughill)	KID	20	Monasterevin WS (Lughill)			N635064	263507	206482	3 No. Sp	DUB	2794	09/21/99	7.19	nda	11.2	11.2	nda	nda		5.6		nda	659	804	Monasterevin WS (Lughill)	<0.01	0.007	7.696	nda	34.10*	nda	291	24.7	nda	nda	nda		25.4	nda	12.72	1.63	15.42	nda	128.3	0.0022	<0.0005
Monasterevin WS (Lughill)	KID	20	Monasterevin WS (Lughill)			N635064	263507	206482	3 No. Sp	DUB	725	02/09/00	7.22	nda	10.9	10.9	nda	nda		6.83		nda	701	789	Monasterevin WS (Lughill)	<0.01	0.007	7.41	nda	32.81*	nda	287	21	nda	nda	nda		20	nda	12.03	1.84	13.07	nda	133.8	<0.02	<0.0005
Monasterevin WS (Lughill)	KID	20	Monasterevin WS (Lughill)			N635064	263507	206482	3 No. Sp	DUB	5810	11/21/00	7.262	nda	10.7	10.7	nda	6.36	6.36		nda	773	800	Monasterevin WS (Lughill)	0.018	<0.005	8.45	nda	37.42*	nda	279	23.1	nda	nda	<1	DCORP	20.7	nda	9.3	<1	12	nda	126.3	<0.05	<0.001
Monasterevin WS (Lughill)	KID	20	Monasterevin WS (Lughill)			N635064	263507	206482	3 No. Sp	DUB	1468	04/04/01	7.075	nda	10.8	10.8	nda	6.56	6.56		nda	753	785	Monasterevin WS (Lughill)	0.02	0.016167	8.159	nda	36.13*	nda	300	15.96	nda	nda	<1	DCORP	23.1	nda	11.88	0.84	12.08	nda	127.2	0.1549	0.0034
Newtown / Kilcock WS	KID	22	Newtown / Kilcock WS			N818394	281850	239447	Bore	DUB	3715	11/21/95	7.31		nda		nda	nda			nda	574		Newtown / Kilcock WS	0.14	0.013	0.06	0.13	0.57564	nda	210.665	13.69	nda	nda	nda		41.3	nda	7.5	2.51	6.05	nda	95.96	1.952	0.113
Newtown / Kilcock WS	KID	22	Newtown / Kilcock WS			N818394	281850	239447	Bore	DUB	2954	08/20/96	7.16		nda		nda	nda			nda	624		Newtown / Kilcock WS	0.078	0.009	0.084	nda	0.35*	nda	248	14.4	nda	nda	nda		70	nda	7.28	2.74	5.91	nda	124.9	5.046	0.398
Newtown / Kilcock WS	KID	22	Newtown / Kilcock WS			N818394	281850	239447	Bore	DUB	4101	11/21/96	7.26		nda		nda	nda			nda	576		Newtown / Kilcock WS	0.137	0.015	0.062	nda	0.27*	nda	252	10.51	nda	nda	nda		41.38	nda	8.31	2.41	2.09	nda	94.41	1.468	0.135
Newtown / Kilcock WS	KID	22	Newtown / Kilcock WS			N818394	281850	239447	Bore	DUB	4710	12/09/97	7.23		nda		nda	nda			nda	557		Newtown / Kilcock WS	0.134	0.012	0.1	nda	0.44*	nda	254	nda	nda	nda	nda		nda	nda	nda	nda	nda	nda	nda	4.585	0.144
Newtown / Kilcock WS	KID	22	Newtown / Kilcock WS			N818394	281850	239447	Bore	DUB	649	02/11/98	7.24		nda		nda	nda			nda	539		Newtown / Kilcock WS	0.163	0.013	0.027	nda	0.13*	nda	322	16.772	nda	nda	nda		100.161	nda	7.226	2.209	6.794	nda	124.6	4.072	0.157
Newtown / Kilcock WS	KID	22	Newtown / Kilcock WS			N818394	281850	239447	Bore	DUB	3169	09/09/98	7.25		nda		nda	nda			nda	542		Newtown / Kilcock WS	0.197	0.017	<0.01	nda	<0.04*	nda	220	11.8	nda	nda	nda		61.7	nda	9.1	2.8	6.6	nda	114.7	2.134	0.147
Newtown / Kilcock WS	KID	22	Newtown / Kilcock WS			N818394	281850	239447	Bore	DUB	94	01/13/99	7.3	nda	11.8	9.5	nda	nda		7.2	64.5	nda	543	nda	Newtown / Kilcock WS	0.17	0.015	0.021	nda	0.9*	nda	258	14.8	nda	nda	nda		75	nda	8.3	2.5	7.5	nda	140.6	3.065	0.211
Newtown / Kilcock WS	KID	22	Newtown / Kilcock WS			N818394	281850	239447	Bore	DUB	2792	09/21/99	7.3	nda	13.9	13.9	nda	nda		3		nda	535	648	Newtown / Kilcock WS	0.068	0.011	0.127	nda	0.56*	nda	245	13.77	nda	nda	nda		50.6	nda	7.67	2.22	6.58	nda	108.5	1.135	0.1041
Newtown / Kilcock WS	KID	22	Newtown / Kilcock WS			N818394	281850	239447	Bore	DUB	692	02/07/00	7.19	nda	11.3	11.3	nda	nda		3.52		nda	589	633	Newtown / Kilcock WS	0.14	0.015	0.07	nda	0.31*	nda	252	13.45	nda	nda	nda		73.6	nda	7.82	2.26	6.57	nda	121.8	1.0674	0.1286
Newtown / Kilcock WS	KID	22	Newtown / Kilcock WS			N818394	281850	239447	Bore	DUB	5793	11/20/00	7.16	nda	12.7	12.7	nda	0.41	0.41		nda	611	624	Newtown / Kilcock WS	0.172	0.103611	0.042	nda	0.19*	nda	244	11.5	nda	nda	<1	DCORP	52.4	nda	6.6	1.3	6.6	nda	107.4	1.6531	0.1539
Newtown / Kilcock WS	KID	22	Newtown / Kilcock WS			N818394	281850	239447	Bore	DUB	1377	04/03/01	7.183	nda	12.7	12.7	nda	3.63	3.63		nda	622	645	Newtown / Kilcock WS	0.08	0.007104	0.142	nda	0.63*	nda	238	9.92	nda	nda	<1	DCORP	70	nda	8.07	1.17	5.94	nda	104.85	1.0454	0.2133
Pollardstown Fen	KID	23	Pollardstown Fen	Pollardstown Fen		N773154	277282	215459	Spring	DUB	3714	11/21/95	7.34		nda		nda	nda			nda	672		Pollardstown Fen	<0.005	0.012	2.84	2.92	12.92976	nda	302.489	13.69	nda	nda	nda		18.97	nda	10.01	1.45	19.08	nda	98.48	0.144	0.0152
Pollardstown Fen	KID	23	Pollardstown Fen	Pollardstown Fen		N773154	277282	215459	Spring	DUB	2957	08/20/96	7.24		nda		nda	nda			nda	679		Pollardstown Fen	<0.01	0.011	2.933	nda	12.97*	nda	338	14.7	nda	nda	nda		18.6	nda	11.59	1.51	19.07	nda	119.2	0.239	0.0197
Pollardstown Fen	KID	23	Pollardstown Fen	Pollardstown Fen		N773154	277282	215459	Spring	DUB	4105	11/21/96	7.3		nda		nda	nda			nda	681		Pollardstown Fen	<0.01	0.004	2.932	nda	12.97*	nda	318	12.84	nda	nda	nda		17.9	nda	10.14	0.52	18.5	nda	129.7	0.0223	0.0047
Pollardstown Fen	KID	23	Pollardstown Fen	Pollardstown Fen		N773154	277282	215459	Spring	DUB	4332	11/04/97	7.28		nda		nda	nda			nda	595		Pollardstown Fen	<0.01	0.01	2.87	nda	12.71*	nda	330	12.511	nda	nda	nda		16.687	nda	8.762	<0.01	18.875	nda	112.923	0.194	0.0138
Pollardstown Fen	KID	23	Pollardstown Fen	Pollardstown Fen		N773154	277282	215459	Spring	DUB	692	02/12/98	7.36		nda		nda	nda			nda	597		Pollardstown Fen	<0.01	0.007	2.855	nda	12.66*	nda	322	13.8	nda	nda	nda		18.3	nda	10.8	0.7	19.6	nda	112.7	0.223	0.006
Pollardstown Fen	KID	23	Pollardstown Fen	Pollardstown Fen		N773154	277282	215459	Spring	DUB	3151	09/08/98	7.33		nda		nda	nda			nda	602		Pollardstown Fen	<0.01	0.0109	3.095	nda	13.73*	nda	319	12.8	nda	nda	nda		18	nda	11.6	0.7	19.6	nda	109.2	0.1	0.0097
Pollardstown Fen	KID	23	Pollardstown Fen	Pollardstown Fen		N773154	277282	215459	Spring	DUB	3151	09/08/98	7.33		nda		nda	nda			nda	602		Pollardstown Fen	<0.01	0.011	3.1	nda	13.73*	nda	319	12.8	nda	nda	nda		18	nda	11.6	0.7	19.6	nda	109.2	0.1	0.0097
Pollardstown Fen	KID	23	Pollardstown Fen	Pollardstown Fen		N773154	277282	215459	Spring	DUB	89	01/13/99	7.33	nda	9.6	9.6	nda	nda		6.17	56	nda	568	nda	Pollardstown Fen	<0.01	0.014	2.846	nda	12.62*	nda	302	16.4	nda	nda	nda		20.8	nda	11.8	0.9	21.4	nda	130	0.111	0.0077
Pollardstown Fen	KID	23	Pollardstown Fen	Pollardstown Fen		N773154	277282	215459	Spring	DUB	2795	09/21/99	7.43	nda	11.3	11.3	nda	nda		7.3		nda	607	723	Pollardstown Fen	<0.01	0.011	2.963	nda	13.12*	nda	290	15.85	nda	nda	nda		19.78	nda	11.19	0.66	19.95	nda	111.7	0.0998	0.0153
Pollardstown Fen	KID	23	Pollardstown Fen	Pollardstown Fen		N773154	277282	215459	Spring	DUB	722	02/09/00	7.42	nda	9.9	9.9	nda	nda		8.72		nda	632	710	Pollardstown Fen	<0.01	0.007	2.85	nda	12.62*	nda	257	15.9	nda	nda	nda		19.4	nda	10.92	0.63	19.69	nda	116.8	<0.02	0.0014
Pollardstown Fen	KID	23	Pollardstown Fen	Pollardstown Fen		N773154	277282	215459	Spring	DUB	5796	11/20/00	7.198	nda	9.9	9.9	nda	3.68	3.68		nda	681	697	Pollardstown Fen	<0.01	0.075726	2.757	nda	12.21*	nda	290	12.5	nda	nda	23	DCORP	17.8	nda	6.9	<1	14.4	nda	95.1	<0.05	0.0272
Pollardstown Fen	KID	23	Pollardstown Fen	Pollardstown Fen		N773154	277282	215459	Spring	DUB	1380	04/03/01	7.319	nda	10.2	10.2	nda	7.25	7.25		nda	677	703	Pollardstown Fen	<0.01	0.005654	2.974	nda	13.17*	nda	318	10.89	nda	nda	10	DCORP	20.05	nda	10.36	<1	17.65	nda	98.85	<0.05	0.0032
Clogherinkoe WS	KID	40	Clogherinkoe WS			N658387	265500	239000	Bore	DUB	2955	08/20/96	7.36		nda		nda	nda			nda	608		Clogherinkoe WS	<0.01	0.059	1.333	nda	5.89*	nda	300	11.4	nda	nda	nda		20.7	nda	8.71	0.93	12.6	nda	111	0.201	0.0736
Clogherinkoe WS	KID	40	Clogherinkoe WS		Clogheri	N658387	265500	239000	Bore	DUB	4102	11/21/96	7.38		nda		nda	nda			nda	615		Clogherinkoe WS	<0.01	0.047	2.302	nda	10.18*	nda	298	10.55	nda	nda	nda		24.49	nda	10.24	2.14	8.25	nda	119.1	0.0186	0.0256
Clogherinkoe WS	KID	40	Clogherinkoe WS			N658387	265500	239000	Bore	DUB	4367	11/06/97	7.41		nda		nda	nda			nda	524		Clogherinkoe WS	0.012	0.048	2.133	nda	9.43*	nda	282	17.708	nda	nda	nda		25.367	nda	14.3	1.097	12.757	nda	110.966	<0.001	0.017
Clogherinkoe WS	KID	40	Clogherinkoe WS			N658387	265500	239000	Bore	DUB	4711	12/09/97	7.4		nda		nda	nda			nda	552		Clogherinkoe WS	0.028	0.047	2.483	nda	10.98*	nda	298	nda	nda	nda	nda		nda	nda	nda	nda	nda	nda	nda	0.024	0.0185
Clogherinkoe WS	KID	40	Clogherinkoe WS			N658387	265500	239000	Bore	DUB	650	02/11/98	7.37		nda		nda	nda			nda	534		Clogherinkoe WS	<0.01	0.05268	2.306	nda	10.23*	nda	340	13.384	nda	nda	nda		24.659	nda	9.45	0.67	12.625	nda	106.1	0.0083	0.0134
Clogherinkoe WS	KID	40	Clogherinkoe WS			N658387	265500	239000	Bore	DUB	3168	09/09/98	7.37		nda		nda	nda			nda	541		Clogherinkoe WS	<0.01	0.049	2.1	nda	9.30*	nda	269	10.3	nda	nda	nda		22.9	nda	12.8	2	13.1	nda	106.6	<0.01	0.0153
Clogherinkoe WS	KID	40	Clogherinkoe WS			N658387	265500	239000	Bore	DUB	93	01/13/99	7.39		10.8		nda	nda			nda	547		Clogherinkoe WS	<0.01	0.045	3.592	nda	15.90*	nda	291	12.8	nda	nda	nda		28.6	nda	11.9	1.1	14	nda	131.8	0.0097	0.0141
Clogherinkoe WS	KID	40	Clogherinkoe WS			N658387	265500	239000	Bore	DUB	2793	09/21/99	7.29	nda	11	11	nda	nda		3.8		nda	548	663	Clogherinkoe WS	<0.01	0.058	1.939	nda	8.59*	nda	288	11.85	nda	nda	nda		22.6	nda	10.7	0.82	13.44	nda	108.1	0.1462	0.1351
Clogherinkoe WS	KID	40	Clogherinkoe WS			N658387	265500	239000	Bore	DUB	693	02/07/00	7.28	nda	10.8	10.8	nda	nda		6.41		nda	580	653	Clogherinkoe WS	0.02	0.049	2.43	nda	10.76*	nda	265	11.96	nda	nda	nda		23.8	nda	10.53	0.75	12.44	nda	110.2	0.0316	0.0414
Clogherinkoe WS	KID	40	Clogherinkoe WS			N658387	265500	239000	Bore	DUB	5794	11/20/00	7.426	nda	10.4	10.4	nda	nda		3.91		nda	620	637	Clogherinkoe WS	0.01	0.119055	2.185	nda	9.68*	nda	285	9.6	nda	nda	<1	DCORP	21.6	nda	9.5	<1	11.6	nda	95.5	<0.05	0.0095
Clogherinkoe WS	KID	40	Clogherinkoe WS			N658387	265500	239000	Bore	DUB	1378	04/03/01	7.292	nda	10.8	10.8	nda	2.97	2.97		nda	619	646	Clogherinkoe WS	<0.01	0.046382	2.235	nda	9.90*	nda	272	9.13	nda	nda	<1	DCORP	24.35	nda	10.3	<1	11.6	nda	94.75	<0.05	0.0387
Hare Park (Curragh Camp)	KID	42	Hare Park (Curragh Camp)			N770115	277011	211522	Bore	DUB	3046	08/27/96	6.92		nda		nda	nda			nda	788		Hare Park (Curragh Camp)	<0.01	0.018	4.461	nda	19.75*	nda	322	26.24	nda	nda	nda		3.58	nda	33.92	2.21	13.49	nda	145.62	0.293	0.0015
Hare Park (Curragh Camp)	KID	42	Hare Park (Curragh Camp)		HarePar	N770115	277011	211522	Bore	DUB	4103	11/21/96	7.24		nda		nda	nda			nda	790		Hare Park (Curragh Camp)	<0.01	0.01	4.327	nda	19.17*	nda	352	20.33	nda	nda	nda		42.67	nda	17.39	2.51	11.92	nda	161.2	0.0315	<0.0005
Hare Park (Curragh Camp)	KID	42	Hare Park (Curragh Camp)			N770115	277011	211522	Bore	DUB	4369	11/06/97	7.25		nda		nda	nda			nda	694		Hare Park (Curragh Camp)	<0.01	0.008	3.972	nda	17.58*	nda	352	23.415	nda	nda	nda		34.382	nda	17.501	1.389	14.61	nda	137.181	0.05	0.0011
Hare Park (Curragh Camp)	KID	42	Hare Park (Curragh Camp)			N770115	277011	211522	Bore	DUB	694	02/12/98	7.25		nda		nda	nda			nda	719		Hare Park (Curragh Camp)	<0.01	0.01	4.298	nda	19.04*	nda	338	33	nda	nda	nda		27.7	nda	23.3	2.1	13.6	nda	136.3	0.012	<0.0005
Hare Park (Curragh Camp)	KID	42	Hare Park (Curragh Camp)			N770115	277011	211522	Bore	DUB	3164	09/09/98	7.21		nda		nda	nda			nda	707		Hare Park (Curragh Camp)	<0.01	0.022	5.693	nda	25.20*	nda	325	27.1	nda	nda	nda		28.5	nda	22.6	2.2	12.7	nda	133	0.0371	0.0069
Hare Park (Curragh Camp)	KID	42	Hare Park (Curragh Camp)			N770115	277011	211522	Bore	DUB	55	01/12/99	7.375	nda	10.4	10.4	nda	nda		8.33	76.7	nda	675	nda	Hare Park (Curragh Camp)	<0.01	0.018115	4.404	nda	19.48*	nda	322	40.6	nda	nda	nda		29.3	nda	26.6	2.5	13.7	nda	150.3	0.0088	0.001
Hare Park (Curragh Camp)	KID	42	Hare Park (Curragh Camp)			N770115	277011	211522	Bore	DUB	2772	09/20/99	7.14	nda	11.1	11.1	nda	nda		8.7		nda	708	876	Hare Park (Curragh Camp)	<0.01	0.015	4.918	nda	21.78*	nda	325	27.5	nda	nda	nda		24.8	nda	20.1	2.08	13.47	nda	133.8	<0.02	<0.0005
Hare Park (Curragh Camp)	KID	42	Hare Park (Curragh Camp)			N770115	277011	211522	Bore	DUB	694	02/07/00	7.21	nda	10.6	10.6	nda	nda		8.9		nda	736	831	Hare Park (Curragh Camp)	<0.01	0.005	4.43	nda	19.62*	nda	341	30.73	nda	nda	nda		23.7	nda	21.53	2.09	12.59	nda	133.33	<0.02	<0.0005
Hare Park (Curragh Camp)	KID	42	Hare Park (Curragh Camp)			N770115	277011	211522	Bore	DUB	1471	04/04/01	7.266	nda	10.7	10.7	nda	9.26	9.26		nda	838	876	Hare Park (Curragh Camp)	0.02	0.011823	5.085	nda	22.52*	nda	330	36.5	nda	nda	<1	DCORP	30.2	nda	23.6	0.82	15.65	nda	130	<0.05	<0.001
McDonagh(Curragh Camp)	KID	50	McDonagh(Curragh Camp)	McDonagh Pump Stn		N788117	278814	211736	Bore	DUB	3047	08/27/96	7.16		nda		nda	nda			nda	744		McDonagh(Curragh Camp)	<0.01	0.127	5.638	nda	24.97*	nda	293	18.31	nda	nda	nda		5.27	nda	21.32	1.66	12.96	nda	147.09	0.146	0.0015
McDonagh(Curragh Camp)	KID	50	McDonagh(Curragh Camp)	McDonagh Pump Stn		N788117	278814	211736	Bore	DUB	4104	11/21/96	7.84		nda		nda	nda			nda	687		McDonagh(Curragh Camp)	<0.01	0.282	4.835	nda	21.43*	nda	332	11.5	nda	nda	nda		19.43	nda	11.82	0.78	12.7	nda	138.8	0.155	0.001
McDonagh(Curragh Camp)	KID	50	McDonagh(Curragh Camp)	McDonagh Pump Stn		N788117	278814	211736	Bore	DUB	4712	12/09/97	7.83		nda		nda	nda			nda	595		McDonagh(Curragh Camp)	0.015	0.012	4.597	nda	20.37*	nda	332	nda	nda	nda	nda		nda	nda	nda	nda	nda	nda	nda	0.011	0.0018
McDonagh(Curragh Camp)	KID	50	McDonagh(Curragh Camp)	McDonagh Pump Stn		N788117	278814	211736	Bore	DUB	693	02/12/98	7.76		nda		nda	nda			nda	601		McDonagh(Curragh Camp)	<0.01	0.012	4.596	nda	20.37*	nda	320	11.1	nda	nda	nda		18.9	nda	8.2	0.5	15.9	nda	121.2	0.0015	<0.0005
McDonagh(Curragh Camp)	KID	50	McDonagh(Curragh Camp)	McDonagh Pump Stn		N788117	278814	211736	Bore	DUB	3150	09/08/98	7.69		nda		nda	nda			nda	624		McDonagh(Curragh Camp)	<0.01	0.0133	5.218	nda	23.11*	nda	344	11	nda	nda	nda		19.2	nda	9.1	1	16	nda	117.5	<0.01	<0.0005
McDonagh(Curragh Camp)	KID	50	McDonagh(Curragh Camp)	McDonagh Pump Stn		N788117	278814	211736	Bore	DUB	56	01/12/99	7.87	nda	9.8	9.8	nda	nda		12.31	113	nda	597	nda	McDonagh(Curragh Camp)	<0.01	0.011822	4.825	nda	21.39*	nda	310	14.7	nda	nda	nda		22	nda	9.8	0.8	16.9	nda	140.8	0.0125	0.0006
McDonagh(Curragh Camp)	KID	50	McDonagh(Curragh Camp)	McDonagh Pump Stn		N788117	278814	211736	Bore	DUB	2773	09/20/99	7.61	nda	10.6	10.6	nda	nda		11.8		nda	621	730	McDonagh(Curragh Camp)	<0.01	0.011	5.248	nda	23.24*	nda	289	14.14	nda	nda	nda		19.3	nda	8.28	0.58	15.88	nda	118.4	<0.02	<0.0005
McDonagh(Curragh Camp)	KID	50	McDonagh(Curragh Camp)	McDonagh Pump Stn		N788117	278814	211736	Bore	DUB	695	02/07/00	7.76	nda	10.4	0.4	nda	nda		12.1		nda	640	720	McDonagh(Curragh Camp)	<0.01	0.01	4.84	nda	21.43*	nda	322	13.37	nda	nda	nda		19.78	nda	8.34	0.58	15.67	nda	118.8	<0.02	<0.0005
McDonagh(Curragh Camp)	KID	50	McDonagh(Curragh Camp)	McDonagh Pump Stn		N788117	278814	211736	Bore	DUB	5795	11/20/00	7.785	nda	9.9	9.9	nda	nda		11.98		nda	688	707	McDonagh(Curragh Camp)	<0.01	0.08722	4.875	nda	21.59*	nda	313	10.9	nda	nda	<1	DCORP	19.6	nda	7.4	0.5	14.7	nda	96	<0.05	<0.001
McDonagh(Curragh Camp)	KID	50	McDonagh(Curragh Camp)	McDonagh Pump Stn		N788117	278814	211736	Bore	DUB	1379	04/03/01	7.695	nda	10.4	10.4	nda	12.22	12.22		nda	687	717	McDonagh(Curragh Camp)	0.02	0.011522	5.369	nda	23.77*	nda	320	9.72	nda	nda	<1	DCORP	18.7	nda	8.56	<1	14.85	nda	102.35	<0.05	<0.001
Martinstown	KID	72	Martinstown			N773064	277283	206406		DUB	4713	12/09/97	7.24		nda		nda	nda			nda	730		Martinstown	0.023	0.018	10.528	nda	46.63*	nda	352	nda	nda	nda	nda		nda	nda	nda	nda	nda	nda	nda	0.028	0.0029
Osborne Lodge	KID	74	Osborne Lodge			N756147	275579	214671		DUB	2956	08/20/96	7.15		nda		nda	nda			nda	641		Osborne Lodge	<0.01	0.007	1.412	nda	6.25*	nda	338	9	nda	nda	nda		9.3	nda	6.24	0.71	9.8	nda	128.6	0.939	0.0209
Monasterevin WS BH No.1 & Spring)	KID	80	Monasterevin WS BH No.1 & Spring)	Ballykelly		N641126	264100	212600		DUB	4331	11/04/97	7.28		nda		nda	nda			nda	707		Monasterevin WS BH No.1 & Spring)	<0.01	0.007	5.845	nda	25.90*	nda	330	18.378	nda	nda	nda		46.514	nda	8.133	0.664	28.372	nda	125.432	<0.001	0.0111
Monasterevin WS BH No.1 & Spring)	KID	80	Monasterevin WS BH No.1 & Spring)	Ballykelly		N641126	264100	212600		DUB	651	02/11/98	7.29		nda		nda	nda			nda	689		Monasterevin WS BH No.1 & Spring)	<0.01	<0.005	5.979	nda	26.48*	nda	328	23.975	nda	nda	nda		52.301	nda	8.576	1.671	28.33	nda	121	0.0413	0.0099
Monasterevin WS(sprng+Bore1+2)	KID	80	Monasterevin WS(sprng+Bore1+2)			S642125	264230	212502		DUB	3201	10/11/99	7.22	nda	11.2	11.2	nda	nda	nda			nda	740	954	Monasterevin WS(sprng+Bore1+2)	<0.01	0.006	8.05	nda	35.65*	nda	332	21.9	nda	nda	nda		75.4	nda	10.36	2.81	32.5	nda	150.6	<0.02	0.0156
Monasterevin WS(sprng+Bore1+2)	KID	80	Monasterevin WS(sprng+Bore1+2)			S642125	264230	212502		DUB	723	02/09/00	7.19	nda	10.9	10.9	nda	nda		5.11		nda	878	986	Monasterevin WS(sprng+Bore1+2)	<0.01	0.007	7.23	nda	32.01*	nda	308	20.4	nda	nda	nda		83.6	nda	11.07	3.63	30	nda	151.4	<0.02	0.0146