BALLINSPITTLE / GARRETTSTOWN WATER SUPPLY SCHEME

GROUNDWATER SOURCE PROTECTION ZONES

Revised 2002

Prepared by:

Denise Kelly & Geoff Wright

Groundwater Vulnerability Mapping by Una Leader

Groundwater Section

Geological Survey of Ireland

Revised May 2002

Table of Contents

1. Introduction

The objectives of this report are:

- To delineate source protection zones for Ballinspittle/Garrettstown Water Supply Scheme (WSS).
- To outline the principle hydrogeological characteristics of the Ballinspittle/Garrettstown area.
- To assist Cork County Council (Southern Division) in protecting the water supply from contamination.

2. Location and site description

The Ballinspittle/Garrettstown Water Supply is spread across the townlands of Carrigavulleen (north east of the village), Ballinspittle (in the village) and Kilmore (south of the village). The water supply is made up of two separate schemes. The Ballinspittle Supply comprises a gravity feed into a small sump at Carrigavulleen, which is in turn pumped to a small reservoir at Kilkerran. A deep borehole (approx. 90 m) was drilled at the back of this site in 1992, but is no longer in use. The Garrettstown Supply comprises 2 boreholes near the village, which are both pumped to a reservoir at Garrettstown. One is located at the back of some council houses in the village, beside a small stream . The other is located at the edge of the G.A.A. pitch just south of the village (Kilmore).

The degree of protection from pollution afforded by each of these sites varies. The shallow sump at Carrigavulleen is protected by a steel cover, in a pumphouse, by the road. The site is set back from the road. The disused well is also protected by a raised chamber, with a steel cover. The well in the village by the council houses is also protected by a raised chamber approx. 1 m above ground level, which is covered by a locked steel cover. The well at the G.A.A. pitch is similarly protected although the chamber is not as high off the ground.

3. Summary of well details

GSI no.	1403NEW087 (“new” but disused well outside)
Grid ref. (1:25,000)	15913 04633
Townland	Carrigavulleen
Owner	Cork County Council (Southern Division)
Well type	Borehole
Elevation (top of casing)	31 m OD (approx.)
Depth	approx. 93 m (pump at 86 m)
Diameter	0.15 m (6”)
Depth-to-rock	14.63 m of lining from Kinsale files, but depth to rock much less (~ 3 m)
Static water level	0.07 m b.g.l. on 23/1/99 (winter level)
Drawdown	60.3 m over 124 hour test at 111.3 m^3/d
Current Abstraction	65.5 m^3/d when it was in use
Pumping test summary	(i) Abstraction rate: n/a
	(ii) Transmissivity: n/a, but roughly 2.2 m^2/d from yield test below
Yield test summary	(i) 26/6/92 when drilled - 60 m of drawdown at 111.3 m^3/d for a 124 hour test (Kinsale files)

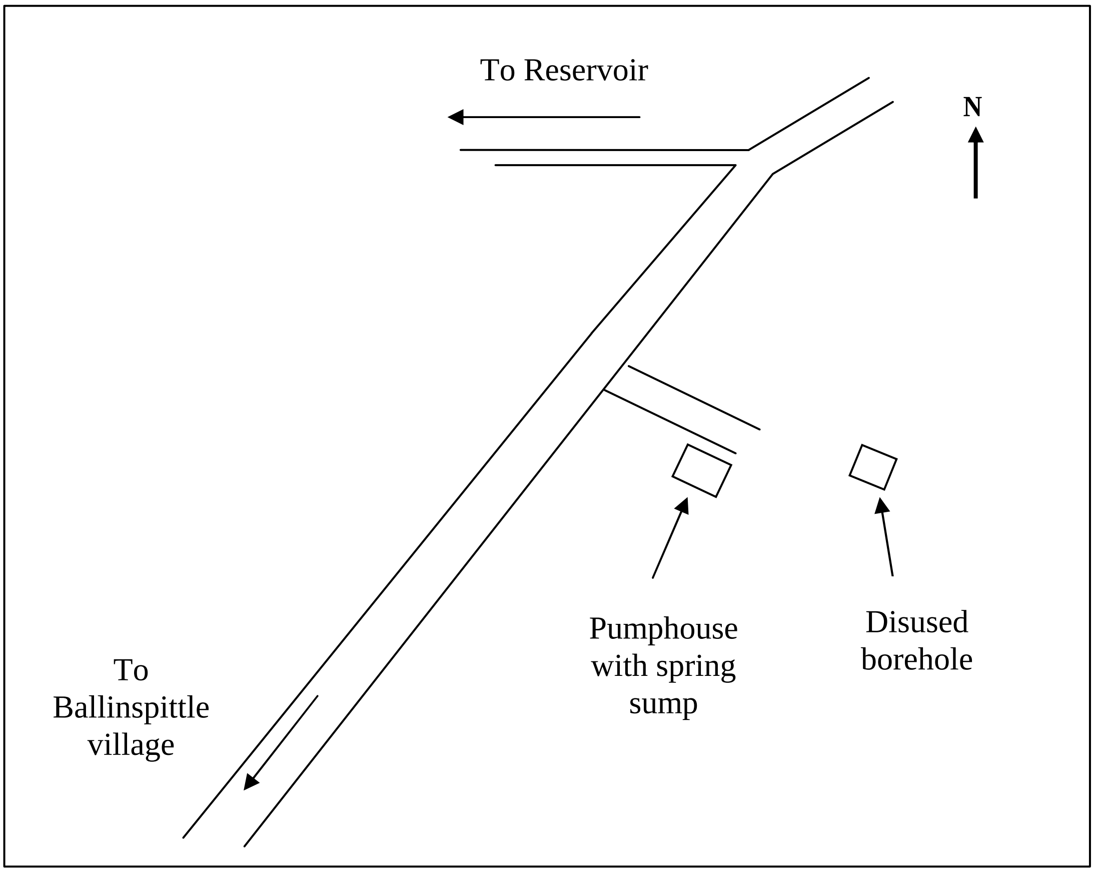


Figure 1 Sketch Map of the area around the spring at Carrigavulleen (Ballinspittle Supply)

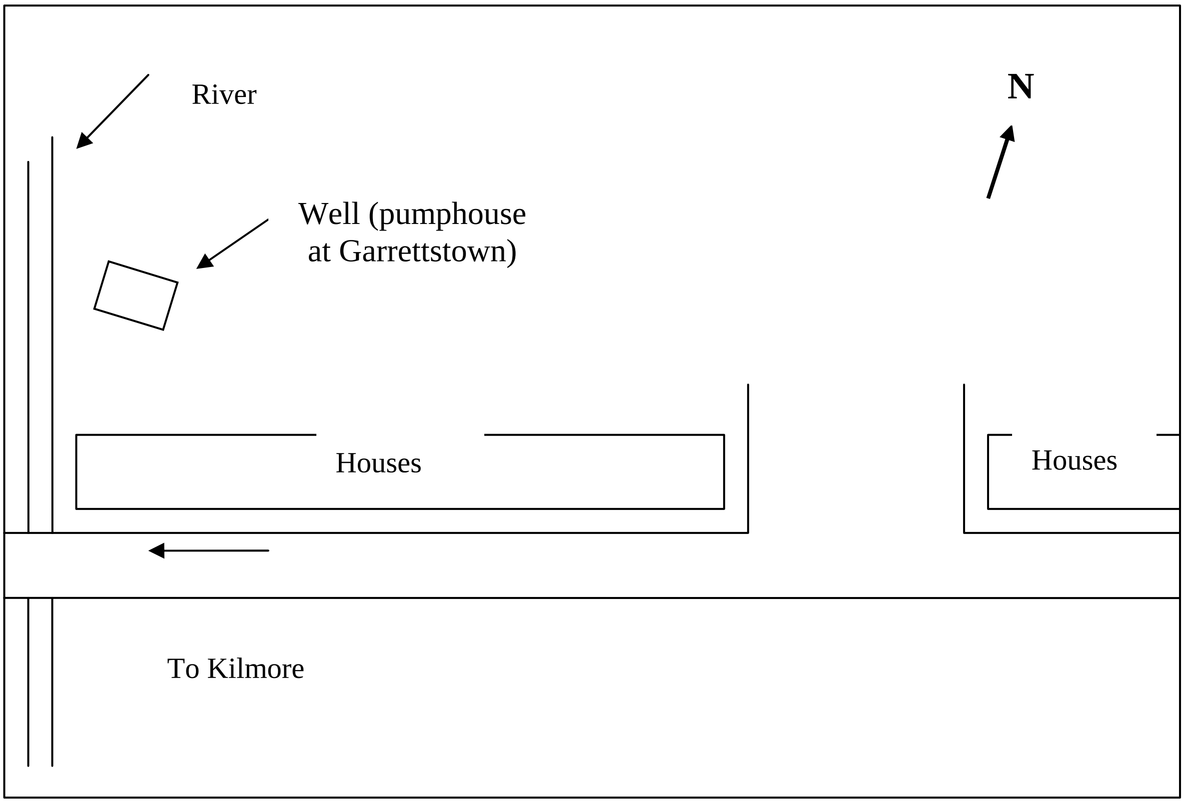


Figure 2 Sketch Map of the area around the Ballinspittle Village Borehole (Garrettstown Supply)

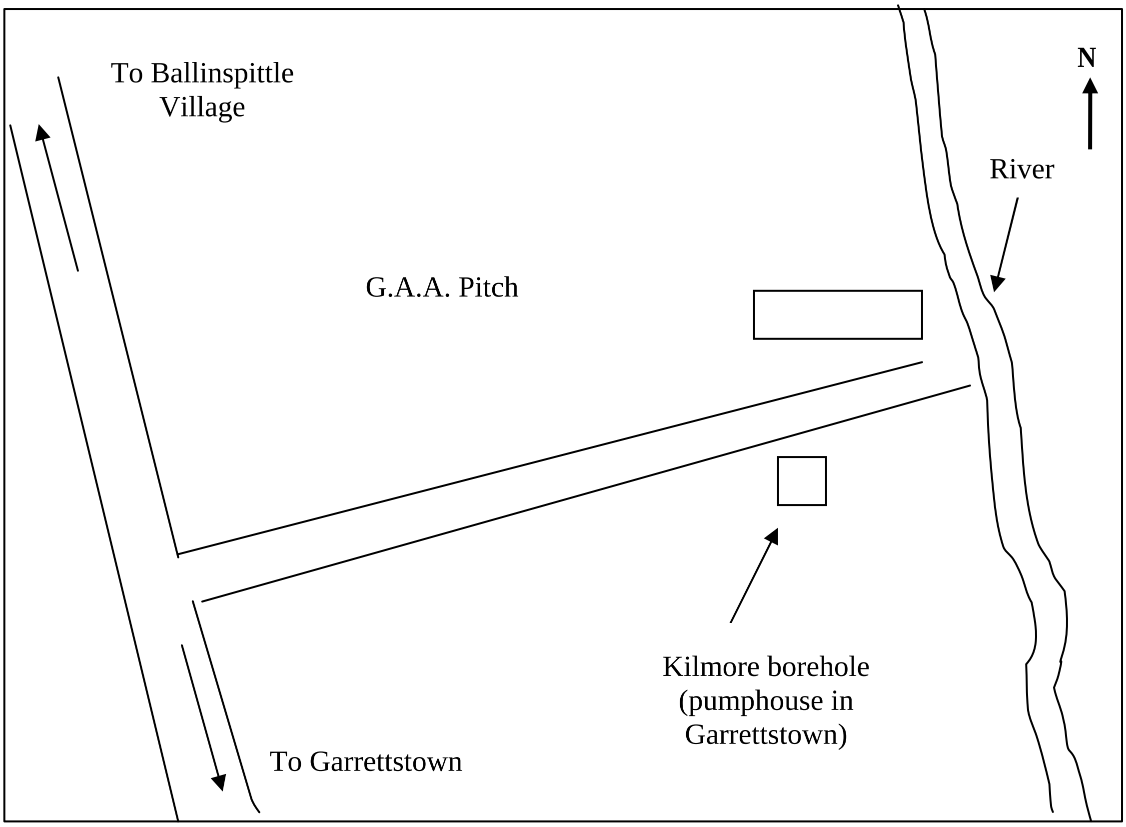


Figure 3 Sketch Map of the area around the Kilmore Borehole (Garrettstown Supply)

GSI no.	1403NEW088 (Ballinspittle "Old" spring / sump)
Grid ref. (1:25,000)	15906 04634
Townland	Carrigavulleen
Owner	Cork County Council (Southern Division)
Well type	shallow sump
Elevation (top of casing)	30.5 m OD (approx.)
Depth	approx. 5.48 m
Diameter	n/a
Depth-to-rock	unknown exactly, but within 3 m
Static water level	ground level
Drawdown	n/a
Current Abstraction	22.7-27.3 m^3/d consumption, up to 36.4 m^3/d in summer
Pumping test summary	(i) Abstraction rate: n/a
	(ii) Transmissivity: n/a
Yield test summary	(i) n/a

GSI no.	1403NEW090 (Well at council houses) “Borehole 1”
Grid ref. (1:25,000)	15870 04615
Townland	Ballinspittle
Owner	Cork County Council (Southern Division)
Well type	Borehole
Elevation (top of casing)	16.14 m OD
Depth	approx. 61 m
Diameter	0.15 m (6”)
Depth-to-rock	unknown exactly but nearby hole estimates > 5 m.
Static water level	unknown, but 1.7 m b.g.l in August 1978
Drawdown	>11.5 m at 262 m^3/d gals/hr in 1978
Current Abstraction	196.4 m^3/d (K. Neville); 273 – 327 m^3/d (from Kinsale files)
Pumping test summary	(i) Abstraction rate: 262 m^3/d in 1978
	(ii) Transmissivity: approx. 15 - 20 m^2/d

GSI no.	1403NEW089 (Well at G.A.A. pitch)
Grid ref. (1:25,000)	15898 04567
Townland	Kilmore
Owner	Cork County Council (Southern Division)
Well type	Borehole
Elevation (top of casing)	15.24 m OD
Depth	unknown
Diameter	0.15 m (6”)
Depth-to-rock	unknown exactly but a nearby augered hole suggests approx. 5 m.
Static water level	ground level (23/1/99 i.e. winter level)
Drawdown	unknown
Current Abstraction	65.5-109 m^3/d (from K. Neville, Cork Co. Co. & Kinsale files)
	Really only used in summer, and can go dry (1998)
Pumping test summary	(i) Abstraction rate: n/a
	(ii) Transmissivity: n/a

4. Methodology

4.1 Desk Study

Bedrock geology information was compiled from the published Geological Survey of Ireland 1:100,000 Bedrock Series (Sheet 25), (Sleeman & Pracht, 1994) and subsoils were compiled from whatever limited subsoil information was available for the area (from Teagasc draft mapping). Basic details such as borehole depths, elevation, abstraction and pumping test data were obtained from GSI records and County Council personnel.

4.2 Site Visits and Fieldwork

This included carrying out well surveys etc. to aid in the conceptualisation of the hydrogeology. Vulnerability to contamination and the current pollutant loading in the area were also examined, using depth to bedrock augering and walkover studies.

4.3 Analysis

The assessment stage utilised field studies and a knowledge of the flow regime in the area to delineate protection zones around the public supply wells.

5. Topography & surface hydrology

The spring/shallow sump source in Carrigavulleen, northeast of Ballinspittle, is located beside the road at an elevation of approximately 30.5 m O.D. It is located in a small north/south trending valley and the land behind to the east rises quite steeply.

The well in the village is situated behind some council houses at an elevation of approximately 16 m O.D. This well is also situated at the bottom of a small valley which rises first gently and then more steeply on either side to the west and northeast. The well in Kilmore, beside the G.A.A. pitch is at an elevation of approximately 15 m O.D. It is close to the river which flows south from Ballinspittle village. The land to the west rises quite steeply just west of the road.

6. Geology

6.1 Bedrock geology

6.1.1 Geological Succession

Geological Unit	Code	Description
Kinsale Formation	KN	Grey mudstone with subordinate sandstone
Pigs Cove Member	KNpc	Sand-lensed mudstone
Narrow Cove Member	KNnc	Flaser-bedded sandstone & mudstone
Cuskinny Member	KNcu	Flaser-bedded sandstone & mudstone
Old Head Sandstone Formation	OH	Flaser-bedded sandstone & minor mudstone

6.1.2 Geological Structure

An important NW-SE fault runs through the area. To the east of the fault, an east-west trending anticline has Old Head Sandstone Formation rocks at its core. To the west the rocks are entirely undifferentiated Kinsale Formation. Apart from its effect on the rock outcrop, the hydrogeological significance of the fault is unknown, but its mapped position runs very close to the boreholes in Ballinspittle and Kilmore. It *may* be an assumed zone of higher hydraulic conductivity as outlined in Section 11.

6.2 Subsoil Geology

6.2.1 Subsoil types

Three subsoil types can be identified in the area: Limestone Till, Till “derived from Devonian and Carboniferous age sandstones and shales” and Alluvium.

Limestone Till

Limestone Till occurs over much of the higher ground to the north, west and south of Ballinspittle village. Depths in these tills range from 1.8 to > 6 m as discussed below. Some samples were taken of these tills during depth to bedrock augering and these samples were analysed using BS 5930 methods. The textures of these subsoils are discussed in Section 10.2.

Sandstone Till

Teagasc's mapping has also identified an area of sandstone till derived from "Devonian and Carboniferous age sandstones and shales". This till type occurs to the south-east of Ballinspittle village and overlies an area of Old Head Sandstone from which it is assumed that it is derived. No samples were taken of this deposit during fieldwork, but it is thought to be quite free-draining as described in Section 10.2.

Alluvium

There is a small area of alluvial deposits which has been identified which follows the river south of Ballinspittle village. Its texture or permeability is unknown, as is its thickness although it could be assumed that it is less than 3 m thick.

6.2.2 Depth to bedrock

Accurate information on depth to bedrock is based on outcrop information, well records, subsoil sections and drilling. Subsoil depths for the Ballinspittle area are fairly shallow. Outcropping bedrock occurs in the higher areas and depth to bedrock augering holes give information on actual depth to bedrock at various points in the area. Teagasc has also looked at aerial photos for this area and helped to delineate areas where bedrock is within 3 m of the surface. These include the higher topographic areas around Kilmore, Ballincurrig, and Kilkerran South. The area around the spring at Carrigavulleen has quite shallow subsoils also. Areas where rock is believed to be greater than 3 m from the surface include, the area around Kilmore crossroads and north-west of it towards Ballycatteen Fort and beyond, as well as some area north of the well in the village itself.

7. Rainfall, Evapotranspiration and Recharge

7.1 Rainfall

Long term average annual rainfall (P) is estimated at 1110 mm (Ballinspittle Rainfall Stn., Met Eireann).

7.2 Evapotranspiration

Long term average annual actual evapotranspiration (Ae) is estimated at 486 mm (EPA).

7.3 Recharge

Long term average annual potential recharge is (1110 - 486) 624 mm. Actual recharge will be a proportion of this, depending on the local runoff coefficient. Considering that the local bedrock is not very permeable, that a significant proportion of the ground is covered with till, and that topographic slopes are fairly steep, actual recharge is estimated at one third of the potential, i.e. 208 mm/year.

8. Hydrogeology

8.1 Aquifer

The aquifer supplying the Ballinspittle water supply at Carrigavulleen is the Narrow Cove Member of the Kinsale Formation (KNnc). The 96 m deep disused borehole very close by to the spring also tapped this formation although it is very close to the underlying Old Head Sandstone Formation. On the basis of regional pumping test data both these formations are classified as **Locally Important Aquifers, moderately permeable only in local zones (Ll)**.

The boreholes of the Garrettstown water supply at Ballinspittle Village and Kilmore both abstract from the rocks of the Kinsale Formation (KN), on the western side of the fault which runs north-west/south-east through the Ballinspittle area. This fault is assumed to be vertical, in the absence of other information. Both these wells are located extremely close to, if not actually on the fault itself, and are possibly higher permeability zones (see Section 11). Once again this formation is classed as a **Locally Important Aquifer, moderately permeable only in local zones (Ll)**.

8.2 Pumping Tests

Pumping tests were carried out in June and August 1978 on the two boreholes in operation at that time, then known as No. 1 (believed to be the present borehole in Ballinspittle village) and No. 2 (46 m away, present status not known).

Borehole #1 was tested at 262 m^3/d for 72 hours. Ultimate drawdown was 11.5 m. Drawdown in the observation well (BH #2) was 8.2 m. Drawdown had not stabilised. An aquifer transmissivity of the order of 15-20 m^2/d was suggested. Data from BH #2 suggest a lower transmissivity, nearer 10 m^2/d. Assuming an effective aquifer thickness of 30 - 40 metres, this suggests an approximate permeability value of 0.3-0.5 m/d.

Pumping tests could not be carried out on the Ballinspittle boreholes in 1999 for operational reasons. However existing data from previous pumping and yield tests, both in this area and throughout the Kinsale Formation as a whole, can be used to derive the aquifer parameters for this area.

9. Water Quality

9.1 Nitrate

Nitrate levels have been a problem at the Carrigavulleen spring at Ballinspittle for some years. Figure 1 presents the available nitrate data for the source. It is clear that the nitrate content of the water varies from moderate (a little over 30 mg/l as NO_3) to unacceptably high (approaching 60 mg/l). It is difficult to make out any clear overall trend, but there is no sign that the trend is downwards.

Although the data are not conclusive, there is a suggestion that most of the annual maxima are in the winter or spring months, when recharge and water levels are high, whereas the annual minima tend to be in the summer or autumn months, when recharge and water levels tend to be lower. This suggests that the winter/spring recharge is carrying nitrogenous contaminants into the groundwater. Since fertiliser and slurry applications tend to be in the summer, the inference is that some other source of contamination may be to blame.

The Garrettstown supply (the wells in the village and at the council houses) are usually sampled by Cork County Council as a mixed sample at Garrettstown Beach, but were sampled at the pumphouse in Garrettstown by the G.S.I. in April and September 1999. Nitrate at this supply does not appear to be a problem with levels below 2 mg/l of NO_3 (1.78 mg/l in both April and September 1999). However as this is a mixed sample it would be difficult to pick out any future increasing trend in nitrate levels in each individual borehole.

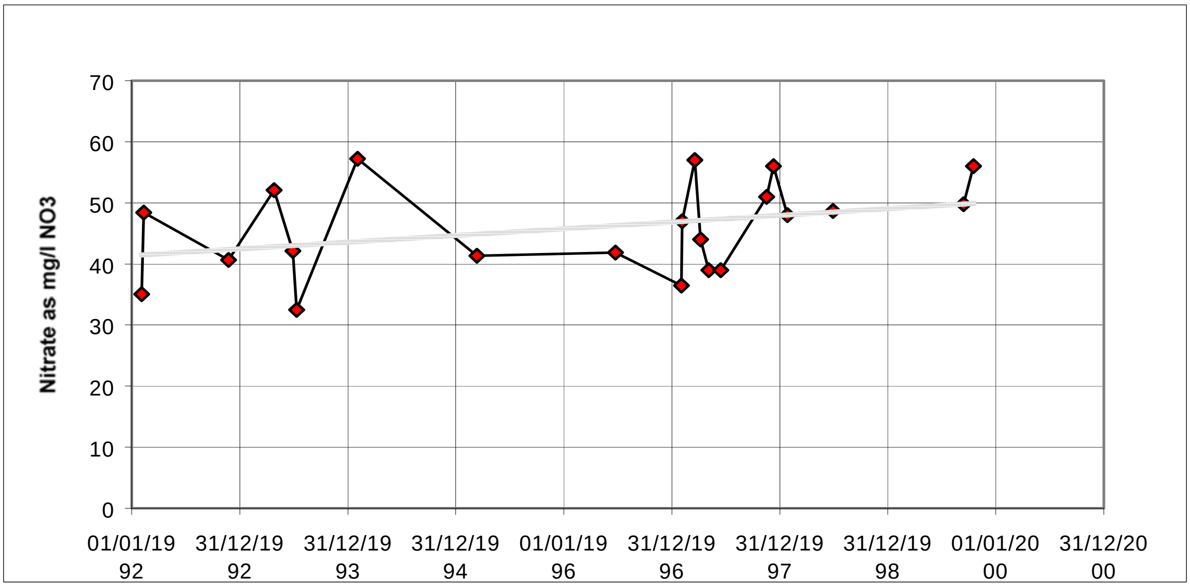


Figure 1: Nitrate concentrations at Ballinspittle 'Old' source.

9.2 Bacteria

The supply at Carrigavulleen is chlorinated. Although it is unclear whether historical records were sampling raw water or not, it seems that there have been quite a few sizeable breaches in the bacteriological water quality between 1991 and 1998 with *E.coli* levels ranging from 1 to 88 per 100 ml and total coliforms ranging from 1 to 99 per 100 ml.

A sample was taken as part of the G.S.I. water quality sampling in April 1999 at the Garrettstown pumphouse. This sample represents a mixed sample from both the well in Balllinspittle village and the well in Kilmore. It is unsure whether this sample was chlorinated or not, but there was no reported coliforms. A sample from September 1999 also found no coliforms. Historical data is also available for this Garrettstown Supply and is noted as 'Ballinspittle New'. Levels of bacteria above EU M.A.C's are also found at this supply and range from 1 to 56 per 100 ml for *E.coli* levels and 1 to 73 per 100 ml for total coliforms.

9.3 Other parameters

Water quality data are available for the Ballinspittle area from 1991 to date. Sampling of both the 'Ballinspittle Old' supply at Carrigavulleen and the 'Ballinspittle New' supply at the Garrettstown W.S. has been carried out on a regular basis, and as part of the South Cork Groundwater Protection Scheme some additional sampling was carried out. Results of laboratory analysis of water samples taken in April and September 1999 suggest that water in both public supplies (Ballinspittle and Garrettstown) generally have good water quality apart from the obvious nitrate problems in Carrigavulleen. Historical data from the "Ballinspittle New" records which represent the Garrettstown (mixed) supply do not seem to highlight any problems with iron as they were probably taken from a treated sample. However, there is a permanganate treatment system in place both in Carrigavulleen and in the Garrettstown pumphouse due to high iron levels which are found in the untreated water. An untreated sample taken in September 1999 shows a very high level of iron at 6.2 mg/l. Hardness values ranging from 120 to 185 mg/l $CaCO_3$ indicate that water in the Ballinspittle area is generally slightly to moderately hard. All other parameters appear to be normal.

Other parameters measured during sampling in 1999 are shown below in Table 1.

Parameter	Results of Laboratory Analyses		
	Ballinspittle W.S (Carrigavulleen)	Garrettstown W.S. (mixed sample from both boreholes)	
	14/09/999	14/04/99	14/09/99
Conductivity (μS/cm)	365	433	306
Temperature (°C)	16	10	14
pH	6.5	6.7	6.6
Total Hardness	145.37	185	119.97
Total Alkalinity (mg/l)	78	n/a	86
Calcium	42.7	43.9	28.1
Magnesium	9.53	18.4	12.1
Chloride	38.5	36.8	37.5
Sulphate	15.9	32.7	81 (?)
Sodium	22.8	27.9	24.8
Potassium	3	2.5	1.3
Nitrate (as NO_3)	49.8	1.78	<1.78
Iron	<0.1	<0.05	6.2
Manganese	<0.05	<0.05	<0.05
Total Coliforms per 100 ml	0	0	0
E.Coli count per 100 ml.	0	0	0

Table 1 Hydrochemical parameters from sampling at Ballinspittle/Garrettstown Water Supplies

10 Groundwater Vulnerability

10.1 Subsoil Thicknesses

Depth to Bedrock was discussed briefly in Section 6.2.2. Subsoil depths for the Ballinspittle area are fairly shallow and areas where subsoils are 3 m or less have been delineated and are used in defining areas where groundwater is extremely vulnerable ***(E)*** to contamination. There are also areas where depth to bedrock is greater than 3 m. However, a lack of borehole data means that 5 and 10 m contours could not be drawn reliably in this area.

10.2 Subsoil Permeabilities

Mapping by Teagasc has shown that there are a number of different subsoil types around the Ballinspittle area as briefly discussed in Section 6.2.1. Further investigation of the tills in the area by vulnerability mapping and augering of some depth to bedrock holes and collection of subsoil samples has given information on the textures and the permeabilities of the different subsoil types.

Limestone till covers most of the area to the north, west and south of Ballinspittle. A hole augered into this till near the spring source at Carrigavulleen encountered bedrock at 3.2 m and above this was at least 2 m of subsoil with a texture of SAND. Another auger hole, about 250 m south of this, found 4 m of subsoil over bedrock, consisting of 1.5 m of stony CLAY with some silt, below which was more CLAY with rock fragments.

Closer to the village, but still in the Limestone tills, as mapped by Teagasc, a hole was augered close to the well at the back of the council houses (Borehole 1). This hole was augered to a depth of 5.3 m but encountered no bedrock. The subsoils here consisted of approximately 1.5 m of sandy SILT with clay, 4 m of clayey GRAVEL and about 0.5 m of sandy CLAY. Two further holes were augered close to the well at the G.A.A. pitch south of the village in Kilmore. One encountered bedrock at a depth of 1.8 m although no sample was taken. The other, drilled only 25 m away, was augered to 6 m but met no bedrock. This highlights the variability in subsoil thicknesses in this area. The subsoils found at this point consisted of stony sandy CLAY (with silt) underlain by SILT/CLAY.

It seems that the limestone tills in this area are quite low permeability deposits. The fields around Carrigavulleen are quite large close to the spring itself and are used for pasture and cattle farming. The fields are smaller and boggier (from the 6 inch:1 mile maps for the area) further up the catchment and these may be the areas used for pig farming (from a farm survey carried out by Cork County Council in September 1998). The upper levels of the catchment for this spring source are therefore thought to be quite poorly drained. Around the well in the village, the subsoils are thought to have moderate to low permeability. The area around the well at the G.A.A. pitch is also thought to have quite low permeability subsoil to the west of the stream where the samples were taken from. The groundwater vulnerability of these deposits is therefore considered to be "probably moderately vulnerable" *(M)*. However, according to Teagasc (1999) sandstone till thought to be "derived from Devonian and Carboniferous age sandstones and shales" lies on the eastern side of the valley. This till is seen to be much better drained when looking at the valley sides, and is probably derived from the Old Head Sandstones (a thick succession of sandstones and minor mudstones). No samples were taken of this deposit, but it is thought to have a somewhat higher permeability than the limestone tills, although it is still of moderate permeability overall. Groundwater vulnerability of these tills is thought to be highly vulnerable *(H)*.

No samples were taken of the alluvial deposits along the river south of Ballinspittle village. No information is available on the thickness of this alluvium, but because of its location in a stream valley its thickness is assumed to be less than 3 m and therefore the vulnerability rating is assigned by considering the surrounding subsoils and their thicknesses.

Borehole data in the area do not allow a 5 or 10 m depth to bedrock contour to be drawn. Therefore, where subsoils are more than 3 m thick, the groundwater is classed as highly vulnerable *(H)*.

11. Conceptual Model

11.1 Carrigavulleen Spring, Ballinspittle Supply

- This supply consists of a gravity feed, or spring, which flows into a shallow sump, protected by a pumphouse. Although demand around this source is approximately 57 m^3/d, this supply is only capable of 36.3 m^3/d). The underlying bedrock aquifer is the mudstones of the Kinsale Formation. This spring is known to run dry during the summer months and this may be due to the fact that flow to this supply is from very shallow levels. The sump is set at 5.4 m below ground level, which means that it is only abstracting from the top 2 m or less of bedrock. There may also be a large element of groundwater flow to the well from the overlying subsoils, i.e. essentially interflow or shallow subsurface flow. This could also explain the water quality problems at this supply.
- The groundwater catchment of this sump (described in Section 12.2.1) is assumed to be completely coincident with the surface water catchment as this is a spring source. As will also be explained the ZOC of this well should also be considered to be the Source Inner Area of this supply because of expected groundwater travel times.
- Groundwater flow direction in the area around the spring is from the east as it is expected to follow topography. In the upper reaches of the catchment, there is some element of flow from the northeast.
- Groundwater gradients are estimated from topographic gradients, which in this area are relatively gentle when compared with some parts of the Ballinspittle area, and are of the order of 0.06.

- No pumping test data is available for the sump itself. However a yield test was carried out on the deep (93 m) borehole approximately 10 m away in 1992. A 124 hour test measured 60.3 m of drawdown at a yield of 115 m^3/d. A rough transmissivity (T) value can be calculated for the area immediately around the well at around 2.3 m^2/d over the whole 78 m of effective aquifer thickness. This corresponds to a hydraulic conductivity (K) value of 0.03 m/d. This borehole was abandoned after it ran dry about 2 years ago. However, in the case of the spring, conductivity will be a made up of elements from the expected higher conductivity in the upper levels of bedrock along with the low permeability found in the subsoils which it may also be abstracting from. There is no evidence of a fault zone close to this site and so it cannot be expected to be any higher than 0.5 m/d, and in fact is probably much lower, in the order of 0.05 m/d.

- Thin tills cover the bedrock in this area. An area of rock within 3 m has been mapped very close to the spring itself. However, much of the rest of the catchment according to Teagasc's draft mapping is thinly covered by limestone and sandstone tills "derived from Devonian and Carboniferous age sandstones and shales". The texture of these tills was studied using BS 5930 analysis and other vulnerability mapping methods. They were found to be probably moderate to low permeability and ranging from 3 to 5 m in thickness.

- Recharge calculations for this area were described in Section 7.3. It is thought the recharge is in the order of between 250 and 310 mm/yr. This recharge is expected to get to the bedrock aquifer through the overlying shallow tills and in some areas of rock close to surface, through direct contact with the rock itself. As the shallow tills are also thought to be contributing to groundwater abstracted here, recharge may be somewhat higher.

- There is a small stream flowing along the road from north to south, towards Ballinspittle village. The sump and spring are upgradient of it some 15 m to the east. It is assumed that groundwater feeds this stream, but the stream is not being pulled back into the sump and as such is not included in the ZOC of the spring.

- Water quality in this supply is a concern due to nitrate levels which varies from moderate (a little over 30 mg/l as NO_3) to very high (approaching 60 mg/l). There is evidence that maximum levels of nitrate are found in the winter months, which suggests that winter recharge is carrying nitrogenous contaminants into the groundwater. Fertiliser and slurry applications tend to be in the summer, and if so they may not be the direct cause. However if cattle and pigs are being housed in the winter months and this farmyard waste is getting into the groundwater, they may be contributing to the contamination at the source, considering these activities are within the ZOC of this supply. The bacteriological quality of the raw water at this well should be tested regularly as breaches have occurred in the past.

11.2 Ballinspittle Village Borehole, Garrettstown Supply

- This is a fairly deep (61 m) borehole which abstracts from the Kinsale Formation, and is located very close to, if not actually on, a local fault zone. This is a generally north-south trending fault and is thought to be a zone where bedrock permeability is somewhat higher than the surrounding low permeability bedrock. This well currently yields approximately 325 m^3/d.

- Groundwater flow direction in the area around the borehole is expected to follow topography and flow into the valley in which the well is located. There will be groundwater flowing from the north towards the borehole as well as towards the river in the centre of the valley, from the southwest.

- Groundwater gradients are estimated from topographic gradients as data on groundwater levels in nearby wells is not available. The gradients on the north side of the valley are quite steep and are in the order of 0.06.

- Due to operational reasons a pumping test could not be carried out during fieldwork in 1999. However, a pumping test was carried out on this borehole in 1978, as described in Section 8.2. A transmissivity (T) value of between 15 and 20 m^2/d was calculated, which implied a hydraulic conductivity (K) value of 0.3 to 0.5 m/d. It is assumed that there may also be some more permeable upper levels and a ‘K’ value of 1 m/d is taken in the calculation of an upgradient distance for the 100 day time of travel zone as explained in Section 11. Analysis of the pumping test data also found that the main inflow zones in this borehole are around 10.7 m below the ground surface as well as zones which are deeper but which required a longer test than was carried out to analyse properly.

- Depth to bedrock in the ZOC of this well is also considered to be fairly thin. Thin limestone tills overlie the bedrock in this area. BS 5930 analysis of a sample taken from a nearby augered hole found that these tills have a texture of sandy silt, clayey gravel and sandy clay (as described in Section 10.2). They are thought to have moderate to low permeability. There are also areas where this till is less than 3 m thick, and these occur mainly in the upper reaches of the catchment.
- Recharge calculations for this area were described in Section 7.3. It is thought the recharge for the ZOC of this well is in the order of 310 mm/yr, as there may be a little less runoff than at Carrigavulleen. This recharge is expected to get to the aquifer through the overlying shallow tills and in some areas of rock close to surface, through direct contact with the rock itself.
- Water quality records for the Garrettstown supply as a whole are available. However because of the set up of the distribution of water from the Ballinspittle Village and Kilmore Boreholes (i.e. water pumped directly to the Garrettstown Reservoir and then re-distributed) and because of the lack of sample taps at either of the actual boreholes, samples are always representative of mixed water from these two wells. As such it is very difficult to pick out any individual quality problems or trends for each borehole. As a mixed supply, there do not seem to be any problems with nitrate, although high iron levels are known to occur. Bacteriologically speaking, this water is quite clean.
- From the data collected during the 1978 pumping test it is thought that there is a connection with the nearby stream (flowing from the northwest) and it may affect drawdown at the well. As such part of the river is included in the ZOC of this well, although its protection from potential pollution will have to be looked at in greater detail.
- The groundwater catchment of this well (described in Section 12.2.2) is assumed in part to be coincident with the surface water catchment.
- The aquifer, namely the Kinsale Formation, is thought to be unconfined.

11.3 Kilmore Borehole, Garrettstown Supply

- Although the depth of this borehole is not known it is thought to be abstracting from the Kinsale Formation and is once again located very close to a local fault zone. This north-south trending fault is a continuation of the one in the village and may give a higher permeability than expected in an otherwise low permeability bedrock. This well currently yields approximately 105 m^3/d.
- Groundwater flow direction in the area around the borehole is expected to follow topography and flow towards the centre of the valley in which the well is located. Flow to the well is mainly from the southwest from the Kilmore Wood area.
- Groundwater gradients from water levels in wells are not available for this area. Topographic gradients in this area are quite steep, of the order of 0.14. However as will be explained in Section 12.2.3, it is expected that the transmissivities of these rocks could not sustain such a steep gradient. Hence, the water table is probably deeper and the groundwater gradients shallower than topography would initially suggest.
- Pumping test data are not available for this well. Data from the well in the village can be extrapolated to fit the hydrogeological conditions here at Kilmore due to the similarities in location geological setting and gradient. A hydraulic conductivity (K) value of approximately 0.5 m/d is taken to represent the bedrock at this site. Its proximity to the localised fault would indicate higher permeability bedrock than expected for the Kinsale Formation and the upper levels of the aquifer have an assumed K value of 1 m/d. For calculation of the Source Protection Areas (see Section 12.2.3) a depth of well was assumed at around 30 m.

- The river to the east of this well is approximately 100 m away and is considered to be too far away to be influenced by the pumping of this well, considering the conductivity of the rocks and the gradients involved. It is not included in the ZOC of this well.
- The till cover in the area around the well is very thin. A hole augered close by did not encounter rock before 6 m although one drilled some 25 m away encountered rock at a depth of 1.8 m, showing the variability in depth to rock over a small area. A large area of the ZOC has been mapped as having rock within 3 m of the surface. The remainder is overlain by a thin covering of limestone till. This till was analysed using BS 5930 and some vulnerability mapping, and was assessed as having a low permeability.
- The steepness of the topography around this well, the high average annual rainfall (approximately 1110 mm/yr.) and the inferred high runoff of about 65%, suggests a recharge of approximately 208 mm/yr (as explained in Section 7.3). This recharge is expected to get to the aquifer through the overlying shallow tills and in some areas of rock close to surface, through direct contact with the rock itself.
- As explained above in Section 9, water quality for this individual well is difficult to assess because of the practice of collecting mixed samples. Once again, iron levels are a concern, although nitrate levels are not thought to be a problem.
- The groundwater catchment of this well (described in Section 12.2.3) is assumed in part to be coincident with the surface water catchment.
- The water level in this well was at ground level (approx. 16.75 m O.D.) on 23 January 1999, i.e. a winter groundwater level, when recharge conditions were high. The aquifer, namely the Kinsale Formation, is thought to be unconfined.

12. Delineation of Source Protection Areas

12.1 Introduction

This section describes the delineation of the areas around the wells that are believed to contribute groundwater to the public water supplies in Ballinspittle W.S. (Carrigavulleen) and Garrettstown W.S. (Ballinspittle village and Kilmore), and that therefore require protection. The areas are delineated on the basis of the conceptualisation of the groundwater flow pattern, as described in Section 11. Given the limited amount of calibration data available, a full groundwater numerical model is not believed to add significant useful information to the conceptualisation.

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 well.

12.2 Outer Source Protection Area (SO)

The Outer Protection Area (SO) is bounded by the complete catchment area to the source, i.e. the zone of contribution (ZOC), which is delineated 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 rock permeability and d) the recharge in the area. The ZOC is delineated as follows:

i) An estimate of the area size is obtained by using the average recharge and the abstraction rate.

ii) The shape of the area is then derived by both analytical modelling and hydrogeological mapping techniques.

iii) To allow for errors in the estimation of groundwater flow direction and to allow for an increase in the ZOC in dry weather, a safety margin is normally incorporated by assuming a higher abstraction rate than the current rate.

12.2.1 Carrigavulleen Spring, Ballinspittle Supply

This supply is a spring / shallow sump, which collects groundwater flowing from the east to the sump which is set about 5.4 m below ground level. It is currently capable of supplying a maximum of only 36.3 m^3/d. However demand around the area is much higher than this; up to 56.8 m^3/d, in summer. This limit in supply is probably due to the construction of the sump. This is a spring source and its catchment is co-incident with the surface water catchment shown on Map 3. Given a recharge of approximately 312 mm/yr for this area which covers about 0.77 km^2, discharge at this spring should be in the order of 665 m^3/d. The remainder of the discharge not collected at the sump for supplying the local area is obviously overflowing into the stream and down towards Ballinspittle Village.

In terms of a ZOC for this spring source, all of the surface catchment must be included. However because of the estimated travel times of groundwater in this area (as will be explained in Section 12.3.1) all of this area has to be included in the Inner Source Protection Zone (SI) and an overall Outer Source Protection Zone (SO) becomes obsolete.

12.2.2 Ballinspittle Village Borehole, Garrettstown Supply

The average abstraction rate for the borehole at Ballinspittle village was estimated using the rate noted by Council staff and in Council files at between 273 and 327 m^3/d. This rate roughly corresponds with that measured during the pumping test in 1978 at 262 m^3/d. Usually the calculation of the ZOCwould include a factor of safety by increasing the average discharge (typically by 50%) to allow for possible future increases in abstraction and for expansion of the ZOC in dry periods. However a report on the 1978 pumping test (Wright, 1978) noted that this was probably the maximum yield this borehole could sustain in the long term, indicated by the fact that the drawdown had not stabilised after 72 hours. If the well were pumped at this rate for longer, drawdown would probably continue to increase and the well would eventually dry out. Therefore, calculation of this ZOC used a discharge of 325 m^3/d. The recharge for the area is eatimated as 312 mm/yr, so the required area needed to provide this discharge is 0.383 km^2, or 38.3 ha.

Hydrogeological mapping of the area around the Ballinspittle Village borehole (Borehole 1) was used to delineate the ZOC to the well. The north-western boundary of the ZOC is thought to be partly coincident with the surface water catchment. The main groundwater flow direction was from the north and there was no evidence to suggest that this varies too much due to the high gradients involved. The southern boundary of the ZOC was drawn based on calculations of the downgradient distance. Using a discharge of 325 m^3/d, a hydraulic conductivity of 0.4 m/d, (see Section 11.2) and a groundwater gradient of 0.06, the downgradient distance is calculated as 61.5 m. There is some connection with the river as explained in Section 8.2, so this is also included in the ZOC although it is not thought that much water from the south-western side of the river reaches the well. Although there is a nearby fault (which is actually within the ZOC), it is not thought that these act as barriers to groundwater flow. Therefore, the eastern and western boundaries of the ZOC can be drawn, based on the flow directions and flow lines, as is shown in Map 3. The mapped ZOC has an area of approximately 0.4 km^2 (40 ha), which is comparable with the calculated area outlined above.

12.2.3 Kilmore Borehole, Garrettstown Supply

The average abstraction rate for the borehole at Kilmore was estimated using the rate noted by Council staff and in Council files of 104.5 m^3/d. Usually during calculation of the ZOC, a factor of safety is built into the average discharge, and it is increased (typically by 50%) to allow for possible future increases in abstraction and for expansion of the ZOC in dry periods. However, due to very steep topographic gradients and the fact that this well dries out in summer, this method cannot be used at this borehole as a rate of 157 m^3/d could not be sustained. Therefore, calculation of this ZOC used a discharge of 104.5 m^3/d. The recharge for the area is thought to be approximately 208 mm/yr, so the required area needed to provide the increased discharge above is 0.18 km^2, or 18 ha.

Hydrogeological mapping of the area around the Kilmore borehole was used to delineate the ZOC to the well. The southern boundary of the ZOC is thought to be coincident with the surface water catchment. The main groundwater flow direction is from the southwest, but in order to take account of some heterogeneity of flow from the western side of the catchment, probably in the upper few metres of the a variation in the flow direction of $\pm 10^o$ was included as a safety margin. Elsewhere there is little evidence to suggest that the flow direction varies too much due to the high gradients involved. The northeastern boundary of the ZOC was drawn based on calculations of the downgradient distance. The groundwater gradient used for calculation of the downgradient distance here is shallower than the topographic gradient. This is due to the fact that groundwater is being abstracted from a low permeability bedrock, which, with a low transmissivity would not be able to sustain this discharge with such a steep gradient. It is therefore thought that the water table under this ridge upgradient of the well is lower than originally thought and the gradient from the ridge to the well is therefore shallower. Using a discharge of 104.5 m^3/d, a hydraulic conductivity of 0.4 m/d, which is extrapolated from the village well due to the similarities in geological conditions, (see Section 11) and a groundwater gradient of 0.06, the downgradient distance is calculated as 19.8 m. The nearby river is well over 100 m away and is not thought to be in hysraulic connection with the borehole. Although there is a nearby fault (which is actually just within the ZOC, downgradient of the well), it is not thought to have much effect on the permeability of the rocks in the ZOC. The southeastern and northwestern boundaries of the ZOC are based on the flow directions and flow lines, as is shown in Map 3. The mapped ZOC has an area of approximately 0.176 km^2 (17.6 ha), which is comparable with the calculated area outlined above.

12.3 Inner Source Protection Area (SI)

The Inner Protection Area (SI) is the area defined by a 100 day time of travel (TOT) to the source 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 microbial contamination.

12.3.1 Carrigavulleen Spring, Ballinspittle Supply

As explained in Section 12.2.1, the entire ZOC of this supply should be considered as an Inner Source Protection Area (SI), because of the nature of groundwater flow in this area. If, as is thought, the groundwater flows to the spring in the upper 2 m of bedrock and in the overlying subsoils, it can be assumed that water from the top of the catchment will reach the spring within 100 days. This is due to the presumed high permeability of the upper few metres of bedrock and the high flow rates which could be expected in the horizontal flow in the tills. Raw water samples from this source have shown the poor bacteriological quality of this water, which supports the idea that this supply is susceptible to pollution within a short space of time.

12.3.2 Ballinspittle Village Borehole, Garrettstown Supply

Permeability values for the aquifer around this source were derived from pumping test data (see Section 8.2). This estimate of permeability (0.4 m/d) is an average over the effective 35 m depth of the aquifer. It is assumed that the upper few metres of bedrock will be more permeable, particularly as groundwater will have flowed over time towards the valley creating weathered, fissured zones in these upper levels. Therefore, for the purpose of protecting an inner zone, a high permeability (representative of the zone of greatest and fastest flow) must be taken into account to give maximum protection to the borehole. Therefore, a permeability of 1 m/d was used to estimate the 100 day time of travel zone distance to the well. Using an effective porosity value of 0.02 and a groundwater gradient of 0.06, the 100 day time of travel distance to the well is estimated at 300 m (see Map 3).

12.3.3 Kilmore Borehole, Garrettstown Supply

Permeability values for the aquifer around this source were extrapolated from the values derived at the Ballinspittle Village borehole. Once again this K value (0.4 m/d) is an average over the effective presumed 35 m depth of the aquifer. It is also assumed here that the upper few metres of bedrock will be more permeable, for the same reasons outlined above. A permeability of 1 m/d was also used in Kilmore to estimate the 100 day time of travel zone distance to the well. Using an effective porosity value of 0.02 and a groundwater gradient of 0.06 (as explained in Section 11) the 100 day time of travel distance to the well is estimated at 300 m (see Map 3).

13. Groundwater Protection Zones

The groundwater protection zones are obtained by integrating the two elements of land surface zoning (source protection areas and vulnerability categories) – a possible total of 8 source protection zones (see the matrix in the table below). In practice, the source protection zones are obtained by superimposing the vulnerability map on the source protection area map. Each zone is represented by a code e.g. **SI/H**, which represents an **Inner Protection area** where the groundwater is **highly** vulnerable to contamination. There are 2 groundwater protection zones present around the Carrigavulleen spring, 4 around the Ballinspittle village borehole (Borehole 1) and 4 around the well at Kilmore (Borehole 2), as shown in the matrix below and in Map 3.

Matrix of Source Protection Zones

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

The response measures imposing restrictions on certain developments and activities within these zones are included in the "Groundwater Protection Schemes" publication by the DELG, EPA and the GSI in 1999. These measures indicate the degree of restriction recommended in each protection zone.

14. Land Use and Potential Pollution Sources

Carrigavulleen spring

This land was surveyed by Cork County Council in September 1998 and is used for farming of cattle and pigs. There are also some houses within the catchment of this spring source and most of these are assumed to have their own septic tanks, although a detailed assessment of their locations was not made as part of this study. The main hazards within the Zone of Contribution are considered to be landspreading and the application of fertilisers as well as the activities in the small piggery. These hazards should be monitored closely.

Ballinspittle village borehole

Land use around the well is mainly limited to the council houses and the farming activities which occur towards Kilmore Cross and activities at Kilmore Wood. The main hazards are considered to be the application of fertilisers. There is a lot of grassland in the area which rises gently to the north. Farm surveys need to be carried out in this area.

The council houses, downgradient of the well, are connected to the main sewer system, although there is one large holding tank for waste (large septic tank and filtration system) which is located south of the village. This tank is quite close to the borehole and has no treatment system installed and discharges into the nearby stream. The council estate needs to be monitored as a potential pollution source, as does the nearby river as its proximity and connection to the borehole must be considered.

The G.A.A. pitch is situated beside the well and may pose a hazard through applications of fertiliser and/or pesticides.

Other hazards include septic tank systems, as well as possible spillages along the roads upgradient of and close to the wells. There is a fertiliser depot in the village, but it is not in the catchment of any of the existing supplies, although it is in an area of shallow subsoils. No detailed assessment of hazards was carried out as part of this study.

15. Conclusions and Recommendations

15.1 The Ballinspittle Water Supply Scheme consists of one spring (or shallow sump) source Carrigavulleen townland which is protected by a pumphouse which also houses the controls and water quality treatment system. This supply is pumped to the nearby reservoir north of here and is then pumped to the surrounding area. The Garrettstown supply consists of 2 wells, one in Ballinspittle village itself behind the council houses and another in the townland of Kilmore on the road to Garrettstown, adjacent to the GAA pitch. Both of these wells pump to the reservoir and pumphouse at Garrettstown and water is then distributed to the village of Ballinspittle and the Garrettstown area.

15.2 The shallow sump/spring in Carrigavulleen is a considered to be a low-yielding spring. Its maximum yield is not known but its demand is in the region of up to 36.4 m^3/d in the summer. The deep well located some 10 m away is presently not in use. It was capable of over 100 m^3/d when it was drilled in 1992, but was abandoned some two years ago as it eventually ran dry.

15.3 The Garrettstown W.S. borehole in Ballinspittle village was tested in June and August 1978. It was pumped for 72 hours at a rate of 262 m^3/d. Data from this test give a specific capacity in the order of 15-20 m^3/d/m, although drawdown had not stabilised at the end of the test. A transmissivity value of approximately 10-20 m^2/d was calculated using data from this borehole and a nearby observation well. Its current yield is noted as 327 m^3/d. As explained in Section

15.2 12.2.2, it is unlikely that its yield can be increased by 50% as would usually be done in defining a safe ZOC. *A safety buffer may need to be added to be discussed with the County Council*. The other borehole in the Garrettstown supply is located at Kilmore and this well is capable of 65 to 100 m^3/d. No data exist on the sustainability of this yield and it is normally only used as a backup to the other borehole in the summer and also has a tendency to go dry during high demand. Again it is unlikely that the yield can be increased for this well *and a safety buffer may need to be added*.

15.3 All these boreholes in Ballinspittle/Garrettstown are abstracting from the Kinsale Formation (either undifferentiated or the Narrow Cove Member as outlined in Section 8.1). These are classified as **locally important aquifers which are moderately productive only in local zones** (**Ll**). The spring in Carrigavulleen is probably abstracting from the upper 2 m of bedrock and some element of groundwater flow from the overlying subsoils.

15.4 The spring at Carrigavulleen is located within an area of rock close to surface and bedrock is definitely within 3 m of the surface. The remainder of the ZOC is covered by limestone till as well as an area of sandstone till (derived from Devonian and Carboniferous age sandstones and shales, according to Teagasc (2000)). The two wells in the Garrettstown W.S. are located in areas of limestone till with some areas of shallow subsoils and rock close to surface within their ZOCs. As such they lie in areas of high and extreme vulnerability as shown on the Vulnerability Map (Map 2).

15.5 Water quality at Carrigavulleen is a concern due to the high nitrate levels (particularly in the winter months) as well as the bacteriological quality of the raw water which is indicating some form of contamination, possibly from landspreading. In the Garrettstown W.S. (Ballinspittle Village and Kilmore boreholes) the main water quality concern is with iron levels. The wells are treated with permanganate, but untreated water can indicate quite high levels, for example 6.2 mg/l.

15.7 The inner and outer protection zones delineated in the report are based on our current understanding of groundwater conditions and on the available data. Additional data obtained in the future may indicate that amendments to the boundaries are necessary. Due to the difficulties in using the current discharge increased by 50%, for calculation of a safe ZOC, *a safety buffer may need to be added around the ZOC delineated as part of this report.*

15.8 It is recommended that:

- Sampling taps should be installed at the Ballinspittle Village and Kilmore boreholes so that individual raw water samples from each borehole can be taken and analysed. In this way any trends (increasing or otherwise) can be picked up quickly and attributed to one or other of the boreholes and the source of the problem identified more easily. A tap should also be set up in the pumphouse at Carrigavulleen to sample the raw water from there.
- chemical and bacteriological analyses of raw water rather than treated water should be carried out on a regular basis (every 6 months).
- the chemical analyses should include all major ions – calcium, magnesium, sodium, potassium, ammonium, bicarbonate, sulphate, chloride, and especially nitrate.
- particular care should be taken in considering any proposed activities or developments which might significantly increase nitrate levels or cause contamination at either of the WSS wells.
- the potential hazards in both ZOCs should be located and assessed;
- interim codes of practice should be drawn up for dealing with underground petroleum storage/transfer, and spillages along the roads in the area.

16. References

British Standards Institution (1981) *Code of Practice for Site Investigations*. BS 5930:1981. British Standards Institution, London, 147 p.

DELG/EPA/GSI (1999) *Groundwater Protection Schemes*. Department of the Environment and Local Government, Environmental Protection Agency and Geological Survey of Ireland, 24 pp.

Kelly, D., Leader, U. & Wright, G.R. (2002) *South County Cork Groundwater Protection Scheme.* Groundwater Section, Geological Survey of Ireland.

Lee, M. (1999) *Surface Hydrology and Vegetation as Secondary Indicators of Groundwater Recharge and Vulnerability*. Unpublished MSc. (research) thesis, Department of Civil, Structural & Environmental Engineering, Trinity College, Dublin

Sleeman, A.G. & Pracht, M. (1994) Bedrock Geology 1:100,000 Map Series, Sheet 25, South Cork, Geological Survey of Ireland.

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

Teagasc / Coillte Forest Inventory and Planning System (FIPS) project (1999) Draft Soils mapping.

Wright, G.R (1978) *Report on 72-hour pumping test on Borehole No 1., Ballinspittle Water Supply Scheme, 8 - 11 August 1978*. GSI Groundwater Section Report for Cork County Council.

Wright, G.R. (2000) *QSC Graphs - An aid to aquifer classification in data-poor aquifers in Ireland*. In Robins, N. S. & Misstear, B.D.R. (eds) *Groundwater in the Celtic Regions: Studies in Hard Rock and Quaternary Hydrogeology*. Geological Society of London, Special Publication 182, 169-177.

Appendix 1

Pumping Test Data

SITE Ballinspittle **DATE** 26-May-92

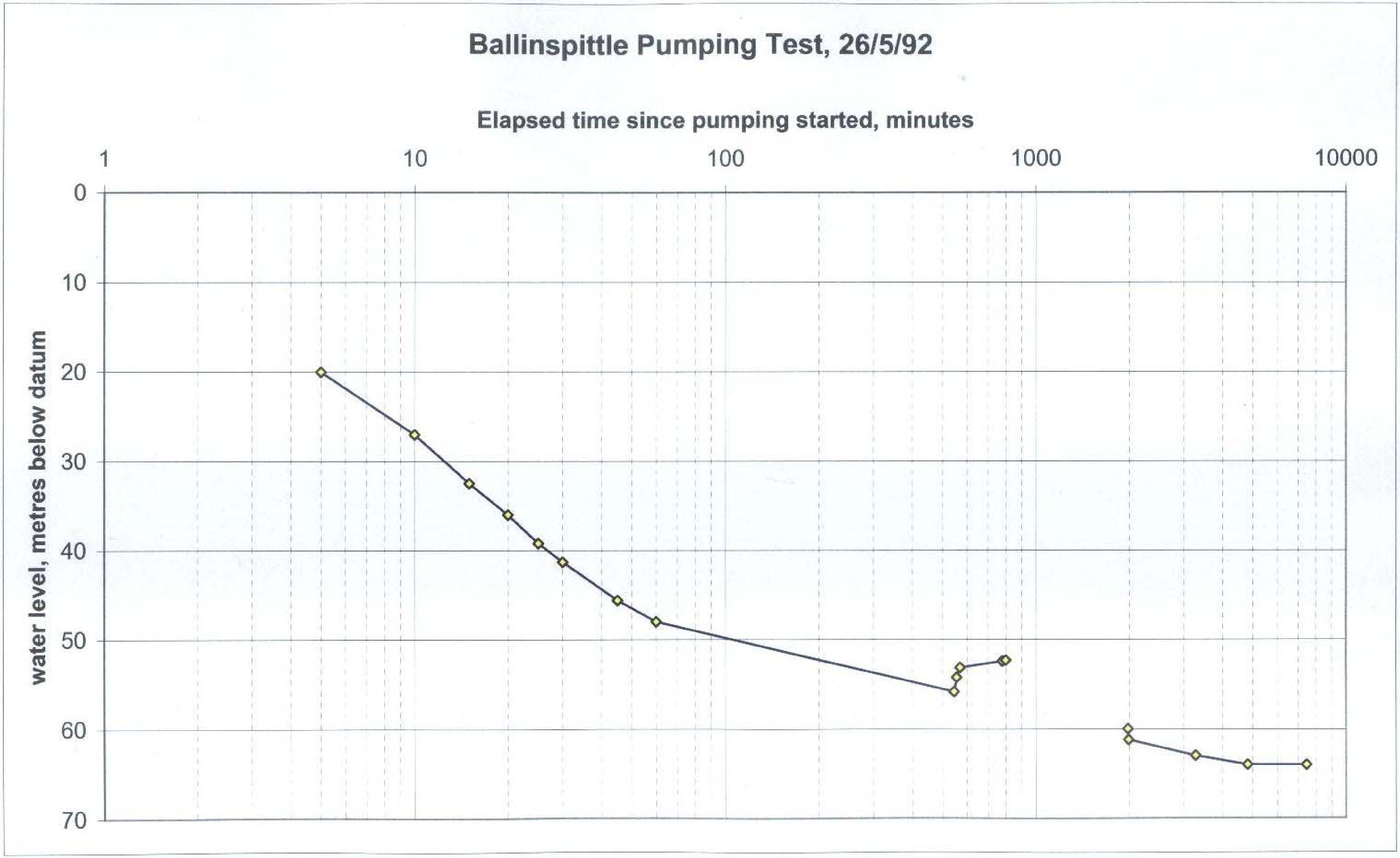
Groundwater Section
Geological Survey of Ireland

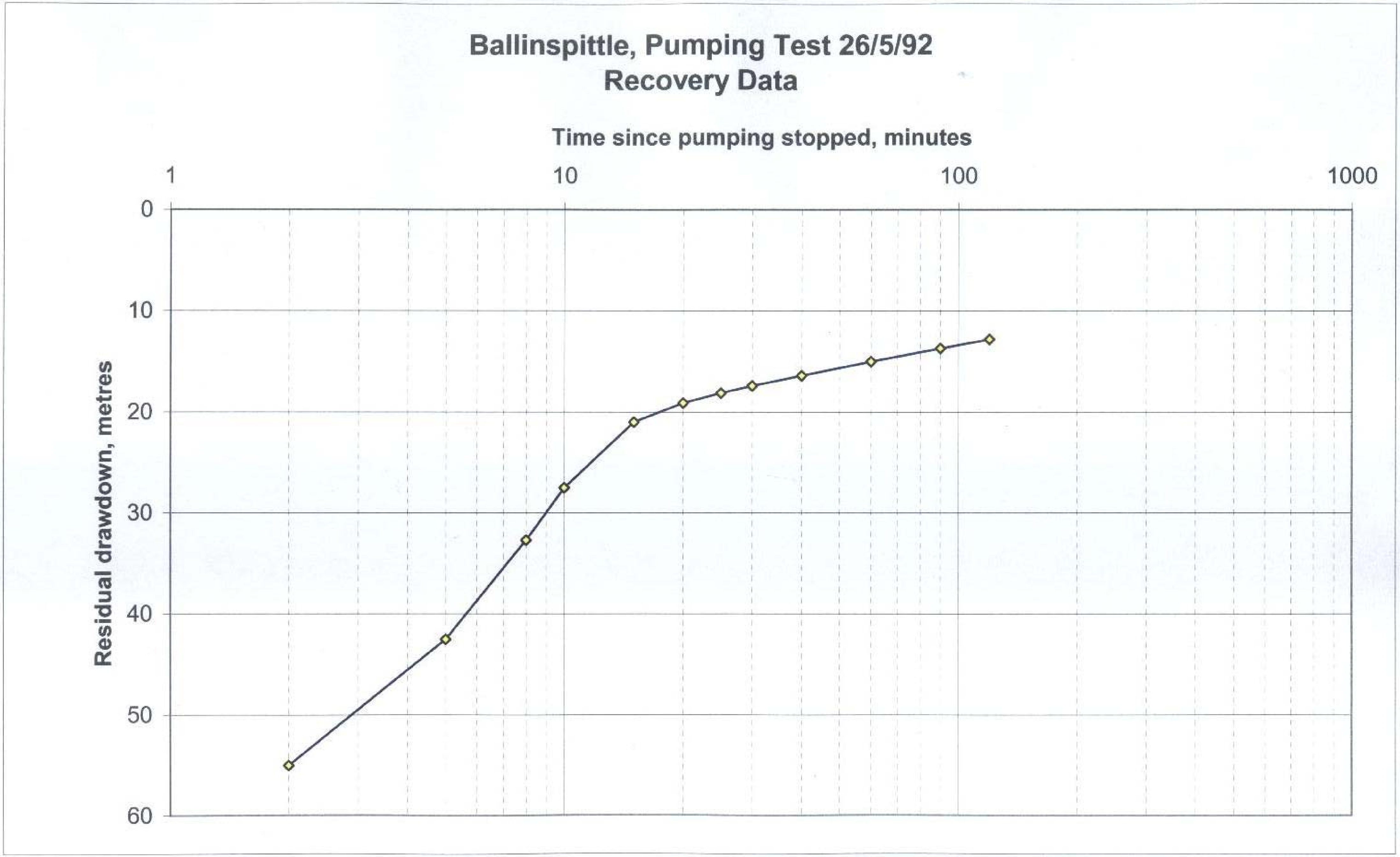
Project Sth Cork GWPS

PUMPING TEST PUMPING WELL

Borehole Name	Ballinspittle	Well Depth	~91 m	Datum Point	
Borehole No.	1403NEW087	Well Diameter	150 mm	Height of Datum	
Well Owner	Cork Co Co	Pump Depth	87 m	Ground Elevation	
Location		Aquifer	Kinsale Formation	Datum Elevation	
Grid ref.	15913 04633			Weather	
6" Sheet No.	CORK 124			Observer	

Date	Time	Elapsed Time	Water level below datum	Drawdown	Discharge		Discharge	Remarks	
		Mins	(m)	(m)	Meter	Spot	(m3/d)		
26/5/1992	08:00	0	3.70	0.00					
	08:05	5	20.00	16.30					
	08:10	10	27.00	23.30					
	08:15	15	32.50	28.80					
	08:20	20	36.00	32.30					
	08:25	25	39.20	35.50					
	08:30	30	41.30	37.60					
	08:45	45	45.60	41.90					
	09:00	60	48.00	44.30					
	17:05	545	55.80	52.10					
	17:15	555	54.20	50.50					
	17:30	570	53.10	49.40					
	21:00	780	52.40	48.70			91.6		
	21:20	800	52.30	48.60					
27/5/1992	16:50	1970							
	17:00	1980	60.00	56.30					
	17:10	1990	61.20	57.50			111.3		
28/5/1992	14:25	3265	63.00	59.30			111.3		
	14:30	3270	63.00	59.30					
29/5/1992	16:10	4810	64.00	60.30					
1/6/1992	12:20	7460	64.00	60.30				end of test	
	12:22	2	55.00	51.30				recovery	
	12:25	5	42.50	38.80					
	12:28	8	32.70	29.00					
	12:30	10	27.50	23.80					
	12:35	15	21.00	17.30					
	12:40	20	19.10	15.40					
	12:45	25	18.10	14.40					
	12:50	30	17.40	13.70					
	13:00	40	16.40	12.70					
	13:20	60	15.00	11.30					
	13:50	90	13.70	10.00					
	14:20	120	12.80	9.10					


Ballinspittle Pumping Test, 26/5/92
Elapsed time since pumping started, minutes
1
10
100
1000
10000
0
10
20
30
40
50
60
70
water level, metres below datum


Ballinspittle, Pumping Test 26/5/92
Recovery Data
Time since pumping stopped, minutes
1
10
100
1000
Residual drawdown, metres
0
10
20
30
40
50
60

Appendix 2

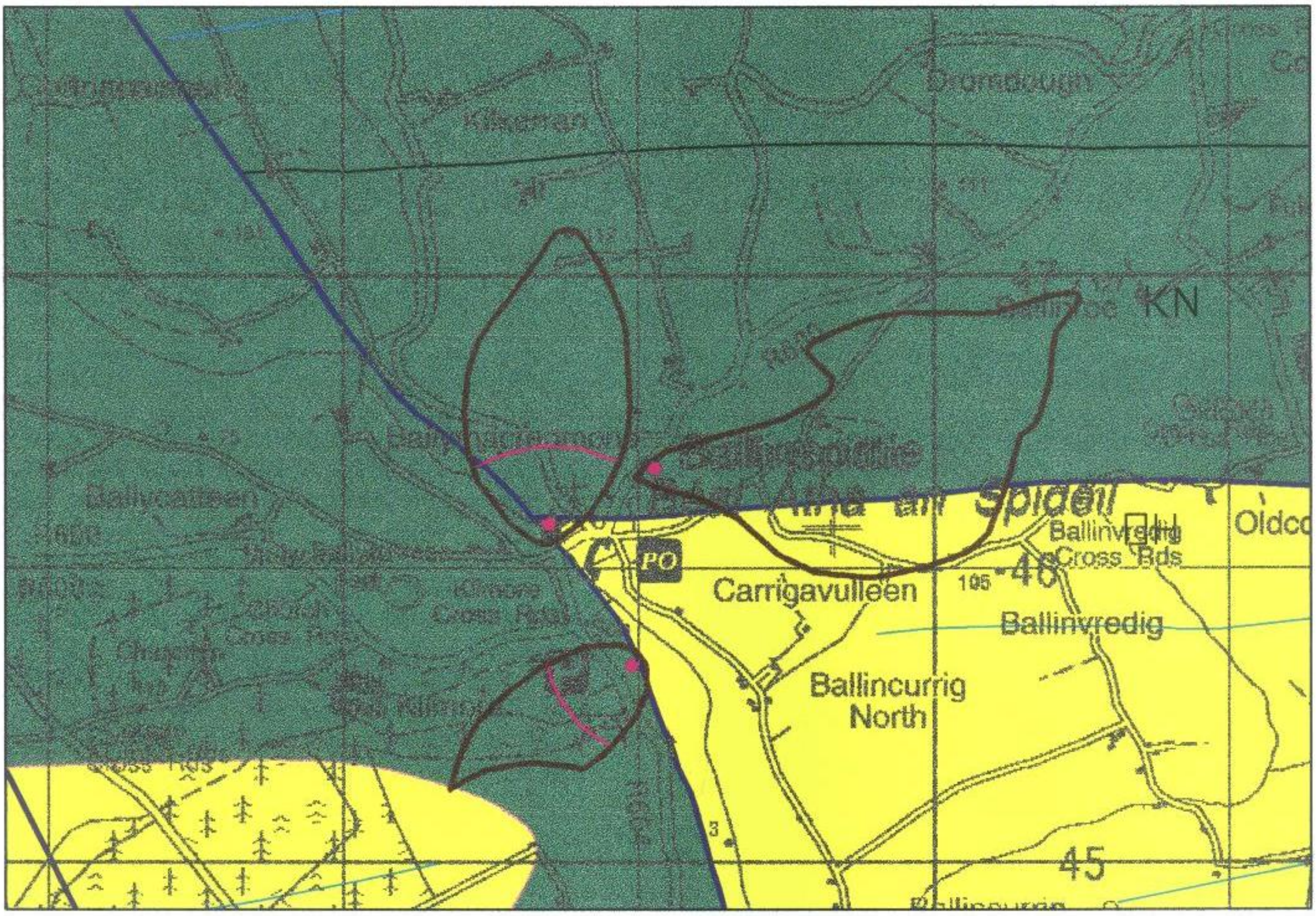
Water Quality Data

Ballinspittle WSS Water Quality

	Lab	Date	SO4	Cl	Alk.	TH	Fe	Mn	Nitrite	NO3	NH4	Al	E. coli	TC	pH	Temp	EC Lab	F	Zn
Units			mg/l	mg/l	mg/l CaCo3		mg/l	mg/l	mg/l N	mg/l	mg/l	mg/l	no/100l	no/100l	Lab	Lab	uS/cm	mg/l	mg/l
MAC			250	250			0.2	0.05	0.03	50	0.23	0.2	0	0		oC	1500	1	1
	Inniscarra	3/1/1991											0	0					
	Inniscarra	6/1/1991							0.008	0	0.048		0	0	7.3	10.5	469		
	Inniscarra	15/4/1991											0	1					
	Inniscarra	15/5/1991											0	0			569		
	Inniscarra	30/9/1991											13	18			357		
	Inniscarra	14/10/1991											28				383		
	Inniscarra	20/1/1992											0	0		7	453		
	Inniscarra	3/2/1992							0.002	35.05	0.003		0	0	6.5	8.7	384		
	Inniscarra	10/2/1992							0	48.42	0.013		0	0	6.6	9	443		
	Inniscarra	2/3/1992											0	0			598		
	Inniscarra	11/5/1992											0	0		12	580		
	Inniscarra	8/6/1992											0	0		17	519		
	Inniscarra	30/6/1992											0	0			449		
	Inniscarra	28/7/1992											9	25		17	443		
	Inniscarra	4/8/1992											2	1		18	409	0.28	
	Inniscarra	10/8/1992											0	0		18	479		
	Inniscarra	18/8/1992											0	0			462		
	Inniscarra	7/9/1992											0	0			288		
	Inniscarra	28/9/1992											0	0			467		
	Inniscarra	23/11/1992							0	40.67	0.013		0	0	6.7	10	441		
	Inniscarra	2/12/1992											0	0			412		
	Inniscarra	30/12/1992											0	0		10	460		
	Inniscarra	5/1/1993											0	0		9	444		
	Inniscarra	11/1/1993											0	0			431		
	Inniscarra	8/3/1993											0	0			361		
	Inniscarra	23/3/1993											0	0		11	352		
	Inniscarra	26/4/1993							0.003	52.1	0		9	31	6.4	10	416		
	Inniscarra	12/5/1993											0	0		13.5	385		
	Inniscarra	1/6/1993											21	23		15	349		
	Inniscarra	29/6/1993							0.007	42.1	0.01		1	5	6.7	16.5	403		
	Inniscarra	12/7/1993							0.003	32.46			88	99	6.9	17.5	351		
	Inniscarra	20/7/1993														16.5	355		
	Inniscarra	22/7/1993															377		
	Inniscarra	26/7/1993											4	4		17	388		
	Inniscarra	3/8/1993											0	0			395		
	Inniscarra	6/9/1993											0	0			490		
	Inniscarra	23/9/1993											0	0			372		
	Inniscarra	5/10/1993											0	0			404		
	Inniscarra	11/10/1993											0	0			410		
	Inniscarra	28/10/1993											0	0		11	458		
	Inniscarra	2/11/1993											0	0		10	415		
	Inniscarra	30/11/1993											0	0		9	437		
	Inniscarra	13/12/1993											0	0			469		
	Inniscarra	10/1/1994											0	0			464		

Ballinspittle WSS Water Quality

	Lab	Date	SO4	Cl	Alk.	TH	Fe	Mn	Nitrite	NO3	NH4	Al	E. coli	TC	*pH*	*Temp*	EC Lab	F	Zn
Units			mg/l	mg/l	mg/l CaCo3		mg/l	mg/l	mg/l N	mg/l	mg/l	mg/l	no/100l	no/100l	Lab	Lab	uS/cm	mg/l	mg/l
	Inniscarra	25/1/1994											0	0		9	511		
	Inniscarra	2/2/1994			98	175	0.07	0.022	0.001	57.22	0.01		1	0	6.5	4	480		
	Inniscarra	8/3/1994											0	0			471		
	Inniscarra	28/3/1994											0	0			438		
	Inniscarra	13/4/1994											0	0			447		
	Inniscarra	9/5/1994											0	0			402		
	Inniscarra	7/6/1994											0	0			431		
	Inniscarra	27/6/1994											0	0			401		
	Inniscarra	18/7/1994											0	0			376		
	Inniscarra	16/8/1994											0	0			400		
	Inniscarra	26/9/1994											0	0			396		
	Inniscarra	7/11/1994											0	0			425		
	Inniscarra	5/12/1994											0	0			455		
	Inniscarra	11/1/1995											0	0			415		
	Inniscarra	13/3/1995	171	38	112	178	0.1	0.066	0.003	41.36	0.01	0.03	0	0	6.9	9.5	398		0.05
	Inniscarra	8/5/1995										0.03	0	0			349	0.5	
	Inniscarra	29/6/1995										0.03	0	0			293		
	Inniscarra	6/7/1995											0	0			297		
	Inniscarra	24/7/1995											1	3			299		
	Inniscarra	19/9/1995										0.03	0	0			286		
	Inniscarra	15/11/1995											0	0			370		
	Inniscarra	3/1/1996											0	0			417		
	Inniscarra	9/4/1996											0	0			387		
	Inniscarra	7/5/1996											0	0			374		
	Inniscarra	24/6/1996					0	0	0.04	41.87	0.013	0.03	0	0	6.5	16	345		
	Inniscarra	8/10/1996											0	0			348		
	Inniscarra	15/1/1997											0	0			374		
	Inniscarra	11/2/1997					0	0	0.016	36.47	0.013		0	0	6.8	8	356		
	Inniscarra	14/2/1997								47									
	Inniscarra	19/3/1997								57									
	Inniscarra	8/4/1997								44			0	0			356		
	Inniscarra	6/5/1997								39			0	0			353		
	Inniscarra	15/6/1997								39									
	Inniscarra	17/11/1997								51									
	Inniscarra	10/12/1997								56									
	Inniscarra	26/1/1998								48									
	Inniscarra	29/6/1998								48.68	0.02		0	0	6.6	14	367		
	Greater than Guide levels																		
	Greater than MAC levels																		



0 500m 1 km

Ballinspittle Water Supply Scheme

Map 1. Geology

KN Kinsale Formation

OH Old Head Sandstone Formation

Fault

Public Supply Well

Inner Protection Zone

Zone of Contribution

This Bedrock Map is designed for general information and stragegic 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.

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

0 500m 1km

Ballinspittle Water Supply Scheme

Map 2. Groundwater Vulnerability

- Extreme (E)
- Outcrop/Shallow rock (E)
- High (H)
- Moderate (M)
- Low (L)
- Public Supply Well
- Zone of Contribution
- Inner Protection Zone

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.

0 500m 1km

Ballinspittle Water Supply Scheme

Map 3. 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

Public Supply Well

Inner Protection Zone

Zone of Contribution

This **Source Protection Map** is designed for general information and stragegic 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.
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.