Callan Source

Extracted from:
County Kilkenny Groundwater Protection Scheme,
Volume II: Source Protection Zones (Draft. May 2002)

County Kilkenny
Groundwater Protection Scheme

Volume II: Source Protection Zones

(Draft. May 2002)

Tom Gunning, B.E., C.Eng., F.I.E.I.
Director of Services
Kilkenny County Council
County Hall
Kilkenny

Ruth Buckley and Vincent Fitzsimons
Groundwater Section
Geological Survey of Ireland
Beggars Bush
Haddington Road
Dublin 4

Authors

Ruth Buckley, Groundwater Section, Geological Survey of Ireland

Vincent Fitzsimons, Groundwater Section, Geological Survey of Ireland

with contributions by:

Susan Hegarty, Quaternary Section Geological Survey of Ireland

Cecilia Gately, Groundwater Section Geological Survey of Ireland

Subsoils mapped by:

Susan Hegarty, Quaternary Section, Geological Survey of Ireland

Supervision: Willie Warren, Quaternary Section, Geological Survey of Ireland

in collaboration with:

Kilkenny County Council

Table of Contents

Sections 1 to 6 are contained within Volume I. They comprise an overall introduction, classifications of aquifers and vulnerability, and overall conclusions.

Overall conclusions are contained within Volume I.

9. Callan Source

9.1 Introduction

The objectives of this chapter are:

- To delineate source protection zones for the Callan Water Supply Scheme.
- To outline the principal hydrogeological characteristics of the Callan area.
- To assist Kilkenny 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).

9.2 Location and Site Description

The public drinking water source for Callan Town is a spring situated in the townland of Westcourt South (1.5 km to the north west of Callan). The location of the spring is shown on Map 8.

The spring is located within a concrete chamber which is 2 m wide, 5 m long and 0.7 m high. The area is fenced off from animals. The top of the chamber is at 70 m O.D. Overflow is channelled away from the spring into a ditch to the east, which, in turn, flows into the Kings River 400 m to the south east of the spring. The water from the spring flows under gravity along a six inch diameter pipe to the south side of the Kings River to a pump sump in the townland of Mullaunglass.

The spring is situated 100 m north of the Kings River with a height difference between the two of 2.6 m. County Council staff have indicated that the Kings River does not inundate the spring during flood periods.

9.3 Summary of Source Details

GSI no.	2313NWW273
Grid ref. (1:25,000)	24004 14446
Townland	Westcourt South
Source type	Spring
Development date	1934
Owner	Kilkenny County Council
Elevation (ground level)	69.55 m O.D.
Depth to rock	unknown
Static water level	surface
Discharge summary:	
(i) average consumption*	960 m^3/d
(ii) estimated overflow**	480 m^3/d
(iii) estimated total discharge***	1440 m^3/d

**Information supplied by County Council staff*
***Refer to Section 9.9*
*** M.C. O'Sullivan Consulting Engineers (1999) report a dry weather flow of 1080 m^3/day.*

9.4 Methodology

9.4.1 Desk Study

Bedrock geology information was compiled from original 1:10560 (six inch) field sheets and from the GSI bedrock report for the area (Archer *et al*, 1996). Details of the current abstraction rate were obtained from Kilkenny County Council. Data on private groundwater wells in the area were taken from GSI archives. Information on flow regime's in the area was taken from reports and academic theses (Ball, 1972; Daly, 1993; and Naughton, 1978). Data on existing water quality were taken from the EPA (raw waters) and the County Council/Health Board (treated waters).

9.4.2 Site Visits and Field Work

- Site visits and fieldwork included walkover surveys undertaken by both the Groundwater (3 days) and Quaternary (1 day) sections of the GSI to further investigate the subsoil and bedrock geology, the hydrogeology, and the vulnerability to contamination.
- Overflow measurements were taken by the GSI from May to October of 2000, using a piping system installed by Kilkenny County Council.
- Water levels and elevations were recorded in the spring and river.
- Raw water samples were taken on 03/10/00 and 25/04/01 by GSI staff and submitted for analysis at the EPA laboratories in Kilkenny in accordance with their sampling and transportation guidelines.

9.4.3 Assessment

Analytical equations and hydrogeological mapping were utilised to delineate protection zones around the source.

9.5 Topography and Surface Hydrology

Westcourt spring is located 100 m north of the King's River (Map 8). At this point, the King's River meanders across a broad, flat plain with elevations of 60 to 70 m O.D. It's confluence with the Munster River is just 600 m to the west of the spring, and the Munster is joined by the Kilmanagh River just 2.3 km to the north of this confluence. All three rivers originate in the Slieveardagh Hills, which form the north western watershed of the area. The crests of the Slieveardagh hills rise to just over 320 m O.D. The area around the Callan spring appears to be a groundwater discharge zone, with at least three other springs coming to the surface in the vicinity (see Maps 4N and 4S). At least one of these, lying at the confluence of the Munster and Kings Rivers, is a warm spring.

Slopes on the wide valley floor are generally in the order of 0.0014 (1 in 714), and they only steepen appreciably 5.5 km to the north west of the spring, on the slope-side of the Slieveardagh Hills, where they are in the order of 0.08 (1 in 12).

There is a streamflow gauge on the Kings River at Callan, 1.5 km downstream of the spring. Low flow[8] measurements at this station are not thought to be reliable, but have been estimated to be in the order of 0.2 m^3/sec (EPA, 2001).

The natural drainage density is very high on the valley floor upstream of the springs, with the Kings, Kilmanagh and Munster Rivers all flowing within a few square kilometres, and with many artificial drainage ditches.

[8] *Flow which is equalled or exceeded at least 95% of the time.*

A permeability of 10 m/d and a porosity of 0.2 has been assumed for the gravel aquifer, based on experience in other sources.

8.13 Conceptual Model

This section provides a qualitative overview of the geological framework, recharge, flow and discharge patterns across the aquifer contributing groundwater to the source. It represents a summary of the main inferences drawn in previous sections, and provides a foundation upon which the quantitative analyses required for delineating source protection areas can be drawn.

- A schematic depiction is provided in Figure 8.1.
- Three main geological layers occur below the site: (i) sand and gravel overlying (ii) shaley limestone, which overlies (iii) dolomitised limestone. The sand and gravel supplies the infiltration gallery, while the dolomitised limestone is the main source of water for the borehole.
- In the vicinity of the site, groundwater in the sand and gravel and shaley limestone is considered to be unconfined, while groundwater in the dolomitised limestone is considered to be confined (see borehole water levels in Section 8.9).
- During pumping at the gallery, the sand and gravel aquifer is expected to be recharged by the River Nore, by rainfall falling on the aquifer outcrop, and by shallow flow in the top 10 to 15 m of the shaley limestone.
- During pumping from the borehole, the dolomitised limestone is expected to be recharged in generally equal proportions by downward percolation from the River Nore, and by rainfall falling on the dolomitised outcrop area almost 2 km to the east of the site.
- Faulting under the river is such that the dolomitised aquifer does not occur on the western bank and recharge to the source is not expected to occur from the western bank of the Nore.
- Groundwater gradients in the sand and gravel aquifer are estimated at 0.14 (1 in 7), with flow being from the river to the infiltration gallery. Groundwater gradients in the undolomitised limestone are estimated to be 0.1 (1 in 10), while a gradient of 0.02 (1 in 50) has been calculated in the dolomitised limestone, steepening to over 0.7 closer to the pumping well.

8.14 Delineation of Source Protection Areas

8.14.1 Introduction

This section delineates the areas around the source that are believed to contribute groundwater to the source, and that therefore require protection. The areas are delineated on the basis of the conceptualisation of the groundwater flow pattern as described in Section 8.13.

Two source protection areas are delineated:

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

8.14.2 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), and 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 aquifer 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.

9.6 Geology and Aquifers

9.6.1 Bedrock

The Callan source lies in the mid-Kilkenny limestone basin (see Maps 1N and 1S) where the main rock types in the vicinity of the Callan source are all limestones and consist of the Aghmacart, Durrow, Crosspatrick, and Waulsortian Formations. These formations are described in more detail in Chapter 2 of Volume I. Their distribution is quite complex, with vertical and horizontal dimensions playing an important role in groundwater flow to the source. Key points are highlighted below:

- The vertical distribution is presented schematically in Figure 9.1, while the horizontal distribution is presented on Map 8.
- The Callan spring is situated in the middle of an area of Aghmacart and Durrow shaley limestones. Both are classified as **locally important aquifers** which are **moderately productive only in local zones** (**Ll**) (see Section 4.13, Volume I). Fracture flow is expected to be dominant. Regionally, flows are expected to be concentrated in fractured and weathered zones. Given common weathering patterns, most flow is thought to be relatively shallow; concentrating in the top 10 m to 30 m of the rock profile. Crosspatrick Formation limestones lie close-by. They are 'cleaner' and classed as a slightly better aquifer - **locally important aquifer** which is **generally moderately productive** (**Lm**) – but flow patterns are believed to be similar to those in the shaley limestones.
- The regionally important, dolomitised Waulsortian limestone aquifer has been up-faulted nearer to the surface underneath the spring, or is linked to the surface via faults (refer to Figure 9.1). The unit may lie some 500 m below the spring, but deep flows can occur in this aquifer (refer to Chapter 4 of Volume I) and it may be contributing groundwater to the spring. This is supported by the presence of warm springs in the vicinity of the Callan spring.

9.6.2 Subsoil

The main subsoil types are gravel, till and alluvium. These materials are described in more detail in Chapter 3 of Volume I and their distribution in the vicinity of the Callan source shown on Maps 2N, 2S and 8.

As described in Section 4.18.2 of Volume I, the gravels associated with the Kilmanagh and Kings Rivers are considered large, thick and clean enough to be classified as a **Regionally important** gravel (**Rg**) aquifer. The gravels are considered to supply, and form the medium through which bedrock aquifers supply groundwaters to the Callan spring. The deposit is probably up to 15 m thick, and is believed to be predominantly composed of fine gravels and sands interbedded with silts and clays. The silts and clays are believed to become more common between Kilmanagh and the Callan spring. The area of gravel is 1 km wide at the spring, but widens to almost 2 km further north (see Map 8), and extends up to Tullaroan, 14 km to the north. A layer of till, generally 3-4 m in thickness, is thought to overly the gravels between Kilmanagh and Callan spring (see Figure 9.1)

In many places, the rivers have reworked the top layer of the sand and gravel deposit to form a well-sorted fine-grained alluvial deposit. It is only found in a narrow strip along the banks of the rivers, and is thought to be rarely more than 1 or 2 m thick.

Glacial till deposits cover the valley sides of the Munster and Kilmanagh Rivers. Their thickness is variable (less than 1 m to 10 m thick), but they are generally thicker towards the valley floor. The main significance of these tills is in vulnerability and recharge assessments. These issues are described in Sections 9.7 and 9.8.

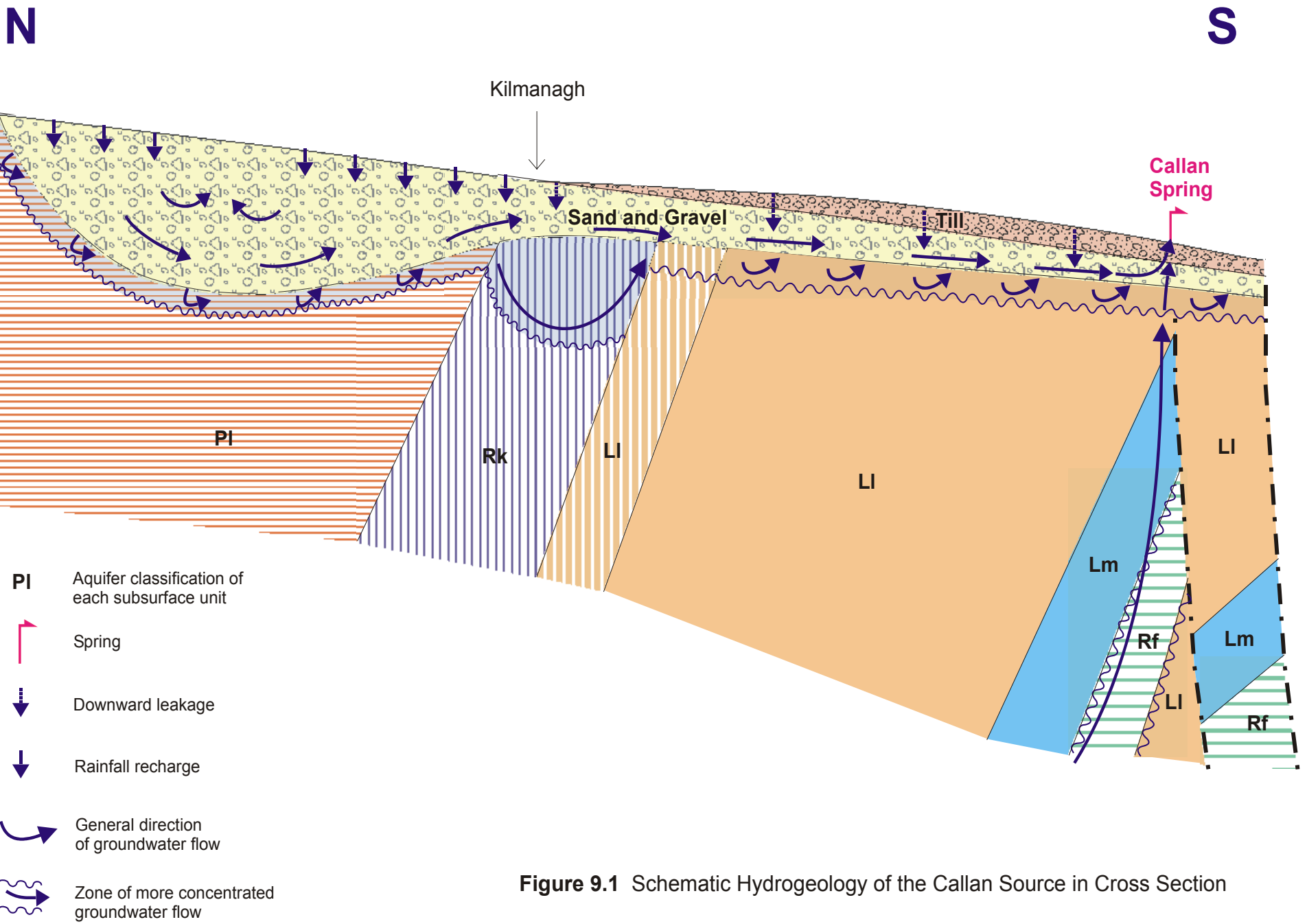


Figure 9.1 Schematic Hydrogeology of the Callan Source in Cross Section

9.7 Groundwater Vulnerability

9.7.1 Introduction

The concept of vulnerability is discussed in Chapter 5 of Volume I. In essence, however, groundwater vulnerability is dictated by the nature and thickness of the material overlying the uppermost groundwater 'target'. As discussed in Section 9.6, the uppermost groundwater resource in the vicinity of the Callan spring occurs within sands and gravels. Where covered by tills, the vulnerability of groundwater within the sand and gravel aquifer is dictated by the permeability and thickness of the overlying till. Elsewhere, the vulnerability is dictated by the thickness of the unsaturated zone in the gravels.

9.7.2 Groundwater Vulnerability in Unconfined Areas to the North of Kilmanagh

Depth to water is a key influence on groundwater vulnerability in these areas. Hydrograph data from well 2315SWW233, lying within 100 m of the Kilmanagh River, indicates water levels frequently less than 2 m below ground (see Figure 4.20 in Volume I). Given that the depth to water will generally increase moving away from a river, it is likely that the thickness of the unsaturated zone will generally be less than 3 m close to the river and in excess of 3 m over most of the remainder of the aquifer. Consequently, the vulnerability has been mapped as generally 'extreme' along a band 100 m wide on either side of the Kilmanagh River where it flows over the unconfined portion of the aquifer. Elsewhere, the vulnerability is considered to be 'high'.

9.7.3 Groundwater Vulnerability in Confined Areas Between Kilmanagh and Callan

Till thickness is a key influence on groundwater vulnerability in the these areas. The overlying tills are believed to have a moderate permeability (see Section 5.3.3, Volume I) and a typical thickness of 3 m to 4 m. Consequently, the vulnerability of groundwater in the gravels below is expected to be generally 'high'.

9.8 Rainfall, Evaporation and Recharge

The term 'recharge' refers to the amount of water replenishing the groundwater flow system. Recharge is generally estimated on an annual basis, and is assumed to consist of an input (i.e. annual rainfall) less water losses (i.e. annual evapotranspiration and runoff). The estimation of recharge is critical in source protection delineation as it largely dictates the size of the zone of contribution.

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[9]:

- Annual rainfall: 910 mm (average of Met Eireann average annual (1961-90) rainfall measured at two sites in Callan).
- Annual actual evapotranspiration (A.E.) losses: 370 mm. This figure ('actual evapotranspiration') was calculated using an extrapolation for the Callan area computed by Ball (1972), using the average 1968 to 1971 data from the station in Oak Park, Co Carlow. More local measurements of actual evapotranspiration are not available.
- Potential recharge: 540 mm/year, based on average annual rainfall less estimated evapotranspiration.
- Annual runoff losses:
  - *Area of thin till cover north of Kilmanagh*: 110 mm/year (20% of potential recharge). This is a typical figure used by the GSI in areas where the till cover is thin.

[9] *Estimations used in this report have generally been rounded off to two significant figures*

- *Confined area south of Kilmanagh*: 510 mm/year (95% of potential recharge). This particularly high runoff estimation is based on visual observations in the area which indicate waterlogged soils and high drainage densities (Chapter 5, Volume I). Ball (1972) estimates that the annual baseflow to the Kings River at Callan is 12%. This suggests that 88% of potential recharge is lost to runoff over the sub-catchment as a whole. Given that this sub-catchment includes areas of high infiltration, it is likely that the proportion lost to runoff exceeds 88% in the poorly drained area to the south of Kilmanagh. The figure of 95% represents a nominal quantity between 88% and 100%.

The calculations are summarised below:

	Confined Portion:	Unconfined Portion:
Average annual rainfall (R)	910 mm	910 mm
Estimated A.E.	370 mm	370 mm
Potential Recharge (R – A.E.)	540 mm	540 mm
Runoff losses factor (RO)	95%	20%
Estimated Actual Recharge (R-A.E.) x (1-R.O)	30 mm	430 mm

9.9 Groundwater Discharge and Groundwater Levels

The supply scheme does not use all of the water discharging from the Callan spring; a proportion overflows from the concrete chamber (see Section 9.3). Discharge from this overflow was measured by the GSI, using a weir constructed by the Sanitary Services section of the County Council.

Results were as follows:

Date	Usage by Scheme (m^3/d)	Overflow (m^3/d)	Spring Discharge (m^3/d)
19/05/2000	800	280	1080
31/05/2000	830	260	1090
18/08/2000	945	0	945
18/10/2000	1110	1390	2500
Average	920	480	1405

This indicates that the quantity of overflow is very much dependent on seasonal recharge to the aquifer. In August, when recharge is expected to be at its lowest, the overflow dried up. In October, after a week of heavy rain, the overflow exceeded the usage by the supply scheme.

The sand and gravels along the river are considered to be confined by the overlying tills between Callan and Kilmanagh. Ball (1972) found that a dug well in the portion of the aquifer from Kilmanagh to Callan was confined in the winter. In addition, a pumping test carried out by the GSI in 1977 provided evidence that there is little hydraulic connection between the sand and gravel and overlying sediments in the area. A dug well installed within the sediments overlying the sand and gravel aquifer was unaffected by pumping at a rate of 30 m^3/day from the aquifer below in a well just 6 m away.

Upstream of Kilmanagh, Naughton (1978) has indicated that the gravel aquifer is unconfined.

9.10 Groundwater Flow Directions and Gradients

Due to the range of aquifer types in the Callan area, the groundwater flow directions are somewhat complex. Data is limited, but it is expected that flows to the spring will generally be from north to south.

The area around the Callan spring seems to be a groundwater discharge zone, with at least four springs in close proximity (Section 9.5). It is envisaged that the discharging water comes from two sources:

- *Northern unconfined portion of the sand and gravel aquifer, lying between Kilmanagh and Tullaroan:* The till cover is thin or absent, drainage densities are low, and there is evidence that rivers lose some or all of their water to ground as they flow across the area (see Section 4.18.2, Volume I). All three factors suggest recharge to the sand and gravel aquifer is high in this area. Though much of the groundwater is expected to discharge back to surface water close to Kilmanagh, it is likely that a significant quantity flows underground southward into the confined portion of the sand and gravel aquifer. Some evidence for this is described by Naughton (1978).
- *Deep groundwater flow from the dolomite aquifer:* As discussed in Section 9.6.1, deep faults are believed to link the dolomite aquifer with the surface in the vicinity of Callan. Figure 9.1 outlines a possible scenario whereby groundwater in the dolomite aquifer is forced to the surface along a fault zone by the presence of a low permeability shaley limestone barrier. Water that has come from depth is likely to have slightly elevated temperatures, and although this is not the case at the Callan spring, two springs a few hundred meters to the north-west are denoted as warm springs (Burdon, 1983).

In summary, it is expected that flows within the sand and gravel aquifer near Callan are being forced to the surface as springs as a result of constriction in the extent of the gravels, and the addition of flow from the deep dolomite aquifer below.

Groundwater gradients are difficult to calculate because of the limited well water level data available. However, assuming that the groundwater supplying the wells comes primarily from flow in the sand and gravels, and therefore has travelled through the sediments, below the river, the topographic gradient along the length of the river is considered to provide a broad indication of the groundwater gradient. The estimated gradient is 0.0014 (1 in 714).

9.11 Hydrochemistry and Water Quality

Data on recent trends in water quality at the Callan source are summarised graphically in Figure 9.2, and the source data can be found in Appendix V.

The following key points have been identified from the data:

- Data from analysis of hardness in five samples indicate a 'very hard' (>350 mg/l $CaCO_3$) calcium-bicarbonate hydrochemical signature. This is typical of most Irish groundwaters, particularly those in limestone regions. Further, levels of magnesium are above 20 mg/l in four out of six analysis available. This supports the suggestion that the spring waters have mixed with waters from the deep magnesium-rich dolomite aquifer.
- Of the parameters examined in the raw[10] groundwater samples taken, only nitrite (in 3 out of 34 available analyses from 1993 to 1998) and faecal coliforms (in nine out of 10 available analyses from 1993 to 2000) were in excess of the European maximum admissible concentration.
- Reported nitrate levels are slightly elevated but are not generally in excess of GSI guide levels and do not appear to have increased significantly between 1983 (14.2 mg/l as NO_3) and 2001 (19.9 mg/l as NO_3).
- With the exception of faecal coliforms, the available analysis of contaminant indicator parameters do not indicate significant problems affecting the source. Most springs are susceptible to bacteriological contamination from surface washings of animal faeces. Where water-logging occurs, as at Callan, the susceptibility is increased. Passing wildfowl may even

[10] *Raw water samples are taken prior to treatment. Assessments are aimed at identifying contamination hazards rather than direct human health issues.*

be the cause. Consequently, it may be that the levels of faecal coliforms identified are not indicative of significant groundwater contamination at the source.

The regional hydrochemistry of the Callan sand and gravel aquifer (**Rg**) and the underlying bedrock aquifers is discussed in Chapter 4 of Volume I.

9.12 Aquifer Parameters

The main aquifer parameters of significance are permeability and porosity. Together with groundwater gradients, these parameters are used to estimate the extent of the inner source protection area in Section 9.14.3.

Transmissivities of 200 m^2/day to 250 m^2/day and permeabilities of 30 m/day to 60 m/day were estimated from two pump tests carried out in the unconfined portion of the sand and gravel deposit near Kilmanagh (Naughton, 1978). There is evidence that the southern, confined portion of the aquifer contains more silt and clay overall than the northern portion where these transmissivity estimates were made. Consequently, it is likely that this southern portion has a lower overall permeability than the values given above.

A porosity of 20% is assumed to represent a reasonably conservative value for gravels.

9.13 Conceptual Model

This section provides a qualitative overview of the geological framework, recharge, flow and discharge patterns across the aquifer contributing groundwater to the source. It represents a summary of the main inferences drawn in previous sections, and provides a foundation upon which the quantitative analyses required for delineating source protection areas can be drawn.

- The main aquifers influencing water flowing to the Callan spring are the Kilmanagh sand and gravels and the dolomite aquifer (see Figure 9.1). The sands and gravels stretch from Callan, up the Kilmanagh River valley, to Tullaroan. They are believed to be unconfined between Tullaroan and Kilmanagh and confined by an overlying layer of till between Kilmanagh and Callan. In the vicinity of the Westcourt spring, the deposits are believed to be up to 15 m thick, and 1 km wide, and to be overlain by up to 4 m of confining fine-grained deposits. The dolomite aquifer is believed to be confined by over 500 m of limestone below the spring.
- Most recharge to the sand and gravel aquifer occurs over the unconfined portion, some 7 km north of spring. Very little recharge is believed to occur over the confined portion of the sand and gravel, mainly as a result of a high watertable. Most recharge to the dolomitised aquifer is likely to occur in the vicinity of Galmoy some 30 km north of the spring.
- Though most recharge to the unconfined sand and gravel is likely to discharge to the Kilmanagh River near Kilmanagh, a proportion is expected to flow southwards underneath the confining tills, and discharge at the Callan spring and the three other springs in the vicinity. Flow in the dolomitised aquifer is thought to be forced to surface, through one or more deep faults in the Callan area, by the presence of a faulted barrier of shaley limestone (see Figure 9.1). The addition of these deep flows, in combination with a constriction in the width of the sand and gravel aquifer, is thought to be the reason why several springs occur in the area.
- Recharge rates to the confined portion of the sand and gravel aquifer are thought to be of the order of 30 mm/year. In the unconfined portion further north, it is likely to be closer to 430 mm/year.
- Groundwater gradients within the sand and gravel are thought to be similar to topographic gradients along the river, around 0.0014 (1 in 714) (see Section 9.10).

9.14 Delineation of Source Protection Areas

9.14.1 Introduction

This section delineates the areas around the spring that are believed to contribute groundwater to the spring, and that therefore require protection. The areas are delineated on the basis of the conceptualisation of the groundwater flow pattern as described in Section 9.13.

Two source protection areas are delineated:

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

9.14.2 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), and is defined as the area required to support an abstraction from long-term recharge. The ZOC is controlled primarily by (a) the groundwater flow direction and gradient, (b) the aquifer permeability and (c) the recharge in the area. The ZOC was delineated using both analytical modelling and the results of hydrogeological mapping and conceptualisation.

Hydrogeological boundaries taken from hydrogeological mapping and the conceptualisation outlined in Section 9.13 are as follows:

- **Northern boundary:** Northern extent of the entire sand and gravel aquifer, including the unconfined portion as well as the confined portion. This extends up the Kilmanagh River valley to just north of Tullaroan.
- **Southern boundary:** The boundary between the sand and gravel aquifer and the glacial till.
- **Eastern boundary:** The boundary between the sand and gravel aquifer and the glacial till.
- **Western boundary:** The boundary between the sand and gravel aquifer and the glacial till.

These boundaries contain the whole sand and gravel aquifer and are the physical limits within which the ZOC is likely to occur. They encompass an area of 30 km^2.

A water balance can be used to determine whether the delineation of the ZOC could be reasonably reduced to a smaller area within these quite extensive physical limits:

The estimated total recharge to the confined portion of the gravel aquifer is 600,000 m^3/yr (30 mm/yr over 20 km^2). A conservative estimate of spring discharge from the gravel aquifer is 1,300,000 m^3/yr. This is derived from the maximum estimated total discharge from the Callan spring and the estimated discharge from the other springs in the vicinity (estimates taken from GSI records). Note that this figure does not represent the total discharge from the gravel aquifer, which would also comprise baseflow to the Kings River and groundwater abstractions. Nevertheless, three conclusions can be drawn from a comparison of recharge with discharge:

- Recharge to the confined portion of the aquifer near the Callan spring is insufficient to support discharge. It is necessary to include the unconfined portion to the north of Kilmanagh into the ZOC, even though this portion lies several kilometres from the source.
- Given that the recharge estimate from only the confined portion of the gravel aquifer comprises nearly 50% of the discharge estimate, the contribution from the dolomite aquifer is unlikely to be significant in comparison with the contribution from the sand and gravel aquifer as a whole. This is supported by evidence of minor nitrate contamination at the spring, which indicates a significant input of relatively young, shallow groundwaters. In addition, it is probable that groundwaters within the deeper, dolomitised aquifer are several hundred years old, having travelled underneath Slievardagh at depths of over 300 m (see Section 4.14). Consequently, it is

considered unlikely that the recharge area for the deeper dolomite groundwaters requires significant protection in the context of groundwater contamination at the Callan source.

- The total extent of the sand and gravel aquifer should be used as the boundary of the ZOC at the Callan spring.

9.14.3 Inner Protection Area

The Inner Protection Area (SI) is the area defined by a 100 day time of travel (TOT) to the source from a point below the water table and it is delineated to protect against the effects of potentially contaminating activities which may have an immediate influence on water quality at the source, in particular from microbial contamination.

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 spring.

Subject to certain assumptions and conditions, Darcy's Law can be used to approximate groundwater flow velocities, as follows:

$$Velocity = groundwater\ gradient \times permeability \div porosity$$

Using the estimates derived in Sections 9.10 and 9.12 for gradient, permeability, and porosity (0.0014, 60 m/day, and 0.2 respectively), the equation gives a velocity of 0.4 m/day. This could be treated as a 'reasonable worst case estimate'. In other words, though some very rapid flow paths may occur, it is thought that most groundwater will move up to 40 m in 100 days. This has been rounded-up to 50 m and the boundary of the SI has been delineated 50 m upgradient of the source (refer to Map 10).

9.15 Groundwater Protection Zones

The groundwater protection zones are obtained by integrating the source protection areas and vulnerability categories – giving a possible total of 8 source protection zones (see the matrix in the table below). In practice, this is done 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 Source Protection area where the groundwater is highly vulnerable to contamination. All of the hydrogeological settings represented by the zones may not be present around any given source. Three groundwater protection zones are present around the Callan source (see Map 10), as shown in the matrix below.

Matrix of Source Protection Zones

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

The appropriate responses imposing restrictions on development are presented in the document 'Groundwater Protection Schemes' (DELG/EPA/GSI, 1999).

9.16 Land Use and Potential Pollution Sources

Agriculture in the area comprises mainly pasture and some tillage. Callan town lies outside the protection zone for Westcourt spring.

The main hazards within the ZOC are considered to be agricultural: in particular, animal activities at and within the perimeter of the spring site.

9.17 Conclusions and Recommendations

- The Callan spring is located in an extensive sand and gravel aquifer. Groundwater in the zone of contribution is generally considered to be 'highly' vulnerable to contamination.
- The protection zones delineated in this chapter 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:
  - chemical and bacteriological analyses of raw water as well as treated water should be carried out regularly. Given some of the raw water quality issues at the source, a monthly frequency has been recommended in Section 7.9. The chemical analyses should include all major ions - calcium, magnesium, sodium, potassium, ammonium, bicarbonate, sulphate, chloride, and nitrate. Analysis of other parameters such as pesticides and hydrocarbons is also recommended;
  - care should be taken in allowing any activities or developments which might significantly increase nitrate levels;
  - the potential hazards in the ZOC should be located and assessed;
  - though the site is fenced off, measures to prevent animal faeces from washing into the spring might be examined. These might include, for example, measures to discourage animal activity at the fence boundary and/or the consideration of drainage ditches to ensure surface waters are drained away from the spring.

References

An Foras Forbatha. 1977. The South Eastern Water Resource Region. Summary of Hydrometric Records.

Archer, J.B., Sleeman, A.G. and Smith, D.C. (1996). Geology of Tipperary. A geological description of Tipperary and adjoining parts of Laois, Kilkenny, Offaly, Clare and Limerick, to accompany the Bedrock Geology 1:100,000 scale map series, Sheet 18, Tipperary. With contributions by K. Claringbold, G. Stanley (Mineral Resources) and G. Wright (Groundwater Resources). Geological Survey of Ireland.

Ball, D.M., (1972). A Short Field and Desk Study of the King's River Catchment, the Republic of Ireland. Unpublished MSc thesis. University College London.

Bates, R.L. and Jackson, J. A. (1984). Dictionary of Geological Terms: Third Edition. Prepared by the American Geological Institute. Published by: Anchor Books.

British Standards Institution. 1999. BS 5930:1999, Code of practice for site investigations. British Standards Institution, London.

Buckley, R. (1999). A Comparison of Different Approaches to Groundwater Vulnerability Mapping in Karst Areas. Unpublished MSc thesis. Environmental Sciences Unit, Trinity College Dublin.

Burdon, D. J. (1983). Irish Groundwater Resources in Relation to Geothermal Energy Investigations. Unpublished Geological Survey of Ireland Report.

Burke, A.M. (1998). Assessing Karstification in Ireland. Unpublished (Research) MSc thesis. Department of Geography, Trinity College Dublin.

Cawley, A. (1990). The Hydrological Analysis of a Karst Aquifer System. Unpublished (Research) MSc thesis. Department of Engineering Hydrology, University College Galway.

Collins, J.F. and Cummins, T. (1996). Agroclimatic Atlas of Ireland. AGMET – Joint working group on Applied Agricultural Meteorology, Dublin.

Connor, B.P. (1999). Phase 1 Report on Drilling of Exploration Boreholes at Norelands, Co. Kilkenny for Kilkenny County Council.

Conry, M. (1974). Kilkenny's 'Golden Vein': It's Soils, Land-Use and Agriculture. Irish Geography Volume VII.

Cullen, K.T. (1983). Report on a Hydrogeological Survey at Avonmore Creameries Limited, Ballyragget, Co. Kilkenny. Unpublished report produced by KTC Consultants.

Cullen, K.T. (1990). Groundwater Development at Avonmore Creameries Ltd., Ballyragget, Co. Kilkenny. Unpublished report produced by KTC Consultants.

Daly, D. and Misstear, B. (1976). A Preliminary Hydrogeological Survey of the Castlecomer Plateau, South East Ireland. Unpublished MSc thesis. Department of Hydrogeology. University of Birmingham.

Daly, D. (1994). Chemical Pollutants in Groundwater: a Review of the Situation in Ireland. Paper presented at *Conference "Chemicals – a Cause for Concern?"* in Cork, 3-4 November 1994.

Daly, D. (1996). *Groundwater in Ireland*. Course notes for Higher Diploma in Environmental Engineering, UCC.

Daly, D., Keegan, M. and Wright, G.R. (1998). County Tipperary (South Riding) Groundwater Protection Scheme. Unpublished GSI report produced for Tipperary S.R. County Council

Daly, E.P. (1978). Groundwater Investigations at Avonmore Creameries LTD., Ballyragget, County Kilkenny. Unpublished internal GSI Report.

Daly, E.P. (1980). The Drilling and Testing of two Boreholes and Groundwater Development in the Westphalian Sandstones of the Slieveardagh Hills, County Tipperary. Internal Report Number 7. Geological Survey of Ireland.

Daly, E. P. (1982). The Groundwater Resources of the South East Industrial Development Region. Geological Survey of Ireland Report for the South East Regional Development Agency.

Daly, E.P. (1985). Groundwater Resources of the Nore River Basin: Hydrogeology of the Kiltorcan Aquifer System. Unpublished internal GSI report.

Daly, E.P. (1988). The Kiltorcan Sandstone Aquifer. Paper presented at the 8th Annual Groundwater Seminar held in Portlaoise, on: The future of Groundwater Development in Ireland.. Published by: IAH (Irish Group).

Daly, E. P. (1989). Natural Chemistry of Groundwater. Paper presented at the 9th Annual Groundwater Seminar held in Portlaoise. Published by: IAH (Irish Group).

Daly, E. P and Boland, M.. (1990). Water, Rocks and the Environment in County Kilkenny. Irish Geological Association: Unpublished Guide to Field Trip 20/21 October 1990.

Daly, E. P. (1992). Groundwater Resources of the Nore River Basin: Interim Report. Geological Survey of Ireland. Unpublished internal GSI report.

Daly, E. P. (1993). Hydrogeology of the Dolomite Aquifer in the Southeast of Ireland. Paper presented at the 13th Annual Groundwater Seminar held in Portlaoise, on: Basin Management and Information Technology. Published by: IAH (Irish Group).

Daly, E.P. (1994). Groundwater Resources of the Nore River Basin. Geological Survey of Ireland, Report Series RS 94/1 (Groundwater). Unpublished internal GSI report.

Daly, E.P. (1995). The Principal Characteristics of the Flow Regime in Irish Aquifers. Paper presented at the 15th Annual Groundwater Seminar held in Portlaoise, on: The Role of Groundwater in Sustainable Development. Published by: IAH (Irish Group).

Daly, D., Moore, Meehan, R., Murphy, G., Fitzsimons, V., Clenaghan, C., Beirne, M., Carty, G., O'Leary, G., O'Dwyer, R. 2000. *Site Suitability Assessments for On-site Wastewater Treatment Systems: Course Manual*. FÁS and Geological Survey of Ireland.

DELG/EPA/GSI (1999) Groundwater Protection Schemes. Department of the Environment and Local Government, Environmental Protection Agency and Geological Survey of Ireland.

Environmental Protection Agency (2001). Website: www.epa.ie/techinfo/default.htm

Environmental Protection Agency (2000). Wastewater Treatment Manuals: Treatment Systems for Single Houses, Environmental Protection Agency.

EOLAS (1992). Bottled Water. National Standards Authority of Ireland, **IS 432:1992.**

Fitzgerald, D. and Forrestal, F. (1996). Monthly and Annual Averages of Rainfall for Ireland 1961-1990. Meterological Service, Climatological Note No. 10, UDC 551.577.2(415).

Fitzsimons, V. And Wright G.R.W (2000). Durrow (Convent) Water Supply Scheme. Groundwater Source Protection Zones. Draft Unpublished GSI Report Produced For Laois County Council.

Flanagan, P.J. (1992). Parameters of Water Quality: Interpretation and Standards. Second Edition. Environmental Research Unit, **ISBN 1 85053 095 5**

Hudson, M., Daly, D., Johnston, P. and Duffy, S. (1998). County Waterford Groundwater Protection Scheme. Unpublished GSI report produced for Waterford County Council.

Keohane, J. (1994). The Establishment of a Database for Groundwater in the South East Region of Ireland. Hydrogeological Report produced as Sub-Programme Measure 1 of the STRIDE Programme. Regional Water Laboratory, Butts Green, Kilkenny.

K.T. Cullen & Co. Ltd. (1997), Pausltown Water Supply. Source Protection Policy. Report for Kilkenny County Council.

Kilroy, G., Coxon, C., Allott, N., and Rybaczuk, K. (1999). The Contribution of groundwater phosphorous to surface water eutrophication. Proceedings of the 9th Annual International Association of Hydrogeologists (Irish Group) Seminar held in Portlaoise.

Lee, M., 1999. Surface indicators and land use as secondary indicators of groundwater recharge and vulnerability. Unpublished (Research) MSc thesis. Department of Civil, Structural and Environmental Engineering, Trinity College Dublin.

Met Eireann, 1996. Potential Evapotranspiration. In: Collins, J.F, and Cummins, T (ed) 'Agroclimatic Atlas of Ireland', pp 134-137

M.C. O'Sullivan Consulting Engineers (1999). Kilkenny Water Supplies. Strategic Review. Report for Kilkenny County Council.

Misstear, B.D.R. (1998). The Logan Method for Analysing Pumping Test Data. Article published in: The GSI Groundwater Newsletter, edited by: Donal Daly. GSI publication No. 34.

Misstear, B.D.R., Daly, E.P., Daly, D. and Lloyd, J.W. (1980). The Groundwater Resources of the Castlecomer Plateau. Geological Survey of Ireland Report Series **RS 80/3** (Groundwater).

Naughton, M.M. (1978). A Hydrogeological Study of the Upper Kilmanagh River Basin, Republic of Ireland. Unpublished (Research) MSc thesis. University of Alabama.

O Suilleabhain C. (2000). Assessing the Boundary Between High and Moderately Permeable Subsoils. Unpublished MSc thesis. Department of Civil, Structural and Environmental Engineering, Trinity College Dublin.

Sleeman, A.G. and McConnell, B. (1995). Geology of East Cork - Waterford. A geological description of East Cork, Waterford and adjoining parts of Tipperary and Limerick, to accompany the Bedrock Geology 1:100,000 scale map series, Sheet 22, East Cork - Waterford. With contributions by K. Claringbold, P. O'Connor, W.P. Warren and G. Wright. Geological Survey of Ireland.

Swartz, M. (1999). Assessing the Permeability of Irish Subsoils. Unpublished (Research) MSc thesis. Department of Civil, Structural, and Environmental Engineering, Trinity College Dublin.

Tietzsch-Tyler, D. and Sleeman, A.G. (1994a). Geology of Carlow - Wexford. A geological description to accompany the Bedrock Geology 1:100,000 map series, Sheet 19, Carlow - Wexford. With contributions by B.J. McConnell, E.P. Daly, A.M. Flegg, P.J. O'Connor and W.P. Warren. Edited by B. McConnell. Geological Survey of Ireland.

Tietzsch-Tyler, D. and Sleeman, A.G. (1994b). Geology of South Wexford. A geological description of South Wexford and adjoining parts of Waterford, Kilkenny and Carlow to accompany the Bedrock Geology 1:100,000 scale map series, Sheet 23, South Wexford. With contributions by M.A. Boland, E.P. Daly, A.M. Flegg, P.J. O'Connor and W.P. Warren. Geological Survey of Ireland, 62 pp.

Wright, G.R. (2000). QSC Graphs: and Aid to Classification of Data-poor Aquifers in Ireland. From: Robins, N.S. and Misstear, B.D.R. (eds.) Groundwater in the Celtic Regions: Studies in Hard Rock and Quaternary Hydrogeology. Geological Society, London, Special Publications, **182**. The Geological Society of London 2000.

Wright, G.R. and Woods, L. (2001). County Wicklow Groundwater Protection Scheme (Draft). Unpublished GSI report produced for Wicklow County Council.

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.

A.8 References

Armon, R. and Kott, Y., 1994. The health dimension of groundwater contamination. In: Zoller, U. (Editor), Groundwater Contamination and Control. Published by Marcel, Dekker, Inc., pp71-86.

Daly, D. 1996. Groundwater in Ireland. Course notes for Higher Diploma in Environmental Engineering, UCC.

Daly, D., Thorn, R. and Henry, H., 1993. Septic tank systems and groundwater in Ireland. Geological Survey Report Series RS 93/1, 30pp.

Gerba, C.P. and Bitton, G., 1984. Microbial pollutants : their survival and transport pattern to groundwater. In : G.Bitton and C.P. Gerba (Editors), Groundwater Pollution Microbiology, Wiley - Intersciences Publishers, pp 65-88.

Hagedorn, C., McCoy, E.L. and Rahe, T. M. 1981. The potential for ground water contamination form septic tank effluents. Journal of Environmental Quality, volume 10, no. 1, p1-8.

Henry, H. (1990). An Evaluation of Septic Tank Effluent Movement in Soil and Groundwater Systems. Ph.D. Thesis. Sligo Regional Technical College. National Council for Education Awards - Dublin.

Reneau, R.B. 1996. Personal communication. Virginia Polytechnic Institute and State University.

Sherwood, M., 1991. Personal communication, Environmental Protection Agency.

US EPA. 1987. Guidelines for delineation of wellhead protection areas. Office of Ground-water Protection, U.S. Environmental Protection Agency.

Wild, A. and Cameron, K.C., 1980. Nitrate leaching through soil and environmental considerations with special reference to recent work in the United Kingdom. Soil Nitrogen - Fertilizer or Pollutant, IAEA Publishers, Vienna, pp 289-306.

Appendix V: Laboratory analytical results

EPA Regional Water Laboratory, Kilkenny. Monitoring Data for County Kilkenny Groundwaters 1993 to 1999.

Source	Sampling Date	Sampling Time	To	Ref No	Sampling Location	Taken By	Lab No	EPARef	Stn Grid Ref	Water Supply	Public/Group/Private	Temperature	Odour 1/2/3	Colour Hazen	pH	Conductivity µS/cm	Turbidity NTU	TOC mg/l C	Ammonia mg/l N
Spring at Paulstown Castle	29/04/1992	11:38:00	Kilkenny Co. Co.	KK00600	Spring at Paulstown Castle		1648	KIK46	S 660 570	Gowran/Goresbr./P-town	Public	9.1	1	5	7.3	623			0.03
Spring at Paulstown Castle	01/07/1992	15:55:00	Kilkenny Co. Co.	KK00600	Spring at Paulstown Castle		2681	KIK46	S 660 570	Gowran/Goresbr./P-town	Public	11.4	1	5	7.4	640			0.02
Spring at Paulstown Castle	20/08/1992	15:15:00	Kilkenny Co. Co.	KK00600	Spring at Paulstown Castle		3737	KIK46	S 660 570	Gowran/Goresbr./P-town	Public		1	5	7.2	600			0.02
Spring at Paulstown Castle	18/11/1992	13:29:00	Kilkenny Co. Co.	KK00600	Spring at Paulstown Castle		5086	KIK46	S 660 570	Gowran/Goresbr./P-town	Public	9.8	2	5	7.4	623			0.02
Spring at Paulstown Castle	10/03/1993	16:00:00	Kilkenny Co. Co.	KK00600	Spring at Paulstown Castle		1017	KIK46	S 660 570	Gowran/Goresbr./P-town	Public	9.6	1	5	7.3	660			0.01
Borehole at Castlecomer Yarns	02/06/1993		Kilkenny Co. Co.	KK00300	Tap in yard at Castlecomer Yarns	J. Keohane	2269		25360 17330	Castlecomer Yarns	Private		1	15	7.5	570	1	< 1	0.01
Spring at Paulstown Castle	02/06/1993		Kilkenny Co. Co.	KK00600	Spring at Paulstown Castle	J. Keohane	2270	KIK46	S 660 570	Gowran/Goresbr./P-town	Public		1	5	7.2	696	0.4	5.7	0.01
Borehole at Rathcash	02/06/1993		Kilkenny Co. Co.	KK02000	Joe Pykes house, Rathcash, Clara.	J. Keohane	2271	KIK55	25870 15510	Rathcash	Group		1	5	7.3	682	0.2	< 1	0.01
Springs at Bausheenmore	02/06/1993		Kilkenny Co. Co.	KK00500	At source (springs at Bausheenmore)	J. Keohane	2272	KIK39	25520 14690		Private		1	5	7.3	814	0.35	0.9	0.01
Spring at Westcourt	02/06/1993		Kilkenny Co. Co.	KK00800	Spring at Earlsland, Westcourt, Callan	J. Keohane	2273	KIK91	S 407 442	Callan	Public		1	5	7.3	718	0.2	0.5	0.01
Borehole at Galmoy	03/06/1993	11:25:00	Kilkenny Co. Co.	KK00200	Leahy's House, Galmoy	P.Mullins	2292	KIK17	23020 17120	Galmoy	Group	10	1	5	7.4	790	0.2	< 1	0.01
Galmoy 35	03/06/1993	11:47:00	Kilkenny Co. Co.		M. Phelan	P.Mullins	2293				Private	10	1	5	7.4	792	0.15	< 1	0.01
Galmoy 37	03/06/1993	12:02:00	Kilkenny Co. Co.		Mr. Tom Maher's House	P.Mullins	2294				Private	11	1	5	7.4	769	0.2		0.01
Galmoy 25	03/06/1993	12:15:00	Kilkenny Co. Co.		Hennessy's at House	P.Mullins	2295				Private	10	1	5	7.3	894	0.25	0.2	0.01
Galmoy 202	03/06/1993	12:55:00	Kilkenny Co. Co.		Phelans	P.Mullins	2296				Private	11	1	5	7.4	755	0.3	< 1	0.01
Borehole at Bawnmore	03/06/1993	16:00:00	Kilkenny Co. Co.	KK00100	Phelan's house, Bawnmore	P.Mullins	2297	KIK50	22580 16610	Bawnmore	Group	12	1	5	7.3	820	0.2	0.14	0.01
Spring at Clomantagh	10/06/1993	11:40:00	Kilkenny Co. Co.	KK00900	Beside Nuenna river, 50m SE of road	P.Mullins+J.Keohane	2395		23520 16320		Private		1	5	7.3	664	0.3		0.01
Spring at Clomantagh	10/06/1993	11:50:00	Kilkenny Co. Co.	KK00900	Beside Nuenna river, 50m SE of road	P.Mullins+J.Keohane	2396		23520 16320		Private		1	5	7.3	677	0.35		0.01
Borehole at Dunmore	10/06/1993	12:28:00	Kilkenny Co. Co.	KK00700	C. Murray,s house, Dunmore.	P.Mullins+J.Keohane	2397		24910 16200	Dunmore	Group		1	5	7.4	676	0.2		0.01
Spring Toberpatrick Urlingford	15/06/1993	10:45:00	Kilkenny Co. Co.	KK01500	In chamber at source	C. Murray	2417	KIK34	23000 16350	Urlingford/Johnstown	Public		1	5	7.2	781	0.3	1.6	0.01
Borehole at Kilmanagh	15/06/1993	12:00:00	Kilkenny Co. Co.	KK01400	In pumphouse	C. Murray	2418	KIK45	23930 15250	Kilmanagh/Ballycuddihy	Group		1	5	7.5	659	0.3		0.01
Borehole at Dunmore S/G	15/06/1993	14:30:00	Kilkenny Co. Co.	KK01000	Canteen at Dunmore Sand & Gravel	C. Murray	2419	KIK53	25000 16020	Dunmore Sand & Gravel	Private		1	5	7.4	643	1.2	0.4	0.01
Borehole at Kilkenny Mar	15/06/1993	15:00:00	Kilkenny Co. Co.	KK01300	Cattle holding shed	C. Murray	2420		25070 15670	Kilkenny Mart	Private		1	5	7.6	691	0.2	0.4	0.01
Borehole at Windgap	01/07/1993		Kilkenny Co. Co.	KK01900	Overflow from borehole	C. Murray	2769		24200 13580	Farm supply	Private		1	5	7.2	382	1.5		0.37
Spring at Paulstown Castle	05/08/1993	15:55:00	Kilkenny Co. Co.	KK00600	Spring at Paulstown Castle		3294	KIK46	S 660 570	Gowran/Goresbr./P-town	Public	11.6	1	5	7.3	680			0.01
Galmoy	08/11/1993	11:15:00	Kilkenny Co. Co.		Leahy's House (A 82)	P.Mullins	4754			Galmoy	Group	8	1	5	7.3	806	0.09		0.01
Galmoy	08/11/1993	11:45:00	Kilkenny Co. Co.		Parochial House	P.Mullins	4755			Galmoy	Private	9	1	5	7.3	725	0.09		0.01
Galmoy	08/11/1993	12:20:00	Kilkenny Co. Co.		Phelans, original (A 35)	P.Mullins	4756			Galmoy	Private	8	1	5	7.1	996	0.21		0.01
Galmoy	08/11/1993	12:40:00	Kilkenny Co. Co.		Brophy's (A 25)	P.Mullins	4757			Galmoy	Private	9	1	5	7.4	849	0.15		
Galmoy	08/11/1993	13:50:00	Kilkenny Co. Co.		Phelans (A 24)	P.Mullins	4758			Galmoy	Private	9	1	5	7.4	874	0.19		< 0.01
Galmoy	08/11/1993	13:55:00	Kilkenny Co. Co.		Hennessy's	P.Mullins	4759			Galmoy	Private	9							
Galmoy	08/11/1993	14:44:00	Kilkenny Co. Co.		Gannons (A 36)	P.Mullins	4760			Galmoy	Private	9	1	5	7.3	864	0.13		< 0.01
Galmoy	08/11/1993	14:52:00	Kilkenny Co. Co.		Maher's (A 37)	P.Mullins	4761			Galmoy	Private	9	1	5	7.3	816	0.14		< 0.01
Borehole at Bawnmore	08/11/1993	15:15:00	Kilkenny Co. Co.	KK00100	Phelan's house, Bawnmore	P.Mullins	4762	KIK50	22580 16610	Bawnmore	Group	9	1	5	7.3	829	0.1		< 0.01
Galmoy	08/11/1993	15:45:00	Kilkenny Co. Co.		Dan Phelan (A 202)	P.Mullins	4763			Galmoy	Private	9	1	5	7.3	739	0.07		< 0.01
Spring Toberpatrick Urlingford	09/11/1993	11:45:00	Kilkenny Co. Co.	KK01500	In chamber at source	P. Mullins	4776	KIK34	23000 16350	Urlingford/Johnstown	Public	10	2	< 5	7.3	808	0.22		0.01
Borehole at Castlecomer Yarns	09/11/1993	12:35:00	Kilkenny Co. Co.	KK00300	Tap in yard at Castlecomer Yarns	P. Mullins	4777		25360 17330	Castlecomer Yarns	Private	10	2	5	7.6	568	3.5		0.01
Spring at Paulstown Castle	09/11/1993	14:40:00	Kilkenny Co. Co.	KK00600	Spring at Paulstown Castle	P. Mullins	4778	KIK46	S 660 570	Gowran/Goresbr./P-town	Public	11	2	< 5	7.4	648	0.24		0.01
Borehole at Clara	09/11/1993	15:15:00	Kilkenny Co. Co.	KK00400	At pumphouse	P. Mullins	4779	KIK41	25770 15530	Clara	Group	10	1	< 5	7.4	677	0.17	67.3	0.01
Spring at Westcourt	09/11/1993	16:00:00	Kilkenny Co. Co.	KK00800	Spring at Earlsland, Westcourt, Callan	P. Mullins	4780	KIK91	S 407 442	Callan	Public	10	1	< 5	7.3	722	0.21		0.01
Borehole at Dunmore	10/11/1993	10:30:00	Kilkenny Co. Co.	KK00700	C. Murray,s house, Dunmore.	C.Murray	4796		24910 16200	Dunmore	Group	8.4	1	5	7.5	702	0.1		0.01
Borehole at Dunmore S/G	10/11/1993	10:55:00	Kilkenny Co. Co.	KK01000	Canteen at Dunmore Sand & Gravel	C.Murray	4797	KIK53	25000 16020	Dunmore Sand & Gravel	Private	8.1	1	< 5	7.6	635	0.7		0.01
Borehole at Kilkenny Mar	10/11/1993	11:15:00	Kilkenny Co. Co.	KK01300	Cattle holding shed	C.Murray	4798		25070 15670	Kilkenny Mart	Private	4.9	2	< 5	8	690	0.14		0.01
Borehole at Kilmanagh	10/11/1993	12:22:00	Kilkenny Co. Co.	KK01400	In pumphouse	C.Murray	4799	KIK45	23930 15250	Kilmanagh/Ballycuddihy	Group	10	2	< 5	7.7	644	0.33		0.01
Springs at Bausheenmore	10/11/1993	14:30:00	Kilkenny Co. Co.	KK00500	At source (springs at Bausheenmore)	C.Murray	4800	KIK39	25520 14690		Private	10.2	1	< 5	7.4	812	0.23		0.01
Borehole No.9, Thomastown	10/11/1993	15:10:00	Kilkenny Co. Co.	KK01600	At pumphouse	C.Murray	4801	KIK32	25890 14160	Thomastown	Public	11	2	< 5	7.4	798	0.15		0.01
Borehole at Windgap	10/11/1993	15:50:00	Kilkenny Co. Co.	KK01900	Overflow from borehole	C.Murray	4802		24200 13580	Farm supply	Private	10.8	1	< 5	7.5	375	0.32		0.01
Borehole at Avonmore Dairy	11/11/1993	11:30:00	Kilkenny Co. Co.	KK01200	Holding tank on roof	C.Murray	4803			Avonmore Kilkenny City	Private		2	5	7.8	621	0.11		0.01
Rathcash, Clifden,Co. Kilkenny	08/12/1993	09:45:00	Kilkenny Co. Co.		Joe Pykes	J.Keohane	5212			Rathcash	Group		1	5	7.4	711	0.17		< 0.01
Spring at Paulstown Castle	10/11/1994	11:25:00	Kilkenny Co. Co.	KK00600	Spring at Paulstown Castle		5072	KIK46	S 660 570	Gowran/Goresbr./P-town	Public	9.8	1	5	7.1	680			0.08
Graigue, Callan.	12/01/1995		Kilkenny Co. Co.		James Robinsons well	James Robinson	212			Proposed Supply for James Robinson	Private			< 5	7.6	528	14		
Spring at Paulstown Castle	23/01/1995	15:45:00	Kilkenny Co. Co.	KK00600	Spring at Paulstown Castle		255	KIK46	S 660 570	Gowran/Goresbr./P-town	Public	9.5		5		680			0.01
Spring at Paulstown Castle	16/10/1995	15:23:00	Kilkenny Co. Co.	KK00600	Spring at Paulstown Castle		4410	KIK46	S 660 570	Gowran/Goresbr./P-town	Public	11.8	1	5	7.3	595			< 0.01
Borehole at Castlecomer Yarns	08/01/1996	11:10:00	Kilkenny Co. Co.	KK00300	Tap in yard at Castlecomer Yarns	C. Murray	74		25360 17330	Castlecomer Yarns	Private	11.6	2	20	7.4	583	5.5	2	< 0.01
Borehole at Dunmore	08/01/1996	11:30:00	Kilkenny Co. Co.	KK00700	C. Murray,s house, Dunmore.	C. Murray	75		24910 16200	Dunmore	Group	8	1	5	7.3	615	0.2	3.4	< 0.01
Borehole at Dunmore S/G	08/01/1996	12:00:00	Kilkenny Co. Co.	KK01000	Canteen at Dunmore Sand & Gravel	C. Murray	76	KIK53	25000 16020	Dunmore Sand & Gravel	Private	10.1	2	5	7.7	627	1.6	2.2	< 0.01
Borehole at Kilkenny Mar	08/01/1996	12:15:00	Kilkenny Co. Co.	KK01300	Cattle holding shed	C. Murray	77		25070 15670	Kilkenny Mart	Private	9.5	1	5	7.9	690	0.2	2.4	< 0.01
Borehole at Clara	08/01/1996	12:55:00	Kilkenny Co. Co.	KK00400	At pumphouse	C. Murray	78	KIK41	25770 15530	Clara	Group	11	1	5	7.3	696	0.2	4.5	< 0.01
Borehole at Rathcash	08/01/1996	13:10:00	Kilkenny Co. Co.	KK02000	Joe Pykes house, Rathcash, Clara.	C. Murray	79	KIK55	25870 15510	Rathcash	Group	8.7	2	5	7.4	708	0.1		< 0.01
Spring at Paulstown Castle	08/01/1996	14:40:00	Kilkenny Co. Co.	KK00600	Spring at Paulstown Castle	C. Murray	80	KIK46	S 660 570	Gowran/Goresbr./P-town	Public	10.6	1	5	7.2	623		5.5	< 0.01
Spring at Clomantagh	09/01/1996	10:40:00	Kilkenny Co. Co.	KK00900	Beside Nuenna river, 50m SE of road	C. Murray	89		23520 16320		Private	9.8	1	60	7.3	467	38		0.026
Spring Toberpatrick Urlingford	09/01/1996	11:05:00	Kilkenny Co. Co.	KK01500	In chamber at source	C. Murray	90	KIK34	23000 16350	Urlingford/Johnstown	Public	9.7	1	5	7.3	712	1.7	8	< 0.01
Borehole at Bawnmore	09/01/1996	11:30:00	Kilkenny Co. Co.	KK00100	Phelan's house, Bawnmore	C. Murray	91	KIK50	22580 16610	Bawnmore	Group	8.5	1	5	7.2	835	0.1	3	< 0.01

EPA Regional Water Laboratory, Kilkenny. Monitoring Data for County Kilkenny Groundwaters 1993 to 1999.

Source	Sampling Date	Sampling Time	o-Phosphate mg/l P	Nitrate mg/l N	Nitrite mg/l N	Chloride mg/l Cl	Ca Hardness mg/l CaCO3	Alkalinity mg/l CaCO3	TCS	Total Coliforms per 100 ml	FCS	Fecal Coliforms per 100 ml	Sulphate mg/l SO4	Dry Residue mg/l	Sus_ Solids mg/l	Magnesium mg/l Mg	Total Hardness mg/l CaCO3	Sodium mg/l Na	Potassium mg/l K	Aluminium mg/l Al	Iron mg/l Fe	Manganese mg/l Mn	Copper mg/l Cu	Zinc mg/l Zn	Chromium mg/l Cr	Lead mg/l Pb
Spring at Paulstown Castle	29/04/1992	11:38:00	0.04	6		29				78		44	2		5						< 0.05	< 0.02	< 0.03	< 0.01		
Spring at Paulstown Castle	01/07/1992	15:55:00	0.01	5		28				13		999			5						< 0.04	< 0.02	< 0.03	0.01		
Spring at Paulstown Castle	20/08/1992	15:15:00	0.02	4.3		28									5											
Spring at Paulstown Castle	18/11/1992	13:29:00	0.03	4.6		28				340		280			5											
Spring at Paulstown Castle	10/03/1993	16:00:00	0.02	6.8		38				20		5			5						0.011	0.009	< 0.001	0.015		
Borehole at Castlecomer Yarns	02/06/1993		0.05	0.1	0.006	20				999		999	7			23.8	242	33.1	1.4		9.2	0.797		0.017	< 0.001	< 0.001
Spring at Paulstown Castle	02/06/1993		0.06	8.2	0.005	30		305		999		999	< 1			12.3	355	9.1	3.2		0.051	0.006	< 0.001	< 0.005	< 0.001	< 0.001
Borehole at Rathcash	02/06/1993		0.08	7.2	0.001	24		317		15		1				22.3	359	8.4	1.5		0.033	0.004	< 0.001	0.02	< 0.001	< 0.001
Springs at Bausheenmore	02/06/1993		0.08	6.1	0.006	41		401		999		999	< 1			33.3	425	9.3	4.3		0.077	0.017	< 0.001	0.018	< 0.001	< 0.001
Spring at Westcourt	02/06/1993		0.05	3.8	0.002	24		370		64		21	< 1			27.8	383	9.8	1.2		0.012	< 0.005	< 0.001	< 0.005	< 0.001	< 0.001
Borehole at Galmoy	03/06/1993	11:25:00	0.01	9.4	0.002	29		350		999		999	4			83.2	399	17.1	2.7	0.027	0.026	< 0.005	0.063	0.036	< 0.001	0.011
Galmoy 35	03/06/1993	11:47:00	0.01	10	0.003	28		350		999		999	9			96.8	393	22.8	6.5	0.006	0.022	< 0.005	0.079	0.021	< 0.001	0.001
Galmoy 37	03/06/1993	12:02:00	0.01	5.7	0.002	21		379		999		999	3			84.8	393	20.2	2.2	0.02	0.015	< 0.005	0.111	0.05	< 0.001	0.005
Galmoy 25	03/06/1993	12:15:00	0.007	12	0.003	22		383		275		28	25			80	433	37.9	11.7	0.009	0.036	< 0.005	0.439	0.278	< 0.001	0.016
Galmoy 202	03/06/1993	12:55:00	0.005	5.7	0.003	22		359		20		18	7			58.8	375	26.2	10	0.019	0.021	0.012	0.151	0.027	< 0.001	< 0.001
Borehole at Bawnmore	03/06/1993	16:00:00	0.01	6	0.002	26		398		1		1	8			102	419	21.8	5.4	0.005	0.015	< 0.005	0.068	0.03	< 0.001	< 0.001
Spring at Clomantagh	10/06/1993	11:40:00	0.007	6.1	0.004	22		297		230			< 1			14.1	359	7.5	1.6		0.032	0.009	< 0.001	< 0.005	< 0.001	0.003
Spring at Clomantagh	10/06/1993	11:50:00	0.02	6.5	0.003	23		318		162			< 1			14.3	369	7.6	1.6		0.037	0.008	0.001	< 0.005	< 0.001	< 0.001
Borehole at Dunmore	10/06/1993	12:28:00	0.004	14	0.001	27		251		999		999	2			7.5	354	8.3	0.8		0.031	< 0.005	0.009	< 0.005	< 0.001	< 0.001
Spring Toberpatrick Urlingford	15/06/1993	10:45:00	0.01	7.6	0.005	27		383		34		15	8			22.2	400	9.1	4.7				0.004			< 0.001
Borehole at Kilmanagh	15/06/1993	12:00:00	0.01	4.5	0.001	19		328		175		116	7			18.9	345	8.5	1.1			0.009				< 0.001
Borehole at Dunmore S/G	15/06/1993	14:30:00	0.01	0.2	0.006	18		313		999		999	24			19.3	333	11.3	1				0.039			< 0.001
Borehole at Kilkenny Mar	15/06/1993	15:00:00	0.01	6.3	0.002	18		296		43		20	32			20.8	355	11	1.5				0.03			< 0.001
Borehole at Windgap	01/07/1993		0.02	1.6	0.001	14		137		999		999	< 1		Not Vis.	20	177	6.9	1.1		0.17	0.014		0.01		
Spring at Paulstown Castle	05/08/1993	15:55:00	0.02	6		27				85					5						0.019	< 0.005		0.025		
Galmoy	08/11/1993	11:15:00	< 0.01	10.2		34	309	389					8			30.6	435	8.6	1.1		0.041	< 0.005	< 0.001	0.031	0.0005	< 0.001
Galmoy	08/11/1993	11:45:00	< 0.01	4.4		20	247	378		999		999	11			35.9	395	11.5	1.7		0.03	< 0.005	< 0.001	0.021	0.0004	< 0.001
Galmoy	08/11/1993	12:20:00	< 0.01	5.3		59	384	470		6		999	10			27.4	497	18.6	10.3		0.036	< 0.005	0.006	0.034	0.0004	0.003
Galmoy	08/11/1993	12:40:00	0.003	7.2	0.01	24	300	437		24		999	14			38.1	457	12.7	1.8		0.055	0.002	< 0.001	0.062	0.0005	< 0.001
Galmoy	08/11/1993	13:50:00	0.004	15.1		34.6	288	387		999		999	14			38.7	448	13.4	9		0.032	< 0.005	0.014	0.178	0.0005	< 0.001
Galmoy	08/11/1993	13:55:00								50		7														
Galmoy	08/11/1993	14:44:00	0.008	12.7		28.7	342	415		100		2	8			24.5	443	13.9	9.1		0.044	0.016	< 0.001	0.681	0.0003	< 0.001
Galmoy	08/11/1993	14:52:00	0.007	8.8		26	309	416		999		999	7			32.4	443	8.6	1.4		0.051	< 0.005	0.002	0.026	0.0004	< 0.001
Borehole at Bawnmore	08/11/1993	15:15:00	< 0.01	6		27.6	315	434		1		1	9			33.6	454	9	2.2		0.025	< 0.005	0.005	0.015	0.0004	< 0.001
Galmoy	08/11/1993	15:45:00	0.006	6.4		18.3	305	389		999		999	6			22.6	398	8.7	2.7		0.038	< 0.005	0.008	0.017	0.0004	< 0.001
Spring Toberpatrick Urlingford	09/11/1993	11:45:00	0.01	8.5		27		395		100		21	8				403									
Borehole at Castlecomer Yarns	09/11/1993	12:35:00	0.01	0.2		19		278		1		999	12				229									
Spring at Paulstown Castle	09/11/1993	14:40:00	0.01	5.8		26		296		33		18	8				314									
Borehole at Clara	09/11/1993	15:15:00	0.01	6.8		21		325		167		2	8				340									
Spring at Westcourt	09/11/1993	16:00:00	0.01	4.3		24		370		4		3	5				368									
Borehole at Dunmore	10/11/1993	10:30:00	0.01	13.6		22		296		999		999	< 1			7.3	320	9.2	0.8		0.041	< 0.005	0.001	0.035		< 0.001
Borehole at Dunmore S/G	10/11/1993	10:55:00	0.01	0.1		17		297		84		27	12			17.5	300	12	0.9		0.106	0.229	0.003	0.043		< 0.001
Borehole at Kilkenny Mar	10/11/1993	11:15:00	0.01	6.6		18		307		8		6	19			19	324	12	1.3		0.087	0.013	0.003	0.487		< 0.001
Borehole at Kilmanagh	10/11/1993	12:22:00	0.01	5		19		293		8		2	< 1			16.2	300	9.3	0.9		< 0.005	0.001	0.001	0.06		< 0.001
Springs at Bausheenmore	10/11/1993	14:30:00	0.01	6.5		30				100		100	< 1			34	381	10.1	3.5		0.009	0.001	< 0.001	0.052		< 0.001
Borehole No.9, Thomastown	10/11/1993	15:10:00	0.02	7.3		41				999		999	2			25.4	350	18	3.5		0.017	0.002	0.002	0.565		0.001
Borehole at Windgap	10/11/1993	15:50:00	0.02	1.7		12		173		9		5	2			17	173	8	1		0.016	0.001	< 0.001	0.075		< 0.001
Borehole at Avonmore Dairy	11/11/1993	11:30:00	0.3	6.5		31		230		999		999	15			10.6	265	16.9	6.7		0.04	0.003	0.002	0.178		< 0.001
Rathcash, Clifden,Co. Kilkenny	08/12/1993	09:45:00	0.011	6	0.001	23		334		999		999	8			27.8	358	8.5	1.2		0.01	0.006	0.004	0.084		0.003
Spring at Paulstown Castle	10/11/1994	11:25:00	< 0.01	5.3		29				420		170			5											
Graigue, Callan.	12/01/1995							244								27.4	238	14.1	0.7		1.06	0.09	0.01	0.166		
Spring at Paulstown Castle	23/01/1995	15:45:00	0.01	7		25				500		290			5											
Spring at Paulstown Castle	16/10/1995	15:23:00	0.016	4		22				150		72			5											
Borehole at Castlecomer Yarns	08/01/1996	11:10:00		0.05	0.006	18.5		304		999		999	22			20.2	321	18.6	0.9		0.116	0.434		< 0.02		
Borehole at Dunmore	08/01/1996	11:30:00	< 0.001	9.5	< 0.003	20.9		257		999		999	20			6.1	338	7.7	0.8		< 0.06	< 0.02		< 0.02		
Borehole at Dunmore S/G	08/01/1996	12:00:00	< 0.001	< 0.01	0.004	19.3		311				999	36			17.5	355	11.2	0.9		< 0.06	0.15		< 0.02		
Borehole at Kilkenny Mar	08/01/1996	12:15:00	< 0.001	5.9	< 0.003	19.7		312		5		999	40			18.3	389	10.2	1.3		< 0.06	< 0.02		< 0.02		
Borehole at Clara	08/01/1996	12:55:00	0.01	6.9	< 0.003	22.3		340		65		2	18			19.9	409	8.1	1.4		< 0.06	< 0.02		< 0.02		
Borehole at Rathcash	08/01/1996	13:10:00	0.001	5.1	< 0.003	23.6		360		999		999	18			25	427	7.6	1.1		< 0.06	< 0.02		0.024		
Spring at Paulstown Castle	08/01/1996	14:40:00	< 0.01	8	< 0.003			259	>	80	>	60				7.9	333	8	2.7		0.082	< 0.02		< 0.02		
Spring at Clomantagh	09/01/1996	10:40:00	0.06	5.8	0.032	15.6		195	>	200	>	100	7		Visible	4.2		6.5	1		0.93	0.14		0.115		
Spring Toberpatrick Urlingford	09/01/1996	11:05:00	0.037	11.1	< 0.003	23.1		317	>=	32		3	15			18.9		8.5	4.2		< 0.06	< 0.02		0.077		
Borehole at Bawnmore	09/01/1996	11:30:00	0.013	5.1	< 0.003	23.6		443		999		999	18			37.9		8.6	2.3		< 0.06	< 0.02		0.039		

EPA Regional Water Laboratory, Kilkenny. Monitoring Data for County Kilkenny Groundwaters 1993 to 1999.

Source	Sampling Date	Sampling Time	Cadmium mg/l Cd	Mercury mg/l Hg	Nickel mg/l Ni	Fluoride mg/l F	OMCTSiloxane µg/l	Comments1	Comments2	Comments3
Spring at Paulstown Castle	29/04/1992	11:38:00								
Spring at Paulstown Castle	01/07/1992	15:55:00								
Spring at Paulstown Castle	20/08/1992	15:15:00								
Spring at Paulstown Castle	18/11/1992	13:29:00								
Spring at Paulstown Castle	10/03/1993	16:00:00								
Borehole at Castlecomer Yarns	02/06/1993		< 0.0001					Copy to Castlecomer Yarns Ltd.		
Spring at Paulstown Castle	02/06/1993		< 0.0001							
Borehole at Rathcash	02/06/1993		< 0.0001					Copy to Rathcash G.W.S.		
Springs at Bausheenmore	02/06/1993		< 0.0001							
Spring at Westcourt	02/06/1993		< 0.0001							
Borehole at Galmoy	03/06/1993	11:25:00	< 0.0001		0.007					
Galmoy 35	03/06/1993	11:47:00	0.0001		0.001					
Galmoy 37	03/06/1993	12:02:00	0.0001		< 0.001					
Galmoy 25	03/06/1993	12:15:00	0.0001		0.005					
Galmoy 202	03/06/1993	12:55:00	0.0001		< 0.001					
Borehole at Bawnmore	03/06/1993	16:00:00	0.0001		< 0.001					
Spring at Clomantagh	10/06/1993	11:40:00	< 0.0001							
Spring at Clomantagh	10/06/1993	11:50:00	< 0.0001							
Borehole at Dunmore	10/06/1993	12:28:00	< 0.0001							
Spring Toberpatrick Urlingford	15/06/1993	10:45:00	< 0.0001							
Borehole at Kilmanagh	15/06/1993	12:00:00	< 0.0001							
Borehole at Dunmore S/G	15/06/1993	14:30:00	< 0.0001							
Borehole at Kilkenny Mar	15/06/1993	15:00:00	< 0.0001							
Borehole at Windgap	01/07/1993									
Spring at Paulstown Castle	05/08/1993	15:55:00								
Galmoy	08/11/1993	11:15:00	< 0.0001		< 0.001					
Galmoy	08/11/1993	11:45:00	< 0.0001		< 0.001					
Galmoy	08/11/1993	12:20:00	< 0.0001		< 0.001					
Galmoy	08/11/1993	12:40:00	< 0.0001		< 0.001					
Galmoy	08/11/1993	13:50:00	< 0.0001		< 0.001					
Galmoy	08/11/1993	13:55:00						Taken after well was pumped for approximately 1 1/2 hours.		
Galmoy	08/11/1993	14:44:00	< 0.0001		< 0.001					
Galmoy	08/11/1993	14:52:00	< 0.0001		< 0.001					
Borehole at Bawnmore	08/11/1993	15:15:00	< 0.0001		< 0.001					
Galmoy	08/11/1993	15:45:00	< 0.0001		< 0.001					
Spring Toberpatrick Urlingford	09/11/1993	11:45:00								
Borehole at Castlecomer Yarns	09/11/1993	12:35:00								
Spring at Paulstown Castle	09/11/1993	14:40:00								
Borehole at Clara	09/11/1993	15:15:00						167 Total Coliforms, 5 obvious coliform colonies, 162 probably	coliform colonies.	
Spring at Westcourt	09/11/1993	16:00:00								
Borehole at Dunmore	10/11/1993	10:30:00	< 0.0001							
Borehole at Dunmore S/G	10/11/1993	10:55:00	< 0.0001							
Borehole at Kilkenny Mar	10/11/1993	11:15:00	< 0.0001							
Borehole at Kilmanagh	10/11/1993	12:22:00	< 0.0001					Copy to Mr. Liam Delaney.		
Springs at Bausheenmore	10/11/1993	14:30:00	< 0.0001							
Borehole No.9, Thomastown	10/11/1993	15:10:00	< 0.0001							
Borehole at Windgap	10/11/1993	15:50:00	< 0.0001							
Borehole at Avonmore Dairy	11/11/1993	11:30:00	< 0.0001					Chlorinated sample		
Rathcash, Clifden,Co. Kilkenny	08/12/1993	09:45:00	< 0.0001							
Spring at Paulstown Castle	10/11/1994	11:25:00								
Graigue, Callan.	12/01/1995		< 0.0003					High iron and elevated manganese levels leading to high turbidity.		
Spring at Paulstown Castle	23/01/1995	15:45:00						Interference < mixed background colonies (non< coliform) on Total	Coliform plate.	
Spring at Paulstown Castle	16/10/1995	15:23:00						Interference from background colonies on Total Coliform plate.		
Borehole at Castlecomer Yarns	08/01/1996	11:10:00								
Borehole at Dunmore	08/01/1996	11:30:00								
Borehole at Dunmore S/G	08/01/1996	12:00:00						Total Coliform plate overgrown with non< coliforms.		
Borehole at Kilkenny Mar	08/01/1996	12:15:00								
Borehole at Clara	08/01/1996	12:55:00						Copy to: Paddy Coogan, Clifden, Clara, Co. Kilkenny		
Borehole at Rathcash	08/01/1996	13:10:00						Copy to: Mr. Joe Pyke, Ratcash, Clifden, Co. Kilkenny.		
Spring at Paulstown Castle	08/01/1996	14:40:00								
Spring at Clomantagh	09/01/1996	10:40:00							Spring in farmyard, sample taken at surface.	
Spring Toberpatrick Urlingford	09/01/1996	11:05:00								
Borehole at Bawnmore	09/01/1996	11:30:00								

EPA Regional Water Laboratory, Kilkenny. Monitoring Data for County Kilkenny Groundwaters 1993 to 1999.

Source	Sampling Date	Sampling Time	To	Ref No	Sampling Location	Taken By	Lab No	EPARef	Stn Grid Ref	Water Supply	Public/Group/Private	Temperature	Odour 1/2/3	Colour Hazen	pH	Conductivity µS/cm	Turbidity NTU	TOC mg/l C	Ammonia mg/l N
Borehole at Galmoy	09/01/1996	12:40:00	Kilkenny Co. Co.	KK00200	Leahy's House, Galmoy	C. Murray	92	KIK17	23020 17120	Galmoy	Group	8.6	1	5	7.3	779	0.1	1.8	< 0.01
Borehole at Kilmanagh	09/01/1996	14:20:00	Kilkenny Co. Co.	KK01400	In pumphouse	C. Murray	93	KIK45	23930 15250	Kilmanagh/Ballycuddihy	Group	8.2	1	5	7.6	645	0.1	2.3	0.021
Spring at Westcourt	09/01/1996	15:10:00	Kilkenny Co. Co.	KK00800	Spring at Earlsland, Westcourt, Callan	C. Murray	94	KIK91	S 407 442	Callan	Public	11.1	1	5	7.3	704	0.1	2.9	< 0.01
Borehole at Windgap	09/01/1996	15:40:00	Kilkenny Co. Co.	KK01900	Overflow from borehole	C. Murray	95		24200 13580	Farm supply	Private	11	1	5	7.4	380	0.2	< 0.12	0.023
Spring at Carrigeen,	15/01/1996	13:00:00	Kilkenny Co. Co.		Keoghans Field, Threecastles	J. Jennings	135						2	15	8	1045			0.03
Belview	27/02/1996	14:15:00	Kilkenny County Counci		Well No.2 for proposed new water supply	Brian Connor	763			Belview proposed				5	6.8	351			< 0.01
Belview	29/02/1996	11:45:00	Kilkenny County Counci		Well No.2 for proposed new water supply	Brian Connor	822			Belview proposed			1	5	6.7	359			< 0.01
Belview No. 2	07/03/1996	16:00:00	Kilkenny Co Co		Belview Proposed water supply Well No. 2	Brian Connor	973						1	5	6.7	365			
Belview No. 2	14/03/1996	11:00:00	Kilkenny Co Co		Belview Proposed water supply Well No. 2	Brian Connor	1050						1	5	6.7	357			< 0.01
Belview No. 2	23/03/1996	14:10:00	Kilkenny Co Co		Belview Proposed water supply Well No. 2	Brian Connor	1157						1	5	6.4	290			< 0.01
Belview No. 1	25/03/1996	15:00:00	Kilkenny Co Co		Belview Proposed water supply Well No. 1	Brian Connor	1130						1	5	6.5	290		0.67	< 0.01
Belview No. 1	27/03/1996	13:00:00	Kilkenny Co Co		Belview Proposed water supply Well No. 1	Brian Connor	1173						1	5	6.4	289			< 0.01
Dunmore Wells	02/07/1996	10:10:00	Kilkenny Co. Co.		Readymix	C. Murray	2536						1	5	7.5	651		0.15	< 0.01
Dunmore Wells	02/07/1996	10:15:00	Kilkenny Co. Co.		Leahy's	C. Murray	2537						1	10	8.3	413		< 0.12	< 0.01
Dunmore Wells	02/07/1996	10:15:00	Kilkenny Co. Co.		O'Dwyers	C. Murray	2538						2	5	7.5	513		< 0.12	0.03
Dunmore Wells	02/07/1996	10:35:00	Kilkenny Co. Co.		Tom Langtons	C. Murray	2539						1	10	7.9	350		< 0.12	0.02
Dunmore Wells	02/07/1996	10:55:00	Kilkenny Co. Co.		McDermotts	C. Murray	2540						1	10	7.4	599		0.69	< 0.01
Dunmore Wells	02/07/1996	11:10:00	Kilkenny Co. Co.		Nolans	C. Murray	2541						1	5	7.3	841		0.61	< 0.01
Dunmore Wells	02/07/1996	11:30:00	Kilkenny Co. Co.		O'Neill's	C. Murray	2542						1	10	7.4	700		0.15	< 0.01
Dunmore Wells	02/07/1996	11:45:00	Kilkenny Co. Co.		Fitzpatrick's	C. Murray	2543						1	5	7.4	737		0.53	< 0.01
Dunmore Wells	02/07/1996	12:10:00	Kilkenny Co. Co.		Canteen in Landfdill Site	C. Murray	2544						1	15	7.4	563		2.07	0.05
Dunmore Wells	02/07/1996	12:35:00	Kilkenny Co. Co.		Holohan's	C. Murray	2545						2	15	7.4	633		1.94	0.42
Dunmore Wells	02/07/1996	12:45:00	Kilkenny Co. Co.		Murphy's/Stacks	C. Murray	2546						2	50	7.5	689		< 0.12	0.013
Bellview	02/10/1996	11:10:00	Kilkenny Co. Co.		Well No. 3.	Brian Connor	3853						1	5	6.6	554	0.26		< 0.01
Bellview	03/10/1996	10:30:00	Kilkenny Co. Co.		Well No. 3.	Brian Connor	3873						1	5	6.4	565	0.2		
Bellview Water Supply	08/10/1996	10:30:00	Kilkenny Co. Co.		Well No. 3.	B. O'Connor	3971						1	5	6.5	551			< 0.01
Spring at Paulstown Castle	09/01/1997	12:17:00	Kilkenny Co. Co.	KK00600	Spring at Paulstown Castle	P. Mullins	106	KIK46	S 660 570	Gowran/Goresbr./P-town	Public	9.3	1	< 5	7.3	613	0.23	1.9	< 0.01
Thomastown	10/01/1997	10:17:00	Kilkenny Co. Co.		Borehole No. 5	P. Mullins	111		S 589 411			9.6	1	< 5	7.1	439	0.09	1.3	< 0.01
Borehole No.9, Thomastown	10/01/1997	10:05:00	Kilkenny Co. Co.	KK01600	At pumphouse	P. Mullins	112	KIK32	25890 14160	Thomastown	Public	9.4	1	< 5	7.3	721	0.11	1.5	
Borehole at Dunmore	13/01/1997		Kilkenny Co. Co.	KK00700	C. Murray,s house, Dunmore.	C. Murray	216		24910 16200	Dunmore	Group								
Spring at Paulstown Castle	17/02/1997	11:30:00	Kilkenny Co. Co.	KK00600	Spring at Paulstown Castle	C. Murray	726	KIK46	S 660 570	Gowran/Goresbr./P-town	Public	10.3	1	< 5	7.3	607		0.6	< 0.1
Springs at Bausheenmore	17/02/1997	12:30:00	Kilkenny Co. Co.	KK00500	At source (springs at Bausheenmore)	C. Murray	727	KIK39	25520 14690		Private	10.5	1	< 5	7.3	767		< 1	< 0.1
Spring at Westcourt	17/02/1997	14:05:00	Kilkenny Co. Co.	KK00800	Spring at Earlsland, Westcourt, Callan	C. Murray	728	KIK91	S 407 442	Callan	Public	11.3	1	< 5	7.3	702		< 1	< 0.1
Dunmore	09/05/1997		Kilkenny Co. Co.		Doyle's	M. Daly	1936				Private		1					0.53	2
Dunmore	09/05/1997		Kilkenny Co. Co.		Holohan's	M. Daly	1937				Private		3					1.8	0.5
Dunmore	09/05/1997		Kilkenny Co. Co.		No. 8 Stack	M. Daly	1938				Private		3					0.1	< 0.01
Dunmore	09/05/1997		Kilkenny Co. Co.		Well in landfill site	M. Daly	1939				Private		2						17.6
Dunmore	09/05/1997		Kilkenny Co. Co.		Unused Borehole, Doyle's Field	M. Daly	1940				Private		2					5.4	12.1
Dunmore	12/05/1997	10:45:00	Kilkenny Co. Co.		Readymix	C. Murray	1944					10.2	1	5	7.7	631	0.65	0.22	1.5
Dunmore	12/05/1997	10:55:00	Kilkenny Co. Co.		O'Dwyers	C. Murray	1945					10.8	2	15	7.6	473	3.8	0.09	0.05
Dunmore	12/05/1997	11:05:00	Kilkenny Co. Co.		Langtons	C. Murray	1946					9.7	1	15	8	352	12	0.08	0.04
Dunmore	12/05/1997	11:15:00	Kilkenny Co. Co.		Bergin's	C. Murray	1947					9.8	2	5	7.4	656	0.42	0.33	< 0.01
Dunmore	12/05/1997	11:25:00	Kilkenny Co. Co.		McDermott's	C. Murray	1948					10.8	2	5	7.3	615		0.39	< 0.01
Dunmore	12/05/1997	12:00:00	Kilkenny Co. Co.		Nolans	C. Murray	1949					10.8	2	5	7.3	794	0.19	0.64	< 0.01
Dunmore	12/05/1997	12:15:00	Kilkenny Co. Co.		O'Neill's	C. Murray	1950					10.9	1	5	7.4	700	0.42	0.09	< 0.01
Dunmore	12/05/1997	12:30:00	Kilkenny Co. Co.		Fitzpatricks	C. Murray	1951					10.4	2	5	7.3	736	0.21	0.43	< 0.01
Dunmore	12/05/1997	15:30:00	Kilkenny Co. Co.		Doyle's	C. Murray	1952					10.7	2	5	7.2	816	0.11	0.67	1.41
Dunmore	12/05/1997	15:45:00	Kilkenny Co. Co.		Holohan's	C. Murray	1953					12	2		7.3	640	69	1.88	0.33
Dunmore	12/05/1997	15:55:00	Kilkenny Co. Co.		Stacks/Murphys	C. Murray	1954					11.5	3		7.7	665	16	0.26	< 0.01
Dunmore	12/05/1997	14:35:00	Kilkenny Co. Co.		Canteen at landfill site.	C. Murray	1955			Canteen at landfill	private	11.5	3		7.9	1.8	100		110
Dunmore	12/05/1997	14:50:00	Kilkenny Co. Co.		New Bore at landfill site.	C. Murray	1956					12.4	2		7.2	994	6.1	7.2	0.5
Dunmore	12/05/1997	15:10:00	Kilkenny Co. Co.		Roches Pit, new cell	C. Murray	1957					10.8	2	5	7.3	653	1.2	0.64	< 0.01

EPA Regional Water Laboratory, Kilkenny. Monitoring Data for County Kilkenny Groundwaters 1993 to 1999.

Source	Sampling Date	Sampling Time	o-Phosphate mg/l P	Nitrate mg/l N	Nitrite mg/l N	Chloride mg/l Cl	Ca Hardness mg/l CaCO3	Alkalinity mg/l CaCO3	TCS	Total Coliforms per 100 ml	FCS	Fecal Coliforms per 100 ml	Sulphate mg/l SO4	Dry Residue mg/l	Sus_ Solids mg/l	Magnesium mg/l Mg	Total Hardness mg/l CaCO3	Sodium mg/l Na	Potassium mg/l K	Aluminium mg/l Al	Iron mg/l Fe	Manganese mg/l Mn	Copper mg/l Cu	Zinc mg/l Zn	Chromium mg/l Cr	Lead mg/l Pb
Borehole at Galmoy	09/01/1996	12:40:00	0.002	9.6	< 0.003	27.7		364		999		999	20			31.8		7.9	0.8		< 0.06	< 0.02		0.061		
Borehole at Kilmanagh	09/01/1996	14:20:00	0.099	3.5	< 0.003	20.4		327	>=	15	>=	2	11			18.4		9.1	0.9		< 0.06	< 0.02		0.035		
Spring at Westcourt	09/01/1996	15:10:00	0.02	3.6	< 0.003	24.1		365		52		64	15			29.2		9.5	0.9		< 0.06	< 0.02		0.028		
Borehole at Windgap	09/01/1996	15:40:00	0.122	1.8	< 0.003	16		164		999		999	4			19.2		6.9	1		< 0.06	< 0.02		0.03		
Spring at Carrigeen,	15/01/1996	13:00:00	0.1	36.2	0.014	44		183					25													
Belview	27/02/1996	14:15:00	< 0.02	3.7	< 0.004	28		97		999		999					103									
Belview	29/02/1996	11:45:00	< 0.02	4.1	< 0.004	32.7		81		999		999					83									
Belview No. 2	07/03/1996	16:00:00						114		1		999					116				< 0.06	< 0.02		0.08		
Belview No. 2	14/03/1996	11:00:00	< 0.02	4.5	< 0.004	28		97		14		9									< 0.06	< 0.02		0.026		
Belview No. 2	23/03/1996	14:10:00	< 0.02	6.7	< 0.004	26		77		2		999														
Belview No. 1	25/03/1996	15:00:00	< 0.02	6.8	0.004	28		49		999		999									< 0.06	< 0.02		0.314		
Belview No. 1	27/03/1996	13:00:00	< 0.02	6.7	< 0.004	28		64		1		999														
Dunmore Wells	02/07/1996	10:10:00	< 0.02	< 0.1	0.004	20		317		999		999	29													
Dunmore Wells	02/07/1996	10:15:00	< 0.02	1.5	0.007	16		191	>=	3		999	11													
Dunmore Wells	02/07/1996	10:15:00	< 0.02	< 0.1	0.009	18				999		999	14													
Dunmore Wells	02/07/1996	10:35:00	< 0.02	< 0.1	0.003	13		164	>	80		999	4													
Dunmore Wells	02/07/1996	10:55:00	< 0.02	6.5	0.001	19		283	>=	3		6	15													
Dunmore Wells	02/07/1996	11:10:00	0.22	12	0.002	37		352	>	80		15	25													
Dunmore Wells	02/07/1996	11:30:00	< 0.02	7.4	0.002	28		323		999		999	15													
Dunmore Wells	02/07/1996	11:45:00	0.14	9.2	0.002	28		330	>	80	>	60	16													
Dunmore Wells	02/07/1996	12:10:00	0.03	2.6	0.041	22		250	>	80		6	25													
Dunmore Wells	02/07/1996	12:35:00	0.09	< 0.1	0.015	19		322		2		999	20													
Dunmore Wells	02/07/1996	12:45:00	< 0.02	< 0.1	0.005	21		323	>=	68		999	30													
Bellview	02/10/1996	11:10:00	< 0.02	19.3	0.003	43				999		999				21.3		22.5	2.6		0.12	0.033		0.184		
Bellview	03/10/1996	10:30:00								1		999				21.3		23.3	2.8		0.087	0.034	0.112			
Bellview Water Supply	08/10/1996	10:30:00	0.01	22	0.004	41		68	>=	2		999				21.3		22.8	2.8		0.087	0.029		0.074		
Spring at Paulstown Castle	09/01/1997	12:17:00	0.01	7	0.001	28		252		21		1	19													
Thomastown	10/01/1997	10:17:00	0.01	4.4	< 0.004	23	248			999		999														
Borehole No.9, Thomastown	10/01/1997	10:05:00	0.03	5.7	< 0.004	39	248			999		999														
Borehole at Dunmore	13/01/1997																									
Spring at Paulstown Castle	17/02/1997	11:30:00	< 0.02	6.4	0.01	22		245		200		22				11.5		8.7	2.6							
Springs at Bausheenmore	17/02/1997	12:30:00	< 0.02	7.1	< 0.004	26		345	>	80		50				29.5		8.7	3.6							
Spring at Westcourt	17/02/1997	14:05:00	< 0.02	4.8	0.011	20		329		3		2				23.3		8.3	0.9							
Dunmore	09/05/1997		< 0.02	11.2	< 0.004	45																				
Dunmore	09/05/1997		0.19	< 0.1	0.005	18																				
Dunmore	09/05/1997		< 0.02	< 0.1	< 0.003	21																				
Dunmore	09/05/1997		0.87	11.3	2	295																				
Dunmore	09/05/1997		0.08	3.3	0.1	29																				
Dunmore	12/05/1997	10:45:00	0.01	0.232	0.004	20				15		999														
Dunmore	12/05/1997	10:55:00	0.05	0.15	0.003	16			>=	37		6														
Dunmore	12/05/1997	11:05:00	0.01	0.16	0.004	13				999		999														
Dunmore	12/05/1997	11:15:00	< 0.02	16.2	0.007	23			>=	6		999														
Dunmore	12/05/1997	11:25:00	< 0.02	7.5	0.003	20			>=	13		999														
Dunmore	12/05/1997	12:00:00	0.17	12	0.004	30			>=	210		999														
Dunmore	12/05/1997	12:15:00	0.01	8.2	0.003	27						999														
Dunmore	12/05/1997	12:30:00	0.165	10.1	0.003	26				750		300														
Dunmore	12/05/1997	15:30:00	0.015	1.3	0.031	44			>	80		4														
Dunmore	12/05/1997	15:45:00	0.11	0.15	0.019	18																				
Dunmore	12/05/1997	15:55:00	< 0.02	0.18	2.2	19			>=	16		999														
Dunmore	12/05/1997	14:35:00	3	5.6	3.8	353			>	2000	>	2000														
Dunmore	12/05/1997	14:50:00	0.5	0.9	0.41	31					>	600														
Dunmore	12/05/1997	15:10:00	< 0.02	11	0.002	19			>=	9		999														

EPA Regional Water Laboratory, Kilkenny. Monitoring Data for County Kilkenny Groundwaters 1993 to 1999.

Source	Sampling Date	Sampling Time	Cadmium mg/l Cd	Mercury mg/l Hg	Nickel mg/l Ni	Fluoride mg/l F	OMCTSiloxane µg/l	Comments1	Comments2	Comments3
Borehole at Galmoy	09/01/1996	12:40:00								
Borehole at Kilmanagh	09/01/1996	14:20:00								
Spring at Westcourt	09/01/1996	15:10:00								
Borehole at Windgap	09/01/1996	15:40:00								
Spring at Carrigeen,	15/01/1996	13:00:00						Very high Nitrate.	High Conductivity and chloride.	
Belview	27/02/1996	14:15:00						Sample taken after pumping for 1 hour.		
Belview	29/02/1996	11:45:00								
Belview No. 2	07/03/1996	16:00:00						Sample delivered to the laboratory on 8/3/96 by Finbar Coughlan.		
Belview No. 2	14/03/1996	11:00:00								
Belview No. 2	23/03/1996	14:10:00								
Belview No. 1	25/03/1996	15:00:00								
Belview No. 1	27/03/1996	13:00:00								
Dunmore Wells	02/07/1996	10:10:00								
Dunmore Wells	02/07/1996	10:15:00								
Dunmore Wells	02/07/1996	10:15:00								
Dunmore Wells	02/07/1996	10:35:00								
Dunmore Wells	02/07/1996	10:55:00								
Dunmore Wells	02/07/1996	11:10:00								
Dunmore Wells	02/07/1996	11:30:00								
Dunmore Wells	02/07/1996	11:45:00								
Dunmore Wells	02/07/1996	12:10:00								
Dunmore Wells	02/07/1996	12:35:00								
Dunmore Wells	02/07/1996	12:45:00								
Bellview	02/10/1996	11:10:00						Calcium Hardness = 152 mg/l CaCO3	Very high nitrate.	
Bellview	03/10/1996	10:30:00						Calcium Hardness = 144 mg/l CaCO3		
Bellview Water Supply	08/10/1996	10:30:00						Calcium Hardness = 144 mg/l CaCO3	Interference from background colonies on Total Coliform plate.	Very high Nitrate.
Spring at Paulstown Castle	09/01/1997	12:17:00						See GC/MS Purge & Trap analyses on separate sheet.		
Thomastown	10/01/1997	10:17:00								
Borehole No.9, Thomastown	10/01/1997	10:05:00						See GC/MS Purge & Trap analyses on separate sheet.	Octamethylcyclotetrasiloxane < 0.2 ug/l.	
Borehole at Dunmore	13/01/1997							Sample for GC/MS Purge & Trap analyses only. Results on separate sheet.	Octamethylcyclotetrasiloxane 0.7 ug/l.	
Spring at Paulstown Castle	17/02/1997	11:30:00						Octamethylcyclotetrasiloxane = 0.3 ug/l.		
Springs at Bausheenmore	17/02/1997	12:30:00						Octamethylcyclotetrasiloxane = 1.7 ug/l.	K/Na Ratio = 0.41	
Spring at Westcourt	17/02/1997	14:05:00						Octamethylcyclotetrasiloxane = 1.4 ug/l.		
Dunmore	09/05/1997							Very high ammmonia.	Sample taken after land-fill leachate escaped to groundwater.	Approximate ammonia concentration.
Dunmore	09/05/1997							Strong odour and high ammonia.	Sample taken after land-fill leachate escaped to groundwater.	Approximate ammonia concentration.
Dunmore	09/05/1997							Odour of sulphide.	Sample taken after land-fill leachate escaped to groundwater.	Approximate ammonia concentration.
Dunmore	09/05/1997							Very high TOC, ammonia and nitrite results < serious contamination.	Sample taken after land-fill leachate escaped to groundwater.	Approximate ammonia concentration.
Dunmore	09/05/1997							Very high ammonia and high nitrite.	Sample taken after land-fill leachate escaped to groundwater.	Approximate ammonia concentration.
Dunmore	12/05/1997	10:45:00						Ammonia >1.5 mg/l as N.	Sample taken after leachate at landfill site escaped to groundwater	Amended report, ammonia is >1.5 and not <1.5 as reported on 15/5/97.
Dunmore	12/05/1997	10:55:00							Sample taken after leachate at landfill site escaped to groundwater	
Dunmore	12/05/1997	11:05:00							Sample taken after leachate at landfill site escaped to groundwater	No coliforms detected but possible interference from suspended solids.
Dunmore	12/05/1997	11:15:00							Sample taken after leachate at landfill site escaped to groundwater	
Dunmore	12/05/1997	11:25:00							Sample taken after leachate at landfill site escaped to groundwater	
Dunmore	12/05/1997	12:00:00							Sample taken after leachate at landfill site escaped to groundwater	Interference from suspended solids on the total coliform test.
Dunmore	12/05/1997	12:15:00							Sample taken after leachate at landfill site escaped to groundwater	Background interference on the total coliform test.
Dunmore	12/05/1997	12:30:00							Sample taken after leachate at landfill site escaped to groundwater	Very high coliform levels (total and faecal).
Dunmore	12/05/1997	15:30:00						High ammonia and nitrite concentrations.	Sample taken after leachate at landfill site escaped to groundwater	
Dunmore	12/05/1997	15:45:00						Very turbid. High ammonia indicitave of pollution.	Sample taken after leachate at landfill site escaped to groundwater	Interference from suspended solids on the coliform tests (total & faecal).
Dunmore	12/05/1997	15:55:00						Very turbid. High nitrite. Odour detected.	Sample taken after leachate at landfill site escaped to groundwater	Background interference on the total coliform test.
Dunmore	12/05/1997	14:35:00						Turbidity > 100 NTU and ammonia > 110 mg/l N. Very high coliform levels.	Sample taken after leachate at landfill site escaped to groundwater	
Dunmore	12/05/1997	14:50:00						High ammonia and nitrite levels.	Sample taken after leachate at landfill site escaped to groundwater	Interference on the total coliform test.
Dunmore	12/05/1997	15:10:00							Sample taken after leachate at landfill site escaped to groundwater	Interference on the total coliform test.

EPA Regional Water Laboratory, Kilkenny. Monitoring Data for County Kilkenny Groundwaters 1993 to 1999.

Source	Sampling Date	Sampling Time	To	Ref No	Sampling Location	Taken By	Lab No	EPARef	Stn Grid Ref	Water Supply	Public/Group/Private	Temperature	Odour 1/2/3	Colour Hazen	pH	Conductivity µS/cm	Turbidity NTU	TOC mg/l C	Ammonia mg/l N
Borehole at Dunmore	18/06/1997	11:45:00	Kilkenny Co. Co.	KK00700	C. Murray,s house, Dunmore.	C. Murray	2630		24910 16200	Dunmore	Group	15		15	7.4	604			< 0.01
Dunmore	08/07/1997	14:50:00	Kilkenny Co. Co.		Stacks	M. Daly	2973						2	60	7.6	659	7.5		< 0.01
Dunmore	08/07/1997	15:00:00	Kilkenny Co. Co.		Holohans	M. Daly	2974						1		7.3	639	72		0.4
Borehole at Kilmanagh	01/09/1997	10:24:00	Kilkenny Co. Co.	KK01400	In pumphouse	P. Mullins	3796	KIK45	23930 15250	Kilmanagh/Ballycuddihy	Group	14.4	1	< 5	7.5	641	0.26	0.4	< 0.01
Spring at Westcourt	01/09/1997	11:17:00	Kilkenny Co. Co.	KK00800	Spring at Earlsland, Westcourt, Callan	P. Mullins	3797	KIK91	S 407 442	Callan	Public	11.9	1	< 5	7.3	701	0.14	0.28	< 0.01
Borehole at Windgap	01/09/1997	11:54:00	Kilkenny Co. Co.	KK01900	Overflow from borehole	P. Mullins	3798		24200 13580	Farm supply	Private	11.3	1	< 5	7.3	386	0.39	0.07	< 0.01
Springs at Bausheenmore	01/09/1997	13:36:00	Kilkenny Co. Co.	KK00500	At source (springs at Bausheenmore)	P. Mullins	3799	KIK39	25520 14690		Private	11.9	1	20	7.4	717	2.6	3.3	< 0.01
Borehole at Dunmore S/G	01/09/1997	14:17:00	Kilkenny Co. Co.	KK01000	Canteen at Dunmore Sand & Gravel	P. Mullins	3800	KIK53	25000 16020	Dunmore Sand & Gravel	Private	13.6	1	5	7.7	645	1	0.41	< 0.01
Borehole at Dunmore	01/09/1997	14:26:00	Kilkenny Co. Co.	KK00700	C. Murray,s house, Dunmore.	P. Mullins	3801		24910 16200	Dunmore	Group	16	1	< 5	7.4	643	0.14	0.34	< 0.01
Borehole at Kilkenny Mar	01/09/1997	15:13:00	Kilkenny Co. Co.	KK01300	Cattle holding shec	P. Mullins	3802		25070 15670	Kilkenny Mart	Private	16.7	1	60	8.4	130	27	3.2	0.03
Borehole at Galmoy	27/08/1997	11:19:00	Kilkenny Co. Co.	KK00200	Leahy's House, Galmoy	P. Mullins	3743	KIK17	23020 17120	Galmoy	Group	14.3	1	5	7.6	763	0.15	0.55	< 0.01
Borehole at Bawnmore	27/08/1997	11:39:00	Kilkenny Co. Co.	KK00100	Phelan's house, Bawnmore	P. Mullins	3744	KIK50	22580 16610	Bawnmore	Group	15.4	1	5	7.3	826	0.08	1.04	< 0.01
Spring Toberpatrick Urlingford	27/08/1997	12:05:00	Kilkenny Co. Co.	KK01500	In chamber at source	P. Mullins	3745	KIK34	23000 16350	Urlingford/Johnstown	Public	11.1	1	5	7.2	743	0.12	2.47	< 0.01
Spring at Clomantagh	27/08/1997	12:20:00	Kilkenny Co. Co.	KK00900	Beside Nuenna river, 50m SE of road	P. Mullins	3746		23520 16320		Private	12.4	1	5	7.4	638	1.6	1.01	< 0.01
Borehole at Castlecomer Yarns	27/08/1997	14:00:00	Kilkenny Co. Co.	KK00300	Tap in yard at Castlecomer Yarns	P. Mullins	3747		25360 17330	Castlecomer Yarns	Private	12	1	5	7.4	600	5.8	0.56	0.033
Spring at Paulstown Castle	27/08/1997	14:51:00	Kilkenny Co. Co.	KK00600	Spring at Paulstown Castle	P. Mullins	3748	KIK46	S 660 570	Gowran/Goresbr./P-town	Public	11.9	1	5	7.3	636	0.72	1.13	< 0.01
Borehole at Rathcash	27/08/1997	15:12:00	Kilkenny Co. Co.	KK02000	Joe Pykes house, Rathcash, Clara.	P. Mullins	3749	KIK55	25870 15510	Rathcash	Group	16.9	1	5	7.4	709	0.07	0.49	< 0.01
Borehole at Clara	27/08/1997	15:30:00	Kilkenny Co. Co.	KK00400	At pumphouse	P. Mullins	3750	KIK41	25770 15530	Clara	Group	16.3	1	5	7.4	673	0.06	0.59	< 0.01
Dunmore	03/03/1998	11:10:00	Kilkenny Co. Co.		1. Billy O'Dwyers	C. Murray	1116			1. Billy O'Dwyers		9.8	1	10	7.6	473	3.7	0.03	0.073
Dunmore Group Scheme	19/05/1998	11:45:00	Kilkenny Co. Co.			P. Mullins	2330					17.6	1	5	7.44	636			
	19/05/1998	11:55:00	Kilkenny Co. Co.		Readymix	P. Mullins	2331					14.8	1	< 5	7.59	648			
Borehole at Windgap	09/02/1999	09:30:00	Kilkenny Co. Co.	KK01900	Overflow from borehole	Redmond Bergin	815		24200 13580	Farm supply	Private			5	7.3	330	< 0.1		< 0.2
Spring at Clomantagh	17/02/1999	10:40:00	Kilkenny Co. Co.	KK00900	Beside Nuenna river, 50m SE of road	C. Murray	998		23520 16320		Private	10	1	5	7.3	669	0.6	4	
Spring Toberpatrick Urlingford	17/02/1999	11:00:00	Kilkenny Co. Co.	KK01500	In chamber at source	C. Murray	999	KIK34	23000 16350	Urlingford/Johnstown	Public	9.2	1	5	7.3	747	0.2	4.3	
Borehole at Bawnmore	17/02/1999	11:30:00	Kilkenny Co. Co.	KK00100	Phelan's house, Bawnmore	C. Murray	1000	KIK50	22580 16610	Bawnmore	Group	7	1	5	7.1	881	< 0.1	4.5	
Borehole at Galmoy	17/02/1999	12:00:00	Kilkenny Co. Co.	KK00200	Leahy's House, Galmoy	C. Murray	1001	KIK17	23020 17120	Galmoy	Group		1	5	7.3	776	0.4	2.1	
Borehole at Castlecomer Yarns	17/02/1999	12:50:00	Kilkenny Co. Co.	KK00300	Tap in yard at Castlecomer Yarns	C. Murray	1002		25360 17330	Castlecomer Yarns	Private	10.5	1	40	7.4	535	11.6	2	
Borehole at Dunmore	17/02/1999	14:05:00	Kilkenny Co. Co.	KK00700	C. Murray,s house, Dunmore.	C. Murray	1003		24910 16200	Dunmore	Group	7.7	1	5	7.3	663	< 0.1	1.7	< 0.2
Borehole at Kilkenny Mar	17/02/1999	15:00:00	Kilkenny Co. Co.	KK01300	Cattle holding shec	C. Murray	1004		25070 15670	Kilkenny Mart	Private	9.7	1	10	7.9	690	1.5	1.8	< 0.2
Borehole at Kilmanagh	17/02/1999	16:00:00	Kilkenny Co. Co.	KK01400	In pumphouse	C. Murray	1005	KIK45	23930 15250	Kilmanagh/Ballycuddihy	Group	7.3	1	5	7.6	658	< 0.1	3.9	< 0.2
Spring at Westcourt	14/04/1999	10:47:00	Kilkenny Co. Co.	KK00800	Spring at Earlsland, Westcourt, Callan	P. Mullins	1889	KIK91	S 407 442	Callan	Public	9.8	1	< 5	7.5	699	< 0.1		< 0.01
Borehole at Windgap	14/04/1999	11:14:00	Kilkenny Co. Co.	KK01900	Overflow from borehole	P. Mullins	1890		24200 13580	Farm supply	Private	10.5	1	< 5	7.3	388	0.2		< 0.01
Springs at Bausheenmore	14/04/1999	12:12:00	Kilkenny Co. Co.	KK00500	At source (springs at Bausheenmore)	P. Mullins	1891	KIK39	25520 14690		Private	9.6	1	< 5	7.4	772	0.2		< 0.01
Borehole at Rathcash	14/04/1999	14:00:00	Kilkenny Co. Co.	KK02000	Joe Pykes house, Rathcash, Clara.	P. Mullins	1892	KIK55	25870 15510	Rathcash	Group	9.4	1	< 5	7.3	722	< 0.1		< 0.01
Borehole at Clara	14/04/1999	14:18:00	Kilkenny Co. Co.	KK00400	At pumphouse	P. Mullins	1893	KIK41	25770 15530	Clara	Group	9.6	1	< 5	7.3	695	< 0.1		< 0.01
	07/09/1999	10:20:00	Kilkenny Co. Co.		Kenny's Well, Kilkenny City	T. Doherty	4410												
Bennettsbridge	29/03/2000	14:16:00	Kilkenny Co. Co.		New well - feeding the infiltration gallery	P. Mullins	1688			Bennettsbridge	Public	10.6	1	< 5	7.6	727			< 0.003
Borehole at Kilmanagh	27/09/2000	10:30:00	Kilkenny Co. Co.	KK01400	In pumphouse	C. Murray	5048	KIK45	23930 15250	Kilmanagh/Ballycuddihy	Group	13.8			7.3	664	0.1		< 0.003
Borehole at Windgap	27/09/2000	12:10:00	Kilkenny Co. Co.	KK01900	Overflow from borehole	C. Murray	5049		24200 13580	Farm supply	Private	11.5			7.3	388	0.6		< 0.003
Borehole No.9, Thomastown	27/09/2000	14:15:00	Kilkenny Co. Co.	KK01600	At pumphouse	C. Murray	5050	KIK32	25890 14160	Thomastown	Public	13.3			7.2	758	0.2		< 0.003
Springs at Bausheenmore	27/09/2000	14:50:00	Kilkenny Co. Co.	KK00500	At source (springs at Bausheenmore)	C. Murray	5051	KIK39	25520 14690		Private	11			7.1	787	0.6		0.005
Spring at Paulstown Castle	27/09/2000	15:40:00	Kilkenny Co. Co.	KK00600	Spring at Paulstown Castle	C. Murray	5052	KIK46	S 660 570	Gowran/Goresbr./P-town	Public	11.1			7.1	656	0.4		0.016
Spring at Clomantagh	26/09/2000	10:20:00	Kilkenny Co. Co.	KK00900	Beside Nuenna river, 50m SE of road	C. Murray	5026		23520 16320		Private	11.4	1	15	7.4	282			0.083
Spring Toberpatrick Urlingford	26/09/2000	10:40:00	Kilkenny Co. Co.	KK01500	In chamber at source	C. Murray	5027	KIK34	23000 16350	Urlingford/Johnstown	Public	10.3	1	5	7.2	813			< 0.003
Borehole at Bawnmore	26/09/2000	11:05:00	Kilkenny Co. Co.	KK00100	Phelan's house, Bawnmore	C. Murray	5028	KIK50	22580 16610	Bawnmore	Group	13.5	1	5	7.3	863			< 0.003
Borehole at Galmoy	26/09/2000	12:15:00	Kilkenny Co. Co.	KK00200	Leahy's House, Galmoy	C. Murray	5029	KIK17	23020 17120	Galmoy	Group	14.7	1	5	7.4	789			< 0.003
Borehole at Castlecomer Yarns	26/09/2000	14:00:00	Kilkenny Co. Co.	KK00300	Tap in yard at Castlecomer Yarns	C. Murray	5030		25360 17330	Castlecomer Yarns	Private	12.2	1	20	7.5	578			0.036
Borehole at Dunmore	26/09/2000	14:25:00	Kilkenny Co. Co.	KK00700	C. Murray,s house, Dunmore.	C. Murray	5031		24910 16200	Dunmore	Group	14.7	1	5	7.4	668			< 0.003
Borehole at Dunmore S/G	26/09/2000	14:40:00	Kilkenny Co. Co.	KK01000	Canteen at Dunmore Sand & Gravel	C. Murray	5032	KIK53	25000 16020	Dunmore Sand & Gravel	Private	12.4	1	5	7.6	660			< 0.003
Borehole at Kilkenny Mar	26/09/2000	14:55:00	Kilkenny Co. Co.	KK01300	Cattle holding shec	C. Murray	5033		25070 15670	Kilkenny Mart	Private	14.6	1	5	7.6	708			< 0.003
Borehole at Clara	26/09/2000	15:35:00	Kilkenny Co. Co.	KK00400	At pumphouse	C. Murray	5034	KIK41	25770 15530	Clara	Group	11.6	1	5	7.4	667			< 0.003
Kiloshaun/Barna	03/10/2000	11:15:00	Kilkenny Co. Co./G.S.I.		GWS06	M. Daly	5218								7	663			0.015
Tubrid Lower	03/10/2000	11:40:00	Kilkenny Co. Co./G.S.I.		GWS14	M. Daly	5219								7.2	766			0.012
Balief Clomantagh	03/10/2000	12:00:00	Kilkenny Co. Co./G.S.I.		GWS03	M. Daly	5220								7.3	794			0.007
Graine/Craddockstown	03/10/2000	12:30:00	Kilkenny Co. Co./G.S.I.		GWS07	M. Daly	5221								7.4	727			0.006
Pilltown (PWS07)	03/10/2000	09:45:00	Kilkenny Co. Co./G.S.I.			Ruth Buckley	5222								6.5	184			0.01
Tullahought (GWS16)	03/10/2000	10:30:00	Kilkenny Co. Co./G.S.I.			Ruth Buckley	5223								6.3	194			0.007
Hugginstown (GWS10)	03/10/2000	11:30:00	Kilkenny Co. Co./G.S.I.			Ruth Buckley	5224								6.7	448			0.005
Ahenure (PWS09)	03/10/2000	14:15:00	Kilkenny Co. Co./G.S.I.			Ruth Buckley	5225								7.3	743			0.005

EPA Regional Water Laboratory, Kilkenny. Monitoring Data for County Kilkenny Groundwaters 1993 to 1999.

Source	Sampling Date	Sampling Time	o-Phosphate mg/l P	Nitrate mg/l N	Nitrite mg/l N	Chloride mg/l Cl	Ca Hardness mg/l CaCO3	Alkalinity mg/l CaCO3	TCS	Total Coliforms per 100 ml	FCS	Fecal Coliforms per 100 ml	Sulphate mg/l SO4	Dry Residue mg/l	Sus_ Solids mg/l	Magnesium mg/l Mg	Total Hardness mg/l CaCO3	Sodium mg/l Na	Potassium mg/l K	Aluminium mg/l Al	Iron mg/l Fe	Manganese mg/l Mn	Copper mg/l Cu	Zinc mg/l Zn	Chromium mg/l Cr	Lead mg/l Pb
Borehole at Dunmore	18/06/1997	11:45:00	< 0.02	10		19.7		240		999		999														
Dunmore	08/07/1997	14:50:00	< 0.02	< 0.1	0.003	20			<	100	<	100			Visible	19.5		10.2	0.6							
Dunmore	08/07/1997	15:00:00	0.1	< 0.1	0.016	19			<	200	<	100			Visible	10.3		15.2	0.4							
Borehole at Kilmanagh	01/09/1997	10:24:00	< 0.02	4.6	< 0.004	17	270	287	>	100	>	100	7													
Spring at Westcourt	01/09/1997	11:17:00	< 0.02	4.3	< 0.004	22	262	310		15		5	12													
Borehole at Windgap	01/09/1997	11:54:00	0.02	2.1	< 0.004	15	144	151		6		2	4													
Springs at Bausheenmore	01/09/1997	13:36:00	0.04	5.6	0.004	26	270	304	>	100	>	100	17													
Borehole at Dunmore S/G	01/09/1997	14:17:00	< 0.02	< 0.1	< 0.004	21	252			480		9	36													
Borehole at Dunmore	01/09/1997	14:26:00	< 0.02	10.6	< 0.004	19	272	272		2		999	20													
Borehole at Kilkenny Mar	01/09/1997	15:13:00	0.09	0.5	0.018	3	64		>	160	>	120	< 1.5													
Borehole at Galmoy	27/08/1997	11:19:00	< 0.02	16.1	< 0.004	20	228	298		1		999	19													
Borehole at Bawnmore	27/08/1997	11:39:00	< 0.02	11	< 0.004	23	316	363	>	80		7	17													
Spring Toberpatrick Urlingford	27/08/1997	12:05:00	< 0.02	8.1	< 0.004	22	292	332		51		9	17													
Spring at Clomantagh	27/08/1997	12:20:00	< 0.02	7.4	0.001	18	236	276	>	160	>	120	10													
Borehole at Castlecomer Yarns	27/08/1997	14:00:00	< 0.02	0.13	0.004	20	144	262		999		999	25													
Spring at Paulstown Castle	27/08/1997	14:51:00	< 0.02	7	< 0.004	25	232	256	>	160	>	120	17													
Borehole at Rathcash	27/08/1997	15:12:00	< 0.02	6.2	< 0.004	24	212	314		999		999	15													
Borehole at Clara	27/08/1997	15:30:00	0.02	8.7	< 0.004	21	272	283		29		18	13													
Dunmore	03/03/1998	11:10:00	< 0.02			17.6		206	<	40	<	1														
Dunmore Group Scheme	19/05/1998	11:45:00	0.011	9.4		19				999		999														
	19/05/1998	11:55:00	0.011	0.4		22				12		999														
Borehole at Windgap	09/02/1999	09:30:00	0.05	2	< 0.003	13.3	93	148		999		999	6.1			13.9		7.2								
Spring at Clomantagh	17/02/1999	10:40:00	< 0.04	6.1	< 0.003	15.4		299		10		2	9.5		Not Vis.											
Spring Toberpatrick Urlingford	17/02/1999	11:00:00	< 0.04	5.7	< 0.003	17.5		340		13		1	10.1		Not Vis.											
Borehole at Bawnmore	17/02/1999	11:30:00	< 0.04	7.9	< 0.003	17.9		416		999		999	11.2		Not Vis.											
Borehole at Galmoy	17/02/1999	12:00:00	< 0.04	11.5	< 0.003	24.5		317		29		999	13.3		Not Vis.											
Borehole at Castlecomer Yarns	17/02/1999	12:50:00	< 0.04	0.6	< 0.003	16.7		241		999		999	18.4		Not Vis.											
Borehole at Dunmore	17/02/1999	14:05:00		8.9	< 0.003	21.3	303	262		999		999	15.1		Not Vis.	4.5		9	0.9							
Borehole at Kilkenny Mar	17/02/1999	15:00:00	< 0.04	6.6	< 0.003	18.8	273	270		9		999	37.9		Not Vis.	14.1		11.2	1.3							
Borehole at Kilmanagh	17/02/1999	16:00:00	< 0.04	4	< 0.003	15.2	276	308		999		999	9.7		Not Vis.	12		9.2	0.8							
Spring at Westcourt	14/04/1999	10:47:00	< 0.04	4.2	< 0.004	20	288	330		1		1	11.4			24.2		8.9	0.6							
Borehole at Windgap	14/04/1999	11:14:00	< 0.04	2.2	< 0.004	13	138	174		999		999	5.6			17.9		6.6	0.7							
Springs at Bausheenmore	14/04/1999	12:12:00	< 0.04	5.7	< 0.004	23	272	360		74		2	15			30.5		8.3	2.3							
Borehole at Rathcash	14/04/1999	14:00:00	< 0.04	6.7	< 0.004	21	286	326		999		999	14			22.3		7.9	0.8							
Borehole at Clara	14/04/1999	14:18:00	< 0.04	8.5	< 0.004	19	288	318		45		2	12.8			17.1		7.8	1							
	07/09/1999	10:20:00								999		999														
Bennettsbridge	29/03/2000	14:16:00	< 0.006	5.1		22				999		999			Not Vis.											
Borehole at Kilmanagh	27/09/2000	10:30:00	< 0.006	3.7	< 0.001	14	288		>=	43		999	13			15	349	11	1.2		< 0.06	< 0.02		0.026		
Borehole at Windgap	27/09/2000	12:10:00	0.019	2.4	< 0.001	14	143					999	9.1			15	204	7.9	1.4		< 0.06	< 0.02		0.024		
Borehole No.9, Thomastown	27/09/2000	14:15:00	0.032	5.8	< 0.001	31	293			8		1	19			22	383	18	3.5		< 0.06	< 0.02		0.138		
Springs at Bausheenmore	27/09/2000	14:50:00	0.014	6	< 0.001	23	308		>	80	>	60	20			30	431	10	3.9		< 0.06	< 0.02		0.022		
Spring at Paulstown Castle	27/09/2000	15:40:00	0.008	4.7	0.007	23	290		>	80	>	60	18			11	335	11	3.4		< 0.06	< 0.02		0.021		
Spring at Clomantagh	26/09/2000	10:20:00	0.012	1.5	0.007	6.9	83		>	80	>	60	7.8			2.4	92.8	6	6.5		0.086	< 0.02		0.189		
Spring Toberpatrick Urlingford	26/09/2000	10:40:00	0.009	7.1	0.011	20	338		>	80	>	60	15			19	416	9.4	5		0.106	< 0.02		0.48		
Borehole at Bawnmore	26/09/2000	11:05:00	< 0.006	6.7	< 0.001	18	348		>=	50		28	16			30	471	8.1	3.4		0.114	< 0.02		0.421		
Borehole at Galmoy	26/09/2000	12:15:00	< 0.006	8.2	< 0.001	21	305			999		999	18			27	416	9.6	1.4		0.082	< 0.02		0.258		
Borehole at Castlecomer Yarns	26/09/2000	14:00:00	0.077	1.1	0.003	17	150			7		999	25			17	220	43	1.7		0.664	0.536		0.152		
Borehole at Dunmore	26/09/2000	14:25:00	< 0.006	8.9	< 0.001	23	308			21	<	1	18			3.1	320	9.9	1.4		< 0.06	< 0.02		0.102		
Borehole at Dunmore S/G	26/09/2000	14:40:00	< 0.006	0.67	0.002	19	278		>=	44		999	38			14	294	12	1.4		0.063	0.273		0.076		
Borehole at Kilkenny Mar	26/09/2000	14:55:00	< 0.006	6.2	< 0.001	18	295			47		3	39			16	360	12	1.9		< 0.06	< 0.02		0.151		
Borehole at Clara	26/09/2000	15:35:00	0.03	5.9	< 0.001	18	275			5		999	16			16	340	9.7	1.9		< 0.06	< 0.02		0.068		
Kiloshaun/Barna	03/10/2000	11:15:00	0.023	5.9	< 0.001	14	360	305	>	80	>	80	7.8			10.4	402	6.9	2.1	< 0.05	0.075	0.01	0.004	0.262	0.012	< 0.001
Tubrid Lower	03/10/2000	11:40:00	0.009	8.5	< 0.001	18	413	353		7		1	10.6			15.5	476	7.7	0.6	< 0.05	0.097	0.003	0.005	0.463	0.034	< 0.001
Balief Clomantagh	03/10/2000	12:00:00	0.01	8.5	0.01	18	427	383		62		58	9.6			14.2	485	9.4	5	< 0.05	0.078	0.005	0.005	0.343	0.028	< 0.001
Graine/Craddockstown	03/10/2000	12:30:00	0.007	5.2	< 0.01	15	321	362		999		999	10.7			37.1	7.4	< 0.3		< 0.05	< 0.05	0.002	0.009	0.208	0.019	< 0.001
Pilltown (PWS07)	03/10/2000	09:45:00	0.03	2.9	0.003	14.3	40	53		28		999	4.9			3.1	52.7	8	1.4	< 0.05	< 0.05	0.002	< 0.001	0.124	0.009	< 0.001
Tullahought (GWS16)	03/10/2000	10:30:00	0.027	7.1	< 0.001	17	35	26		2		999	9.8			5.5	57.6	11.4	< 0.3	< 0.05	< 0.05	0.002	0.011	0.084	0.005	< 0.001
Hugginstown (GWS10)	03/10/2000	11:30:00	0.026	4.3	< 0.001	15	193	176	>	80	>	60	14.5			8.4	227	10.5	5.9	< 0.05	< 0.05	< 0.001	0.011	0.071	0.006	< 0.001
Ahenure (PWS09)	03/10/2000	14:15:00	< 0.006	2.6	< 0.001	19	348	347		14		999	16.5			28.3	464	8.8	1.7	< 0.05	< 0.05	0.739	0.009	0.051	0.007	< 0.001

EPA Regional Water Laboratory, Kilkenny. Monitoring Data for County Kilkenny Groundwaters 1993 to 1999.

Source	Sampling Date	Sampling Time	Cadmium mg/l Cd	Mercury mg/l Hg	Nickel mg/l Ni	Fluoride mg/l F	OMCTSiloxane µg/l	Comments1	Comments2	Comments3
Borehole at Dunmore	18/06/1997	11:45:00								
Dunmore	08/07/1997	14:50:00						Total Coliforms present. Accurate count not possible due to	Suspended Solids.	
Dunmore	08/07/1997	15:00:00						Total Coliforms present. Accurate count not possible due to	Suspended Solids.	
Borehole at Kilmanagh	01/09/1997	10:24:00								
Spring at Westcourt	01/09/1997	11:17:00								
Borehole at Windgap	01/09/1997	11:54:00								
Springs at Bausheenmore	01/09/1997	13:36:00								
Borehole at Dunmore S/G	01/09/1997	14:17:00								
Borehole at Dunmore	01/09/1997	14:26:00								
Borehole at Kilkenny Mar	01/09/1997	15:13:00								
Borehole at Galmoy	27/08/1997	11:19:00								
Borehole at Bawnmore	27/08/1997	11:39:00								
Spring Toberpatrick Urlingford	27/08/1997	12:05:00								
Spring at Clomantagh	27/08/1997	12:20:00								
Borehole at Castlecomer Yarns	27/08/1997	14:00:00								
Spring at Paulstown Castle	27/08/1997	14:51:00								
Borehole at Rathcash	27/08/1997	15:12:00								
Borehole at Clara	27/08/1997	15:30:00								
Dunmore	03/03/1998	11:10:00								
Dunmore Group Scheme	19/05/1998	11:45:00								
	19/05/1998	11:55:00								
Borehole at Windgap	09/02/1999	09:30:00						Sodium and calcium for guide only.		
Spring at Clomantagh	17/02/1999	10:40:00				< 0.1				
Spring Toberpatrick Urlingford	17/02/1999	11:00:00				< 0.1				
Borehole at Bawnmore	17/02/1999	11:30:00				< 0.1				
Borehole at Galmoy	17/02/1999	12:00:00				< 0.1				
Borehole at Castlecomer Yarns	17/02/1999	12:50:00				< 0.1				
Borehole at Dunmore	17/02/1999	14:05:00				< 0.1				
Borehole at Kilkenny Mar	17/02/1999	15:00:00				< 0.1				
Borehole at Kilmanagh	17/02/1999	16:00:00				< 0.1				
Spring at Westcourt	14/04/1999	10:47:00				< 0.1				
Borehole at Windgap	14/04/1999	11:14:00				< 0.1				
Springs at Bausheenmore	14/04/1999	12:12:00				< 0.1				
Borehole at Rathcash	14/04/1999	14:00:00				< 0.1				
Borehole at Clara	14/04/1999	14:18:00				< 0.1				
	07/09/1999	10:20:00						Sample for bacteriological analyses only.		
Bennettsbridge	29/03/2000	14:16:00						This is a sample from a new well that feeds the old infiltration gallery for	Bennettsbridge water supply.	
Borehole at Kilmanagh	27/09/2000	10:30:00					3.2		VOC analysis results on separate sheet.	
Borehole at Windgap	27/09/2000	12:10:00					2.1	Total Coliforms not reported.	VOC analysis results on separate sheet.	
Borehole No.9, Thomastown	27/09/2000	14:15:00					1.8		VOC analysis results on separate sheet.	
Springs at Bausheenmore	27/09/2000	14:50:00								
Spring at Paulstown Castle	27/09/2000	15:40:00					10.3		VOC analysis results on separate sheet.	
Spring at Clomantagh	26/09/2000	10:20:00					0.6		VOC analysis results on separate sheet.	
Spring Toberpatrick Urlingford	26/09/2000	10:40:00					1.7		VOC analysis results on separate sheet.	
Borehole at Bawnmore	26/09/2000	11:05:00					0.7	Background interference on Total Coliform plate.	VOC analysis results on separate sheet.	
Borehole at Galmoy	26/09/2000	12:15:00					2.4		VOC analysis results on separate sheet.	
Borehole at Castlecomer Yarns	26/09/2000	14:00:00					0.6		VOC analysis results on separate sheet.	
Borehole at Dunmore	26/09/2000	14:25:00					1.1	Small underdeveloped colonies on Total Coliform plate.	VOC analysis results on separate sheet.	
Borehole at Dunmore S/G	26/09/2000	14:40:00					2.2	Background interference on Total Coliform plate.	VOC analysis results on separate sheet.	
Borehole at Kilkenny Mar	26/09/2000	14:55:00					1.3		VOC analysis results on separate sheet.	
Borehole at Clara	26/09/2000	15:35:00					2.9		VOC analysis results on separate sheet.	
Kiloshaun/Barna	03/10/2000	11:15:00	< 0.0001	< 0.0001	0.008	< 0.1		Samples as part of Kilkenny Groundwater Protection Scheme.		
Tubrid Lower	03/10/2000	11:40:00	< 0.0001	< 0.0001	0.015	< 0.1		Samples as part of Kilkenny Groundwater Protection Scheme.		
Balief Clomantagh	03/10/2000	12:00:00	< 0.0001	< 0.0001	0.012	< 0.1		Samples as part of Kilkenny Groundwater Protection Scheme.		
Graine/Craddockstown	03/10/2000	12:30:00	< 0.0001	< 0.0001	0.007	< 0.1		Samples as part of Kilkenny Groundwater Protection Scheme.		
Pilltown (PWS07)	03/10/2000	09:45:00	< 0.0001	< 0.0001	0.004	< 0.1		Samples as part of Kilkenny Groundwater Protection Scheme.		
Tullahought (GWS16)	03/10/2000	10:30:00	< 0.0001	< 0.0001	0.002	< 0.1		Samples as part of Kilkenny Groundwater Protection Scheme.		
Hugginstown (GWS10)	03/10/2000	11:30:00	< 0.0001	< 0.0001	0.002	< 0.1		Samples as part of Kilkenny Groundwater Protection Scheme.		
Ahenure (PWS09)	03/10/2000	14:15:00	< 0.0001	< 0.0001	0.024	< 0.1		Samples as part of Kilkenny Groundwater Protection Scheme.		

EPA Regional Water Laboratory, Kilkenny. Monitoring Data for County Kilkenny Groundwaters 1993 to 1999.

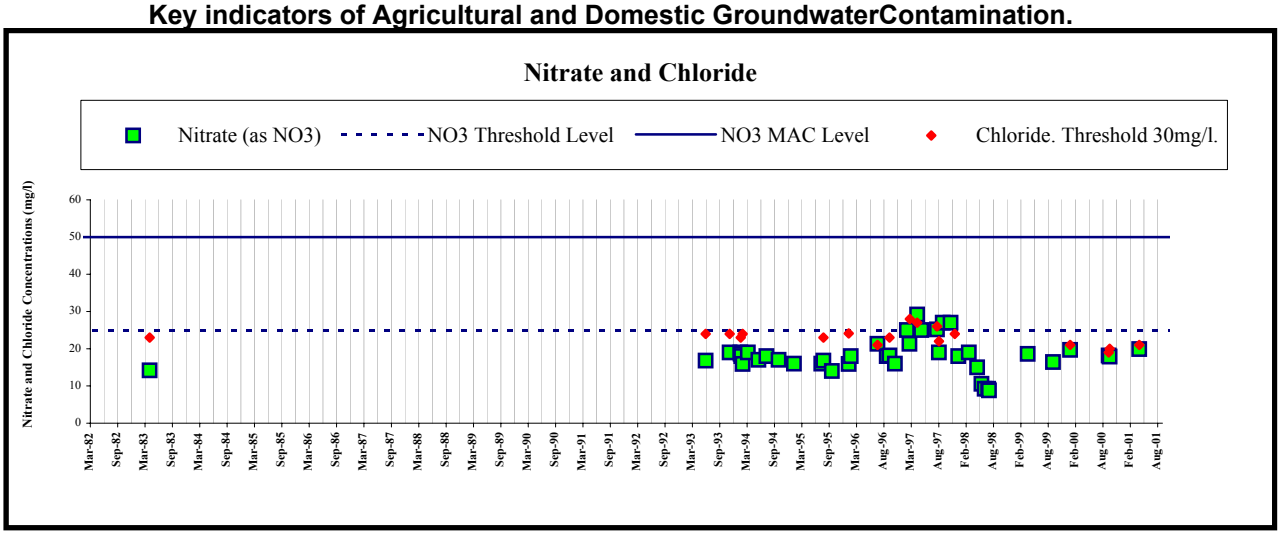
Source	Sampling Date	Sampling Time	To	Ref No	Sampling Location	Taken By	Lab No	EPARef	Stn Grid Ref	Water Supply	Public/Group/Private	Temperature	Odour 1/2/3	Colour Hazen	pH	Conductivity µS/cm	Turbidity NTU	TOC mg/l C	Ammonia mg/l N
Callan (PWS06)	03/10/2000	15:00:00	Kilkenny Co. Co./G.S.I.			Ruth Buckley	5226								7.3	705			0.004
Windgap (GWS17)	03/10/2000	12:45:00	Kilkenny Co. Co./G.S.I.			Ruth Buckley	5227								6.7	267			0.007
Highrath (GWS11)	04/10/2000	12:00:00	Kilkenny Co. Co./G.S.I.		Highrath (GWS11)	M. Daly	5260						1	5	7.1	999			0.024
Maddoxtown (GWS12)	04/10/2000	12:30:00	Kilkenny Co. Co./G.S.I.		Maddoxtown (GWS12)	M. Daly	5261						1	5	7.2	931			0.022
Glenmore Spring (PWS02-1)	04/10/2000	11:10:00	Kilkenny Co. Co./G.S.I.		Glenmore Spring (PWS02-1)	Ruth Buckley	5266							5	6.4	259			0.018
Glenmore Spring (PWS02-2)	04/10/2000	13:25:00	Kilkenny Co. Co./G.S.I.		Glenmore Spring (PWS02-2)	Ruth Buckley	5267												
Cuffesgrange No. 1 (GWS13)	02/10/2000	11:00:00	Kilkenny Co. Co./G.S.I.		Cuffesgrange No. 1 (GWS13)	M. Daly	5094						1	5	7.3	772			0.011
Ballymack (GWS02)	02/10/2000	11:20:00	Kilkenny Co. Co./G.S.I.		Ballymack (GWS02)	M. Daly	5095						1	5	7.2	800			0.004
Newtown Kells (GWS04)	02/10/2000	11:45:00	Kilkenny Co. Co./G.S.I.		Newtown Kells (GWS04)	M. Daly	5096						1	5	7.3	789			0.007
Caherlesk Goolaghmore	02/10/2000	12:20:00	Kilkenny Co. Co./G.S.I.		Caherlesk Goolaghmore	M. Daly	5097						1	5	6.8	459			0.008
Paulstown (PWS7)	04/10/2000	10:30:00	Kilkenny Co. Co./G.S.I.		Paulstown (PWS7)	V. Fitzsimons	5262						1	5	7.3	676			0.016
Tullaroan (PWS5)	04/10/2000	11:30:00	Kilkenny Co. Co./G.S.I.		Tullaroan (PWS5)	V. Fitzsimons	5263						1	5	7.5	616			0.004
Urlingford (PWS5-S)	04/10/2000	12:30:00	Kilkenny Co. Co./G.S.I.		Urlingford (PWS5-S)	V. Fitzsimons	5264						1	5	7.2	803			0.007
Urlingford (PWS5-R)	04/10/2000	12:40:00	Kilkenny Co. Co./G.S.I.		Urlingford (PWS5-R)	V. Fitzsimons	5265							10	7.3	825			0.094
Thomastown BH1 (PWS01-1)	02/10/2000	10:30:00	Kilkenny Co. Co./G.S.I.		Thomastown BH1 (PWS01-1)	Ruth Buckley	5114							5	7	466			0.003
Thomastown BH2 (PWS01-2)	02/10/2000	10:50:00	Kilkenny Co. Co./G.S.I.		Thomastown BH2 (PWS01-2)	Ruth Buckley	5115							5	7.3	748			< 0.003
Bennettsbridge BH (PWS04-B)	02/10/2000	12:10:00	Kilkenny Co. Co./G.S.I.		Bennettsbridge BH (PWS04-B)	Ruth Buckley	5116							5	7.3	721			< 0.003
Bennettsbridge River (PWS04-R)	02/10/2000	12:15:00	Kilkenny Co. Co./G.S.I.		Bennettsbridge River (PWS04-R)	Ruth Buckley	5117							175	8	447			0.022
Bennettsbridge Gravel (PWS04-G)	02/10/2000	12:25:00	Kilkenny Co. Co./G.S.I.		Bennettsbridge Gravel (PWS04-G)	Ruth Buckley	5118							20	7.5	563			0.006
Bennettsbridge Mixed (PWS04-M)	02/10/2000	12:50:00	Kilkenny Co. Co./G.S.I.		Bennettsbridge Mixed (PWS04-M)	Ruth Buckley	5119						1	5	7.4	681			< 0.003
Kilree Stoneyford (GWS08)	02/10/2000	15:00:00	Kilkenny Co. Co./G.S.I.		Kilree Stoneyford (GWS08)	Ruth Buckley	5120						1	5	7.1	866			< 0.003
Spring at Clomantagh	12/02/2001	11:00:00	Kilkenny Co. Co.	KK00900	Beside Nuenna river, 50m SE of roac		633		23520 16320		Private	9.7			7.2	615	1.4		0.007

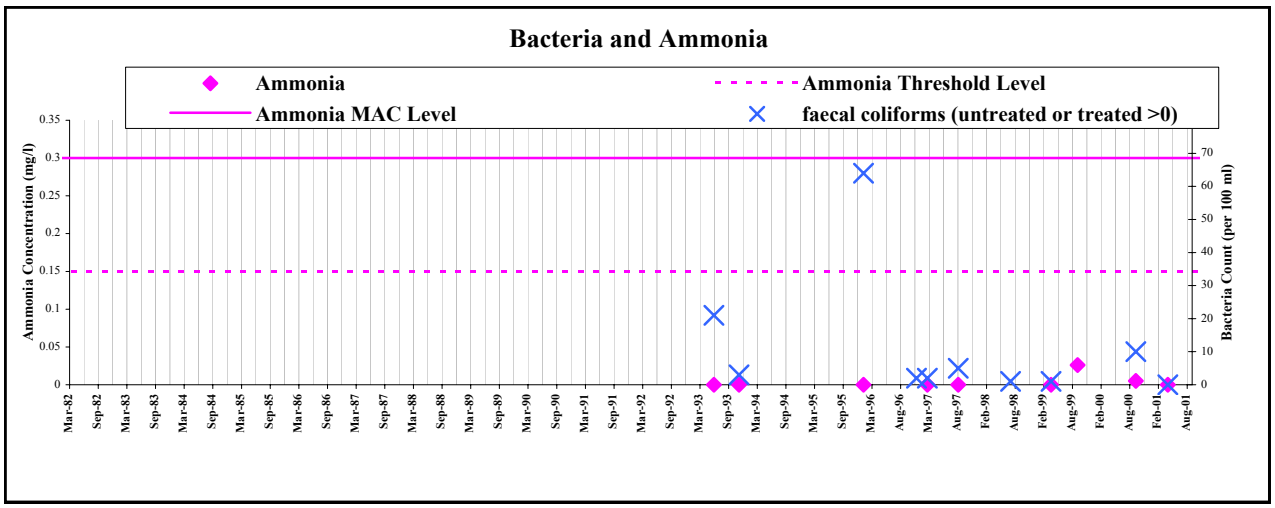
EPA Regional Water Laboratory, Kilkenny. Monitoring Data for County Kilkenny Groundwaters 1993 to 1999.

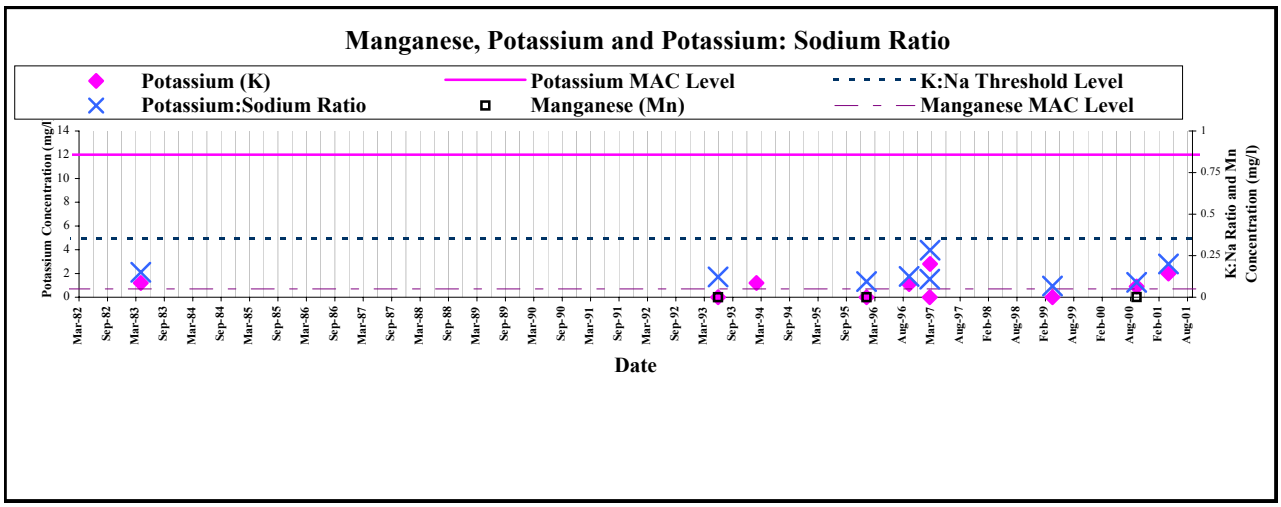
Source	Sampling Date	Sampling Time	o-Phosphate mg/l P	Nitrate mg/l N	Nitrite mg/l N	Chloride mg/l Cl	Ca Hardness mg/l CaCO3	Alkalinity mg/l CaCO3	TCS	Total Coliforms per 100 ml	FCS	Fecal Coliforms per 100 ml	Sulphate mg/l SO4	Dry Residue mg/l	Sus_ Solids mg/l	Magnesium mg/l Mg	Total Hardness mg/l CaCO3	Sodium mg/l Na	Potassium mg/l K	Aluminium mg/l Al	Iron mg/l Fe	Manganese mg/l Mn	Copper mg/l Cu	Zinc mg/l Zn	Chromium mg/l Cr	Lead mg/l Pb
Callan (PWS06)	03/10/2000	15:00:00	0.006	4.1	< 0.001	19	334	336		24		10	11.6			25.1	437	10.1	0.9	< 0.05	< 0.05	0.0014	< 0.001	0.046	0.004	< 0.001
Windgap (GWS17)	03/10/2000	12:45:00	0.062	9.6	< 0.001	15	99.7	64		1		999	6.8			2.8	75.5	7.8	< 0.3	< 0.05	< 0.05	< 0.001	< 0.001	0.039	0.003	< 0.001
Highrath (GWS11)	04/10/2000	12:00:00	0.023	5.3	0.003	49	443	436	>	80	>	60	13.5			30	566	11	5.6	< 0.05	< 0.05	0.003	0.004	0.027	0.024	< 0.001
Maddoxtown (GWS12)	04/10/2000	12:30:00	0.015	11.7	< 0.001	25	383	404		17		4	18.6			29.1	502	11.1	3.3	< 0.05	< 0.05	< 0.001	< 0.001	0.003	0.021	< 0.001
Glenmore Spring (PWS02-1)	04/10/2000	11:10:00	< 0.006	9.6	0.001	22	44	38		45		1	12.8			11.5	91.3	10.9	3.8	< 0.05	< 0.05	< 0.001	< 0.001	0.02	0.003	< 0.001
Glenmore Spring (PWS02-2)	04/10/2000	13:25:00								36		1														
Cuffesgrange No. 1 (GWS13)	02/10/2000	11:00:00	0.02	4.2	0.009	19	362	362	>	80		29	13.1			25	464	11.2	3.6	< 0.05	< 0.05	< 0.001	0.005	0.037	0.005	< 0.001
Ballymack (GWS02)	02/10/2000	11:20:00	< 0.006	6.4	< 0.001	23	345	365		52		7	13.9			36.2	494	11.7	1.5	< 0.05	< 0.05	< 0.001	< 0.001	0.035	0.005	< 0.001
Newtown Kells (GWS04)	02/10/2000	11:45:00	0.006	5.6	< 0.001	26	359	367	>	80		7	13			29.2	479	12.5	1.5	< 0.05	< 0.05	< 0.001	0.004	0.049	0.003	< 0.001
Caherlesk Goolaghmore	02/10/2000	12:20:00	0.008	5.3	< 0.001	19	197	178		51		8	10			15.5	260	9.2	2.3	< 0.05	< 0.05	< 0.001	0.003	0.046	0.004	< 0.001
Paulstown (PWS7)	04/10/2000	10:30:00	0.008	5.7	0.008	22	330	286	>	80	>	60	12.8			11.5	377	10.9	3.8	< 0.05	< 0.05	< 0.001	< 0.001	0.014	0.016	< 0.001
Tullaroan (PWS5)	04/10/2000	11:30:00	< 0.006	2.9	< 0.001	14	301	284		999		999	7.4			10	342	8.2	1.4	< 0.05	< 0.05	< 0.001	< 0.001	< 0.001	0.015	< 0.001
Urlingford (PWS5-S)	04/10/2000	12:30:00	0.006	8	0.002	18	377	369	>	80	>	60	10.7			18.5	453	8	5.9	< 0.05	< 0.05	< 0.001	< 0.001	< 0.001	0.012	< 0.001
Urlingford (PWS5-R)	04/10/2000	12:40:00	0.039	7.2	0.056	19	375	375		1080		370	15.9			13.5	430	10.8	1.1	< 0.05	< 0.05	< 0.001	< 0.001	0.013	0.021	< 0.001
Thomastown BH1 (PWS01-1)	02/10/2000	10:30:00	0.012	4.9	< 0.001	18	186	105		8		999	10.4			15.5	249	11	1.3	< 0.05	< 0.05	< 0.001	0.005	0.05	0.004	< 0.001
Thomastown BH2 (PWS01-2)	02/10/2000	10:50:00	0.037	6.2	< 0.001	30	325	320		6		1	16			22.5	417	17.6	3.3	< 0.05	< 0.05	0.001	0.013	0.046	0.006	< 0.001
Bennettsbridge BH (PWS04-B)	02/10/2000	12:10:00	< 0.006	4.3	0.002	24	320	317		17		999	28.5			25.4	424	16.1	2.3	< 0.05	< 0.05	0.004	< 0.001	0.034	0.002	< 0.001
Bennettsbridge River (PWS04-R)	02/10/2000	12:15:00	0.083	2.1	0.014	16	223	185		42000		5600	15.8			7.8	255	10.3	4.4	0.119	0.279	0.02	0.003	0.037	0.004	< 0.001
Bennettsbridge Gravel (PWS04-G)	02/10/2000	12:25:00	0.05	1.1	0.051	22	260	253	>=	76		4	21.2			10.1	301	18.3	3.8	< 0.05	< 0.05	0.066	0.037	0.042	0.005	< 0.001
Bennettsbridge Mixed (PWS04-M)	02/10/2000	12:50:00	0.02	4.5	0.009	23	311	291		104		5	23			19.2	390	16.7	3.3	< 0.05	< 0.05	0.025	0.002	0.046	0.006	< 0.001
Kilree Stoneyford (GWS08)	02/10/2000	15:00:00	0.131	15.4	< 0.001	19	397	370	>	80		60	11.3			29.9	520	11.4	3	< 0.05	< 0.05	< 0.001	0.008	0.039	0.002	< 0.001
Spring at Clomantagh	12/02/2001	11:00:00	0.015	4.1	0.002	14	305	270		15		12	34.9			6.5	331	5.5	1.3		< 0.01	< 0.02		0.031		

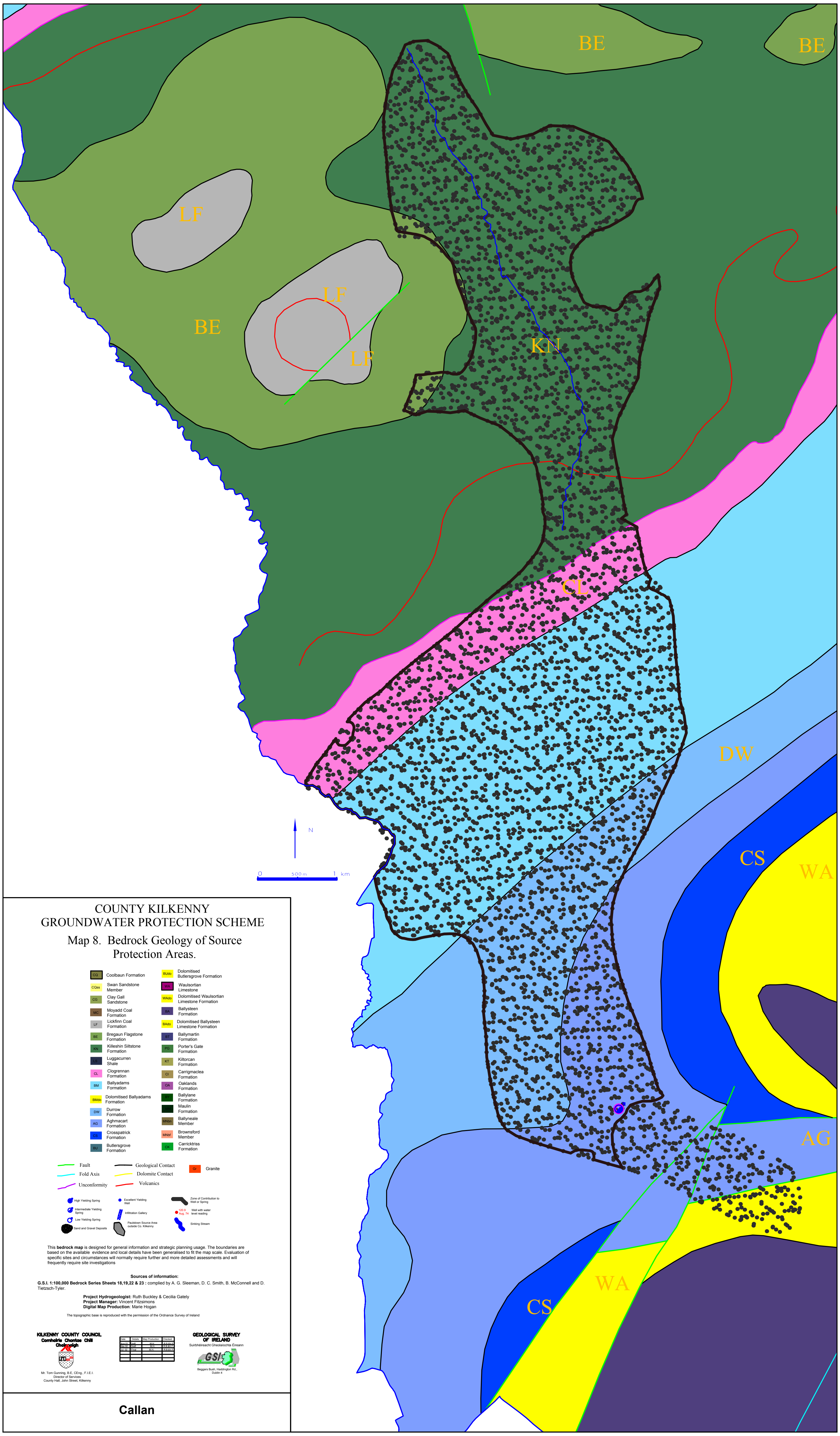
Appendix VI: Summary of trends in water quality over time for selected supply sources in Kilkenny

Figure 9.2- Callan Spring
Key indicators of Agricultural and Domestic GroundwaterContamination.









COUNTY KILKENNY GROUNDWATER PROTECTION SCHEME

Map 8. Bedrock Geology of Source Protection Areas.

CQ	Coolbaun Formation	BUdo	Dolomitised Butlersgrove Formation
CQss	Swan Sandstone Member	WA	Waulsortian Limestone
CG	Clay Gall Sandstone	WAdo	Dolomitised Waulsortian Limestone Formation
MC	Moyadd Coal Formation	BA	Ballysteen Formation
LF	Lickfinn Coal Formation	BAdo	Dolomitised Ballysteen Limestone Formation
BE	Bregaun Flagstone Formation	BT	Ballymartin Formation
KN	Killeshin Siltstone Formation	PG	Porter's Gate Formation
LS	Luggacurren Shale	KT	Kiltorcan Formation
CL	Clogrennan Formation	CI	Carrigmaclea Formation
BM	Ballyadams Formation	OA	Oaklands Formation
BMdo	Dolomitised Ballyadams Formation	BY	Ballylane Formation
DW	Durrow Formation	MN	Maulin Formation
AG	Aghmacart Formation	MNbn	Ballyneale Member
CS	Crosspatrick Formation	MNbf	Brownsford Member
BU	Butlersgrove Formation	CK	Carricktriss Formation

Fault
Fold Axis
Unconformity
Geological Contact
Dolomite Contact
Volcanics
Gr Granite

High Yielding Spring
Intermediate Yielding Spring
Low Yielding Spring
Sand and Gravel Deposits
Excellent Yielding Well
Infiltration Gallery
Paulstown Source Area outside Co. Kilkenny
Zone of Contribution to Well or Spring
120.9 Aug. 74 Well with water level reading
Sinking Stream

This **bedrock map** is designed for general information and strategic planning usage. The boundaries are based on the available evidence and local details have been generalised to fit the map scale. Evaluation of specific sites and circumstances will normally require further and more detailed assessments and will frequently require site investigations

Sources of information:

G.S.I. 1:100,000 Bedrock Series Sheets 18,19,22 & 23 : complied by A. G. Sleeman, D. C. Smith, B. McConnell and D. Tietzsch-Tyler.

Project Hydrogeologist: Ruth Buckley & Cecilia Gately
Project Manager: Vincent Fitzsimons
Digital Map Production: Marie Hogan

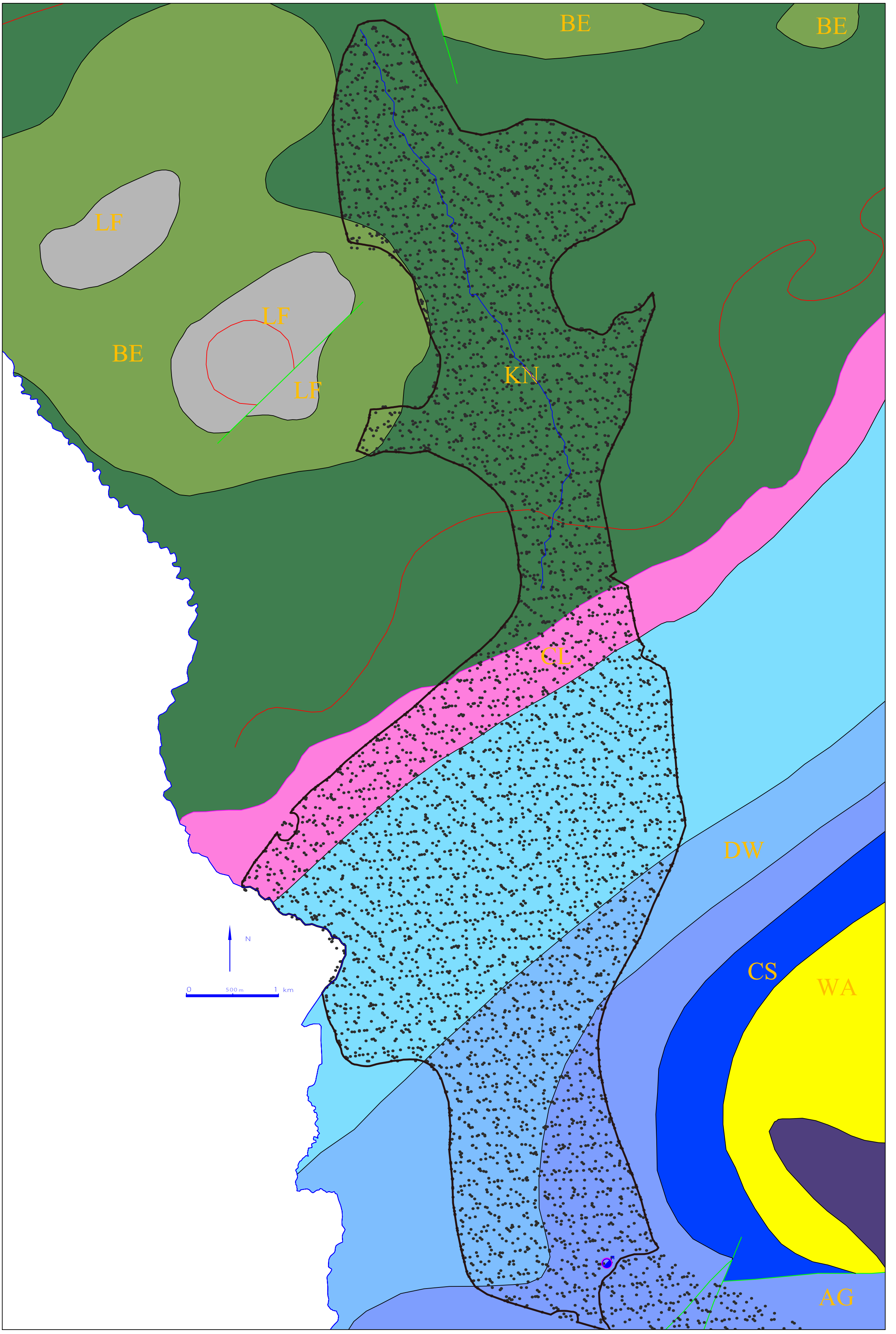
The topographic base is reproduced with the permission of the Ordnance Survey of Ireland

KILKENNY COUNTY COUNCIL
Comhairle Chontae Chill Chainnigh
Mr. Tom Gunning, B.E, CEng., F.I.E.I.
Director of Services
County Hall, John Street, Kilkenny

Date	Details	Map Production	Checked
Aug 01	Draft	M.H.	R.B.&V.F
May 02	Draft	M.H.	R.B.&V.F
Jul. 02	Final	M.H.	R.B.&V.F

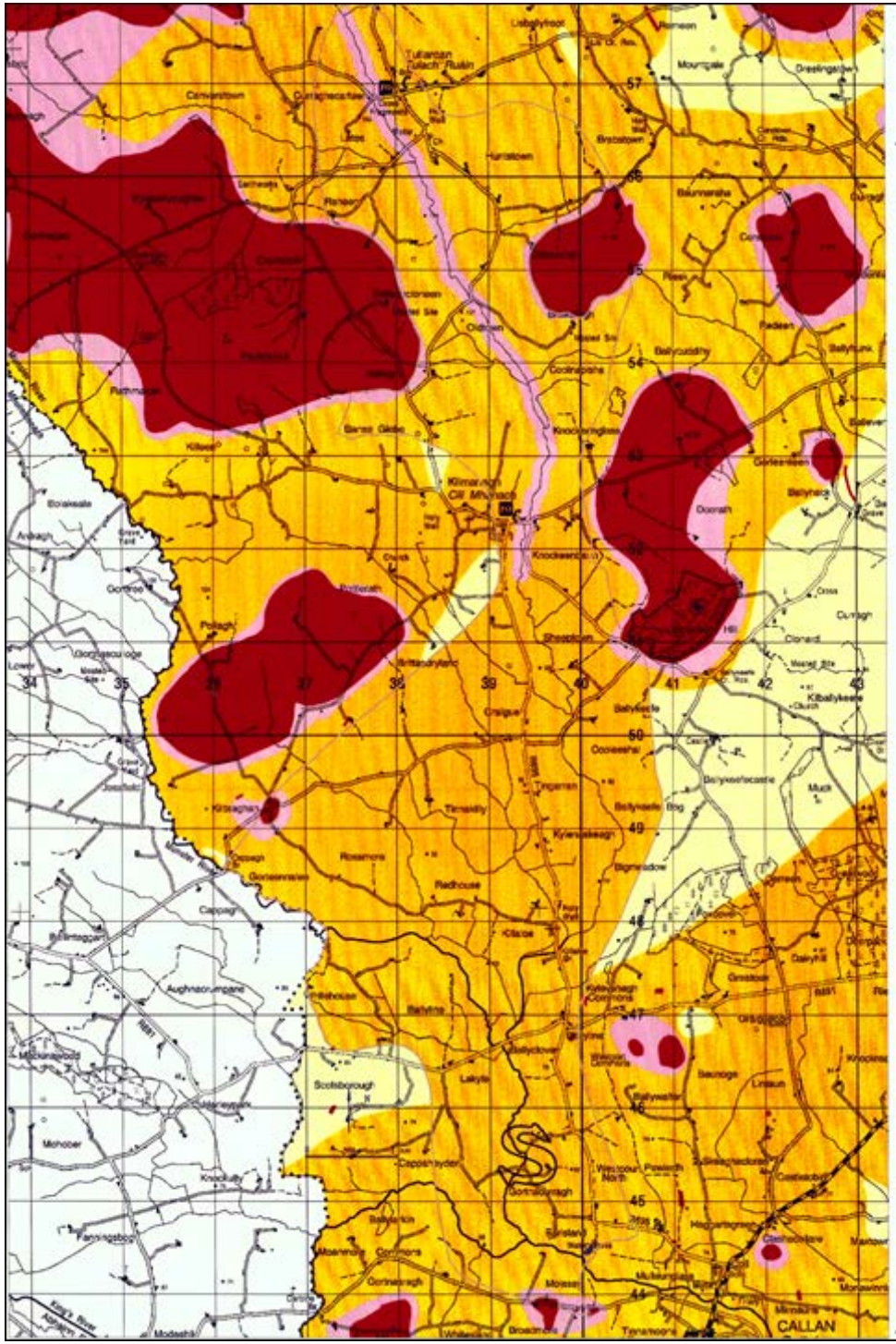
GEOLOGICAL SURVEY OF IRELAND
Suirbhéireacht Gheolaíochta Éireann
Beggars Bush, Haddington Rd., Dublin 4

Callan



Callan PSS

Callan PSS



COUNTY KILKENNY GROUNDWATER PROTECTION SCHEME

MAP 9 VULNERABILITY OF SOURCE PROTECTION AREAS

VULNERABILITY CLASSIFICATION

- Generally Extreme (E)
- Outcrop/Shallow rock/Karst (E)
- Generally High (H)
- Generally Moderate (M)
- Generally Low (L)

- High Yielding Spring
- Excellent Yielding Well
- Intermediate Yielding Spring
- Infiltration Gallery
- Low Yielding Spring
- Portion of Paulstown Outer Source Area lying outside Co. Kilkenny

Vulnerability is a term used to represent the intrinsic geological and hydrogeological characteristics that determine the ease with which groundwater may be contaminated by human activities.

The map shows the **vulnerability** of the first groundwater encountered (in either sand/gravel aquifers or in bedrock) to contaminants released at depths of 1-2 m below the ground surface. Where contaminants are released at significantly different depths, there will be a need to determine groundwater vulnerability using site-specific data. The characteristics of individual contaminants have not been taken into account.

This **vulnerability** map is designed for general information and strategic planning usage.The boundaries are based on the available evidence and local details have been generalised to fit the map scale. Evaluation of specific sites and circumstances will normally require further and more detailed assessements, and will frequently require site investigations to determine the risk to groundwater.

Project Hydrogeologist: Ruth Buckley & Cecilia Gately
Project Manager: Vincent Fitzsimons
Digital Map Production: Marie Hogan

Sources of Information

Bedrock map: Map 1; A.G. Sleeman, D.C. Smith, B. McConnell and D. Tietzsch-Tyler
Outcrop and depth to bedrock mapping: Map 3; S. Hegarty, Quaternary and Geotechnical Section
Permeability mapping: R.Buckley and V.Fitzsimons, Groundwater Section
Soil map: M. J. Conry, An Foras Taluntais
Subsoils Map: Map 2; S.Hegarty, Quaternary and Geotechnical Section

KILKENNY COUNTY COUNCIL
Comhairle Chontae Chill Chainnigh

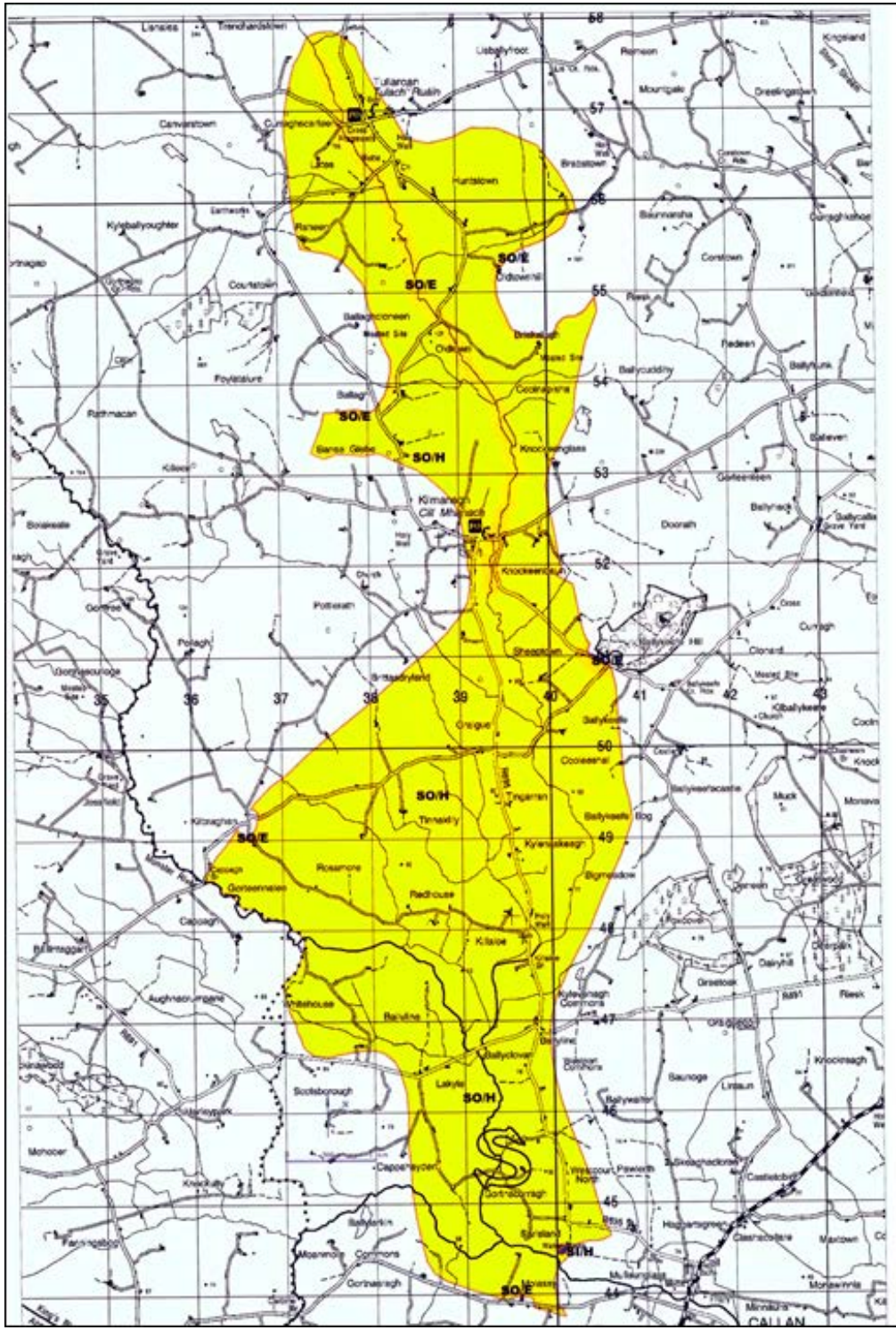
Mr. Tom Gunning, B.E. (Cllg., F.I.E.I
Director of Services
County Hall, John Street, Kilkenny

DATE	DETAILS	DRAWN	CHECKED
Week 01	Draft	BCL	R.B./V.F.
Week 02	Draft	BCL	R.B./V.F.
July 02	Final	BCL	R.B./V.F.

GEOLOGICAL SURVEY OF IRELAND
Suirbhéireacht Gheolaíochta Éireann

Groundwater Section,
Beggars Bush, Haddington Rd.,
Dublin 4

Callan PSS



COUNTY KILKENNY GROUNDWATER PROTECTION SCHEME

MAP 10 SOURCE PROTECTION ZONES

VULNERABILITY RATING	SOURCE PROTECTION ZONES	
	Inner (SI)	Outer (SO)
Extreme (E)	SI/E	SO/E
High (H)	SI/H	SO/H
Moderate (M)	SI/M	SO/M
Low (L)	SI/L	SO/L

- High Yielding Spring
- Excellent Yielding Well
- Intermediate Yielding Spring
- Infiltration Gallery
- Low Yielding Spring
- Portion of Paulstown Outer Source Area lying outside Co. Kilkenny

This **Source Protection Zone map** is designed for general information and strategic planning usage. The boundaries are based on the available evidence and local details have been generalised to fit the map scale. Evaluation of specific sites and circumstances will normally require further and more detailed assessments and will frequently require site investigations to determine the risk to groundwater.

The map is intended for use in conjunction with groundwater protection responses for potentially polluting activities, which lists the degree of acceptability of these activities in each zone and describes the control measures necessary to prevent pollution.

Project Hydrogeologists : Ruth Buckley & Cecilia Gately
Project Manager : Vincent Fitzsimons
Digital Map Production : Marie Hogan

KILKENNY COUNTY COUNCIL
Comhairle Chontae Chill Chainnigh

Mr. Tom Gunning, B.E, CEng., F.I.E.I
Director of Services
County Hall, John Street, Kilkenny

GEOLOGICAL SURVEY OF IRELAND
Suirbhéireacht Gheolaíochta Éireann

Groundwater Section,
Beggars Bush, Haddington Rd.,
Dublin 4