# Establishment of Groundwater Source Protection Zones

# Martinstown, Ballinvreena Water Supply Scheme

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***Prepared by:***
OCM

***With contributions from:***
Dr. Robert Meehan, Ms. Jenny Deakin, Mr. David Ball

***And with assistance from:***
Limerick County Council

# Project description

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

The project "Establishment of Groundwater Source Protection Zones", led by the Environmental Protection Agency (EPA), represents a continuation of the GSI's work. A CDM/TOBIN/OCM project team has been retained by the EPA to establish Groundwater Source Protection Zones at monitoring points in the EPA's National Groundwater Quality Network.

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

# TABLE OF CONTENTS

# TABLES



# FIGURES



# APPENDICES

# 1 Introduction

Groundwater Source Protection Zones (SPZ) have been delineated for the Martinstown Ballinvreena source according to the principles and methodologies set out in 'Groundwater Protection Schemes' (DELG/EPA/GSI, 1999) and in the GSI/EPA/IGI Training course on Groundwater SPZ Delineation.

The Martinstown Ballinvreena Water Supply is provided by one borehole (IE_SH_G_055_13_017), which was installed in 1993. Limerick County Council assumed authority for the borehole from Martinstown Group Water Scheme in 1999.

The objectives of the study are as follows:

- To outline the principal hydrogeological characteristics of the Martinstown Ballinvreena area.
- To delineate source protection zones for the borehole.
- To assist the Environmental Protection Agency and Limerick County Council in protecting the water supply from contamination.

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

# 2 Methodology

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

The site visit and interview with the caretaker took place on 15/06/2010. Field mapping of the study area (including measuring the electrical conductivity and temperature of the source, nearby streams and Ballinvreena Spring, and the assessment of the soils and subsoils) took place on 14/07/2010 and on 11/10/10.

While specific fieldwork was carried out in the development of this report, the maps produced are based largely on the readily available information and mapping techniques using inferences and judgements from experience at other sites. As such, the maps may not be definitively accurate across the whole area covered, and should not be used as the sole basis for site-specific decisions, which will usually require the collection of additional site-specific data.

# 3 Location, Site Description and Well Head Protection

The site is located approximately 2.8 km southeast of Martinstown village in the townland of Cush. The borehole is in a compound adjacent to the public road that links the villages of Cush and Ballinvreena, as shown in Figure 1.

The compound is protected by a palisade fence with access by a padlocked gate. The ground surface in the compound comprises granular fill. The well is in a raised concrete chamber in front of the pump house and beside the reservoir (Photograph 1). A treatment plant in the pump house comprises a chlorination system (sodium hypochlorite). There is no cryptosporidium filter.

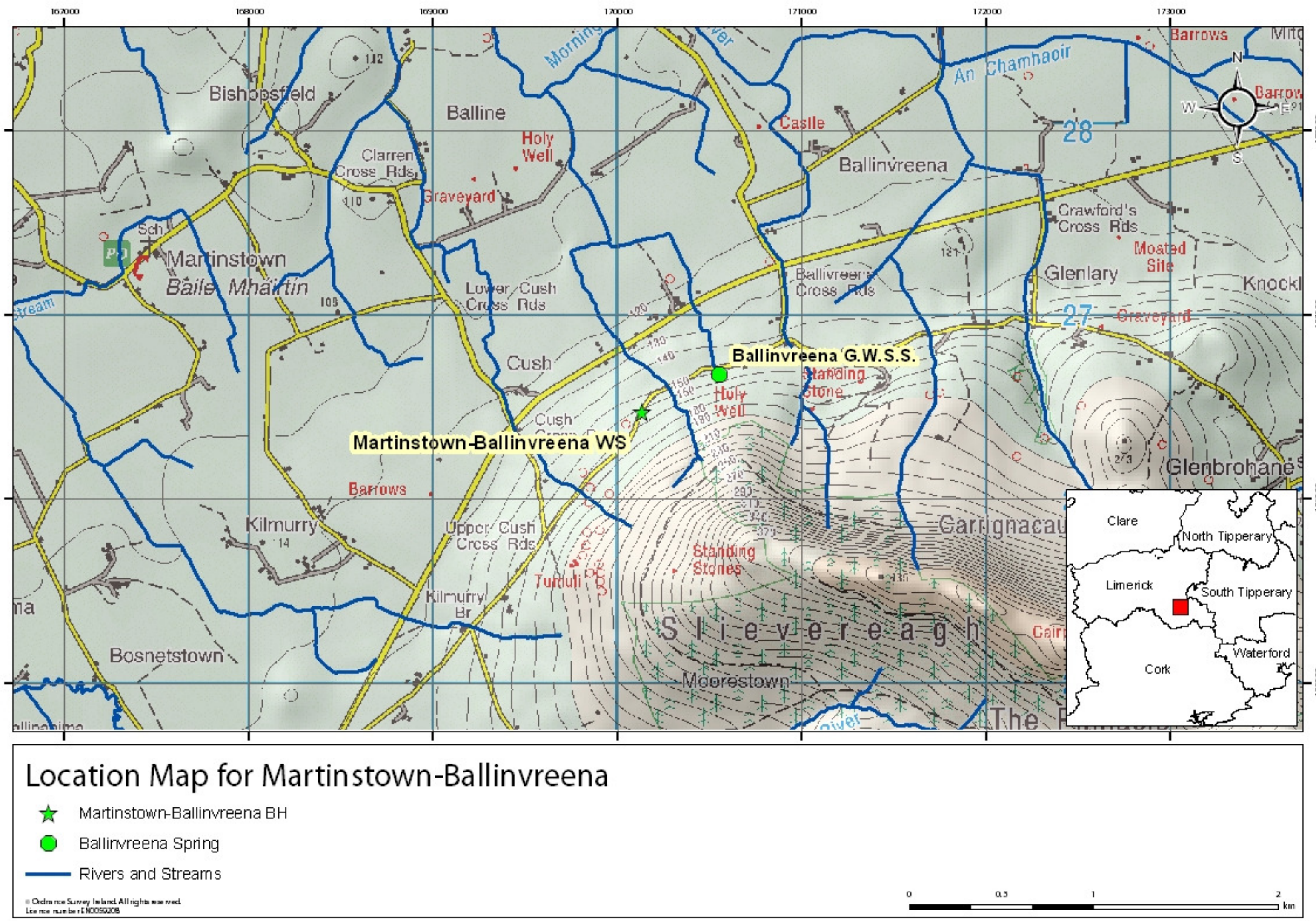


**Figure 1: Location Map**

**Photo 1: Entrance to site from public road**

The borehole is in a concrete chamber (c 2 m by 0.8 m) fitted with a large, lockable, steel cover. The internal concrete block walls are not rendered. It appears that surface run-off or shallow subsurface flows could enter the chamber (Photograph 2). However the steel casing rises 0.40 m above the bottom of the chamber, which prevents entry to the well casing. The borehole is not capped and there is no information (e.g. a borehole or well construction log) to establish whether it is adequately sealed to prevent shallow subsurface inflow or to determine the precise depths of inflow (Photograph 3).

**Photo 2: BH-1 Chamber**

**Photo 3: Internal manhole chamber**

# 4 Summary of Well Details

No original borehole records are available, but basic data have been obtained from report on the hydrogelogical testing of the borehole conducted by Mr. David Ball in 2001, included in Appendix 1.

A test well was initially drilled in 1990 by Dunnes of Mallow to a depth of 200 ft (c.60.8 m). Based on information in Mr. Ball's report, it appears that the well was drilled initially at 10 inch (c. 254 mm) diameter, with a six inch (c. 152 mm) liner installed to 80 ft (c. 24.3 m) below ground level (bgl). Mr. Ball concluded that the liner may have been used because of the presence of thick subsoil and/or unstable, soft/crumbling bedrock. The main water inflow during drilling was encountered around 130 ft (c. 39.6 m) and drilling then continued to 200 ft (c. 60.9 m).

The production borehole is 5 m from the exploration borehole. Based on observations during the site inspection and Mr. Ball's report, the borehole was drilled at 300 mm diameter and 200 mm PVC liner was installed. The depth of the 300 mm steel casing and the depth and the diameter of the uncased open hole section are not known.

Water is pumped from the borehole between 6 and 12 hours per day. The borehole pumps at 34 $m^3$/h, giving a maximum rate of 408 $m^3$/d. The water is pumped to a reservoir which has a capacity of 360 $m^3$. The caretaker indicated that the yield is reliable and that the borehole has never suffered from a shortage of water.

Table 4-1 provides a summary of the details as currently known.

**Table 4-1: Well Details**

| EU Reporting Code | IE_SH_G_055_13_013 |
|---|---|
| Grid ref. (GPS) | 170135, 126474 |
| Townland | Cush |
| Source type | Borehole |
| Drilled | 1993 |
| Owner | Limerick Co Co |
| Elevation (Ground Level) | ~ 163m OD |
| Depth | Unknown |
| Depth of casing | unknown- |
| Diameter | 200 mm |
| Depth to rock | Unknown |
| Static water level | 8.52 m bgl (December 2000)<br>16 m bgl (October 2000)<br>12 m bgl (November 1993) |
| Pumping water level | 15.55 m bgl (15/06/2010) |
| Consumption (Co. Co. records) | 34 $m^3$/h or 408 $m^3$/d |
| Pumping tests: undertaken by D. Ball 2000-2001 (Appendix 1)<br>(i) abstraction rates $m^3$/d | 1993: 72 hours pumping test at 1560 $m^3$/d<br>October 2000: 15 days pumping test at 816 $m^3$/d<br>December 2000-January 2001: 54.8 days pumping test between 1560 and 1634 $m^3$/d |
| (ii) specific capacity | Given the drawdown did not stabilize during pumping test, it is difficult to estimate the specific capacity.<br>The assumption is :<br>Approx 9.32 $m^3$/h/m or<br>Approx 165 $m^3$/d/m |
| (iii) transmissivity | 53 $m^2$/d |

Upon completion of the production borehole, a 72 hour pumping test was undertaken, although the full recovery was not measured. The assessment undertaken by Mr Ball included two pumping tests that were completed in 2000 and 2001. The pumping test details are discussed in Section 9.4 Aquifer Characteristics and details are also included in Appendix 1.

# 5 Topography, Surface Hydrology and Landuse

The borehole is on the north western foot slope of Slievereagh at approximately 163 mOD. The highest point in the locality is 1.5 km southeast of the borehole at 435 mOD. The topographical gradient on the upper catchment slopes is approximately 0.16, decreasing to 0.02 near the borehole.

The borehole is situated between two unnamed streams, one 450 m to the west and the other 50 m to the east. There is a spring identified on the Ordnance Survey map as a 'Holy Well', located 400 m to the northeast at approximately the same elevation as the borehole. The spring is the source for the Ballinvreena

Private Group Water Scheme. The streams and the overflow from the spring flows to the north ultimately join the Morningstar River approximately 1.8 km to the north of the site. The natural drainage density is moderate to high.

Land use in the area is dominated by forestry in the higher ground and by agriculture, primarily grassland dairy farming, in the Morningstar River valley to the north. There are no dwellings within 1 km of the borehole.

# 6 Hydrometeorology

Establishing groundwater source protection zones requires an understanding of general meteorological patterns across the area of interest. Meteorological information was obtained for this study from Met Eireann.

***Annual rainfall:*** 1157 mm. The contoured data map of rainfall in Ireland (Met Éireann website, data averaged from 1961–1990) shows that the source is close to the 1200 mm average annual rainfall isohyet.

***Annual evapotranspiration losses:*** 508 mm. Average potential evapotranspiration (P.E.) is estimated to be 535 mm/yr based on data from Met Éireann. Actual evapotranspiration (A.E.) is then estimated as 95% of P.E., to allow for seasonal soil moisture deficits.

***Annual Effective Rainfall:*** 675 mm. The annual average effective rainfall is calculated by subtracting actual evapotranspiration from rainfall. Potential recharge is therefore equivalent to this, or 675 mm/year.

# 7 Geology

## 7.1 Introduction

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

The desk study data used comprised the following:

- Geology of Tipperary and of East Cork-Waterford. Bedrock Geology 1 : 100,000 Map series, sheet 18 and 22 Geological Survey of Ireland (J.B. Archer, A.G. Sleeman and D. C. Smith, 1996 and A.G. Sleeman and B. McConnel, 1995).
- Forest Inventory and planning system – Integrated Forestry Information System (FIPS-IFS) Soils Parent Material Map, Teagasc (Meehan, 2002).
- Letter Report "Martinstown Water Scheme" (Mr. David Ball, 2001)
- Groundwater Vulnerability Map for County Limerick. Digital Map (Tobin Consulting Engineers on behalf of the Geological Survey of Ireland and Limerick County Council, 2010).

## 7.2 Bedrock Geology

The bedrock geology is illustrated in Figure 2. The boreholes are located along the northern end of a thrust fault zone. The site is underlain by the Devonian age Slievenamuck Conglomerate Rock Unit (conglomerate and purple sandstone). Undifferentiated Namurian rocks (shale and sandstone) are mapped approximately

30 m northwest of the borehole. Approximately 0.5 km to the north, the bedrock comprises Dinantian Upper Impure Limestone.

The thrust fault zone is the northern margin of a major collision and folding episode which occurred during the Hercynian mountain building event, resulting in older Devonian Old Red Sandstone and the underlying Silurian Shales being shoved up and over the younger limestone located in the valley to the north of the thrust. The borehole is in the thrust zone adjacent to the fault. Subsequent deformation events resulted in the rocks in this zone being pulled apart, opening up the previously compressed rocks, and creating a zone of enhanced permeability for water movement (D. Ball, 2001).

## 7.3 Soil and Subsoil Geology

The soil and subsoil are illustrated in Figures 3 and 4, respectively. The soil is classified as Acid Mineral Deep Poorly Drained (AminPD). At the borehole, the bedrock is overlain by Devonian Sandstone Tills (TDSs) derived from the underlying Devonian bedrock. East of the borehole, there are glacially deposited gravels which are derived from limestone (GLs). To the south of the borehole, in more elevated areas, the subsoils are thin or absent (Rck). To the north of the borehole there is Carboniferous Tills (TLs) above the Namurian bedrock.

Where the subsoil is present, the subsoil permeability is characterised as moderate permeability based on BS5930 field assessment approximately 50m to the south and 100m southeast of the borehole of subsoil samples and supported by field observations of well drained lands in the catchment.

## 7.4 Depth to Bedrock

There are no available depth to bedrock data. However, in the high ground above 190 m OD, the bedrock either outcrops or is close to the surface. On the lower ground (from 180 m OD to 120 m OD), the subsoil increases dramatically and may be as much as 24 m at the borehole where 24.4 m (c.80ft) of steel casing was driven, presumably to keep the borehole open above the bedrock during drilling. Based on the 2010 Limerick Vulnerability Map for this area, the depth to bedrock in the vicinity of the borehole, and in the Morning Star River Valley to the north, is >10 m. The depth to bedrock to the east of the borehole ranges from 5 to 10 m.

# 8 Groundwater Vulnerability

Groundwater vulnerability is dictated by the nature and thickness of the material overlying the uppermost groundwater ‘target’ in this case the top of the bedrock. This means that vulnerability relates to the permeability and thickness of the subsoil. A detailed description of the vulnerability categories can be found in the Groundwater Protection document (DELG/EPA/GSI, 1999) and in the draft GSI Guidelines for Assessment and Mapping of Groundwater Vulnerability to Contamination (Fitzsimons et al, 2003).

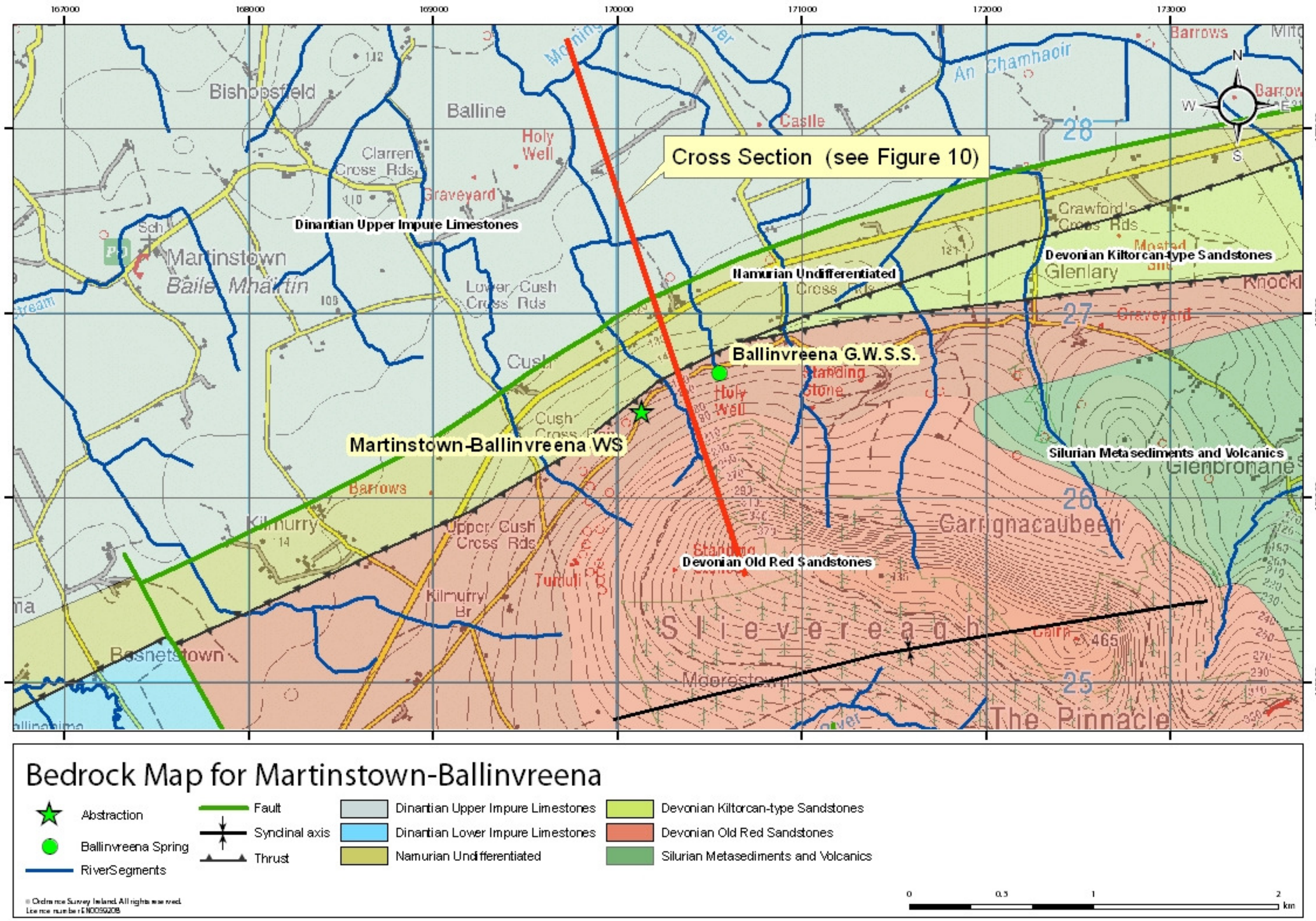


**Figure 2: Bedrock/Rock Unit Map**

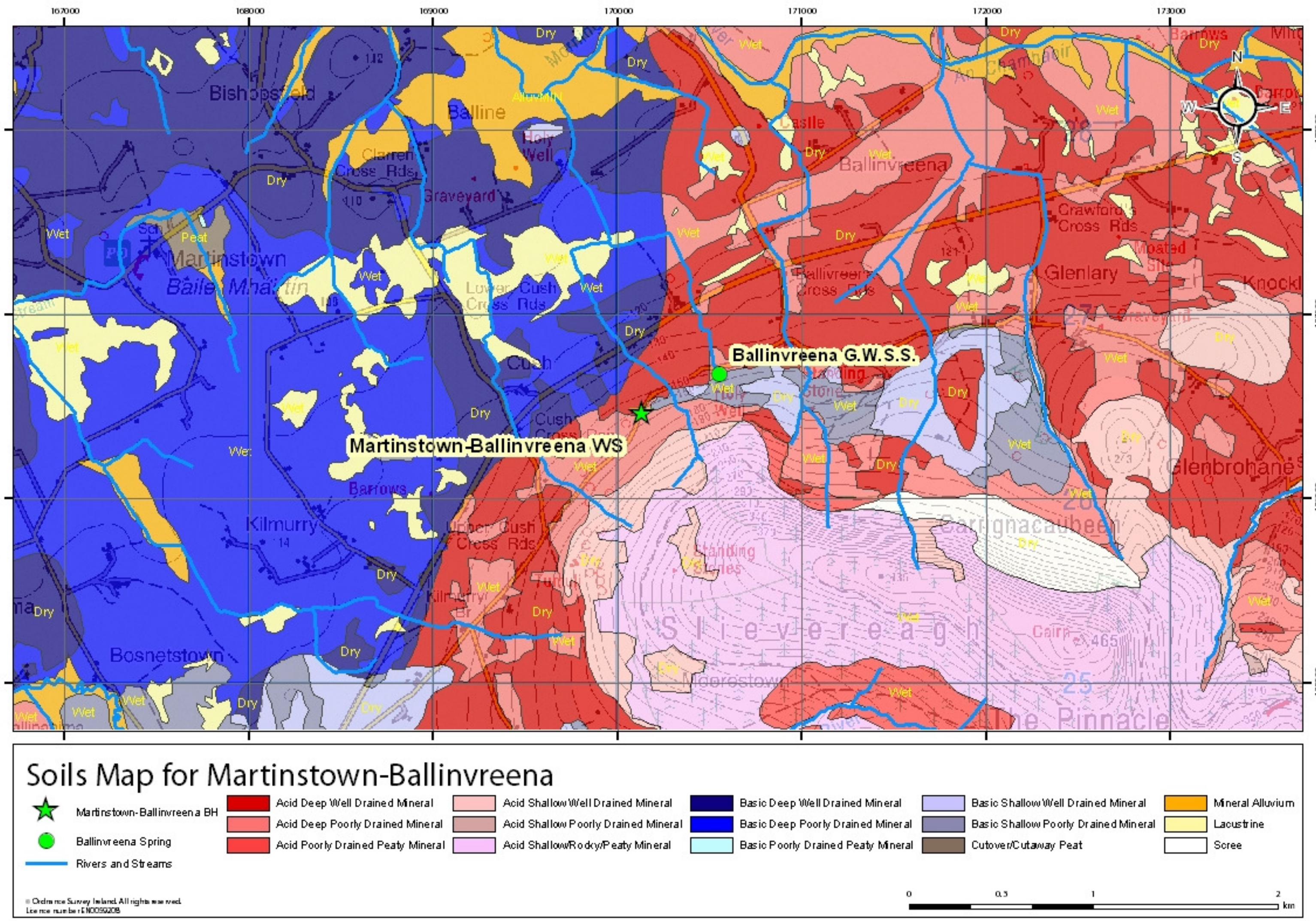


**Figure 3: Soils Map**

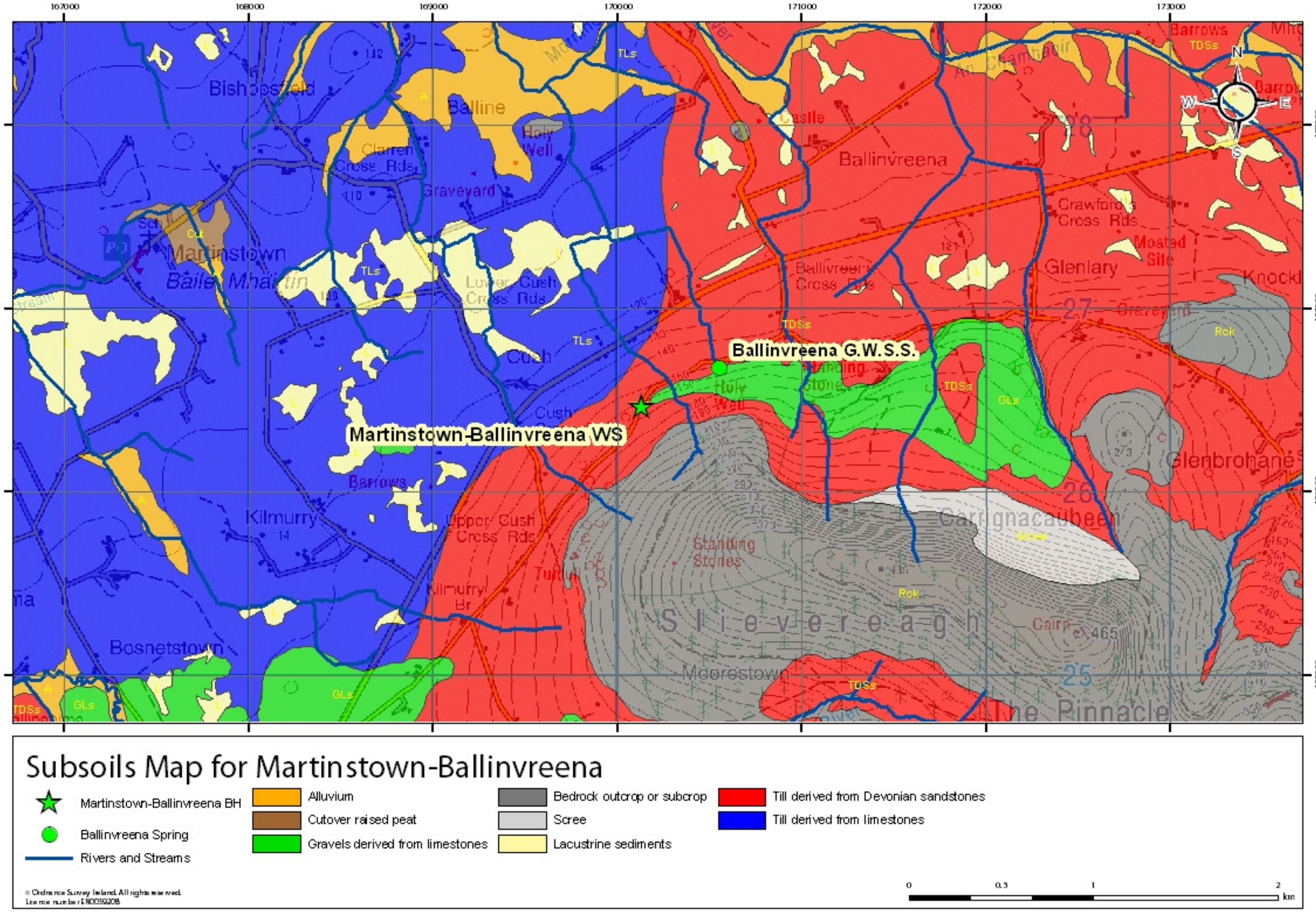


Figure 4: Subsoils Map

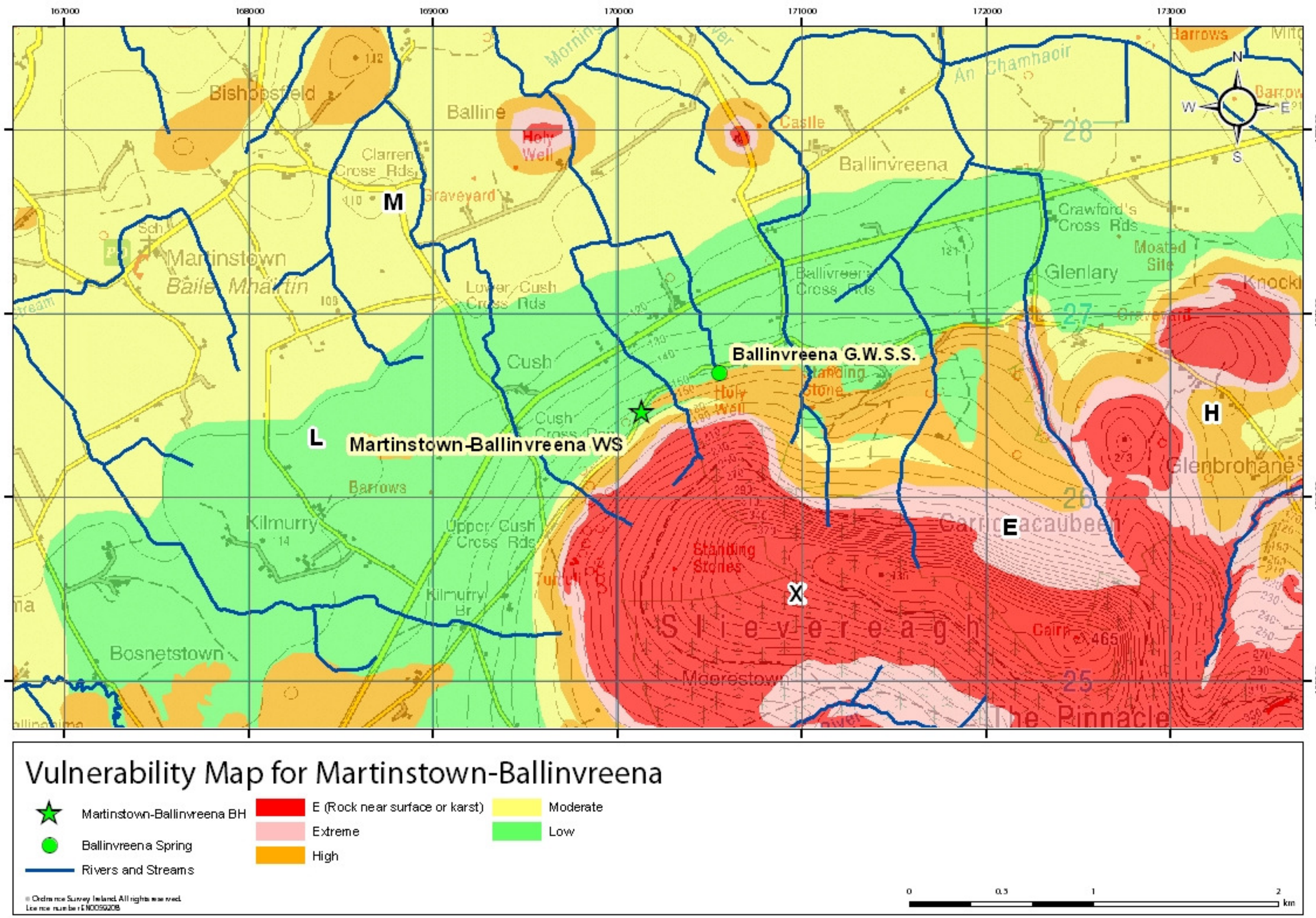


Figure 5: Vulnerability map

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

- Across the high ground to the south and southeast, situated between 180 m OD and 435 m OD, which represents the largest portion of the catchment of the borehole (around 70%), the subsoil is very thin or absent. Here, the vulnerability is classified as Extreme or Extreme with Rock near the surface.
- In the area of the footslope of the Slieveagh mountains, where the well is located, and in the valley between approximately 120 m OD and 180 m OD, the subsoil ranges in thickness from 5 m to 10 m. The vulnerability to the east of the borehole is classified as high while to the west and north of the borehole the vulnerability is classified as low.

# 9 Hydrogeology

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

- GSI Website and Database
- County Council Staff
- EPA website and Groundwater Monitoring database
- Local Authority Drinking Water returns
- Report "Yield testing of the Martinstown source borehole" (M. David Ball, 2001).

## 9.1 Groundwater Body and Status

The Martinstown Ballinvreena borehole is located within the Charleville Groundwater Body (IE_SH_G_055), which has been classified as being of Good Status. The groundwater body descriptions are available from the GSI website: www.gsi.ie and the 'status' is obtained from the Water Framework Directive website: www.wfdireland.ie/maps.html.

## 9.2 Groundwater Levels, Flow Directions and Gradients

Groundwater levels measured at the well are summarised in the Table 9-1.

**Table 9-1: Groundwater levels in the boreholes**

| Date | Static Water Level (m btc) | Pumping Water Level (m btc) | Comments |
|---|---|---|---|
| **1993** | 12 m below the top of the casing | | Prior to tests carried out in 1993 |
| | | 18.58 (but did not stabilize) | Pumping test was undertaken at c.66 $m^3$/hour for a period of 72 hours |
| | 13.52 | | recovering over a 20.6 hour period |

| | | | |
|---|---|---|---|
| **December 2000** | 8.52 | | Prior to the second pumping test |
| **June 2010** | | 15.95 | During the site visit |

Based on an assessment of the topography and surface water drainage, most groundwater infiltrates directly the bedrock to the south and southeast of the borehole and flows to the north-west towards Morningstar River. The topographic gradient in the vicinity of the borehole is steep, around 0.16. It is expected that the groundwater gradient is likely to reflect the topography, therefore a value of 0.16 has been assumed.

## 9.3 Hydrochemistry and Water Quality

The well has been included in the EPA operational chemical monitoring network since 1995. The raw water sample point is a tap located outside of the well head chamber. The laboratory results have been compared to the EU Drinking Water Council Directive 98/83/EC Maximum Admissible Concentrations (MAC) and where relevant mean values have been the European Communities Environmental Objectives (Groundwater) Regulations 2010 recently adopted in Ireland under (S.I. No. 9/2010) as part of the implementation of the Water Framework Directive 2000. The data are summarised and presented graphically in Figures 6 to 8 below.

The following key points have been identified from these data:

- The water has a moderately hard calcium bicarbonate hydrochemical signature (average 170 mg/l $CaCO^3$). The average conductivity is 340 μS/cm and pH is 6.9, which reflects the siliceous bedrock material.
- Faecal coliforms have not been detected and ammonium is below Threshold Level (0.175 mg/l).

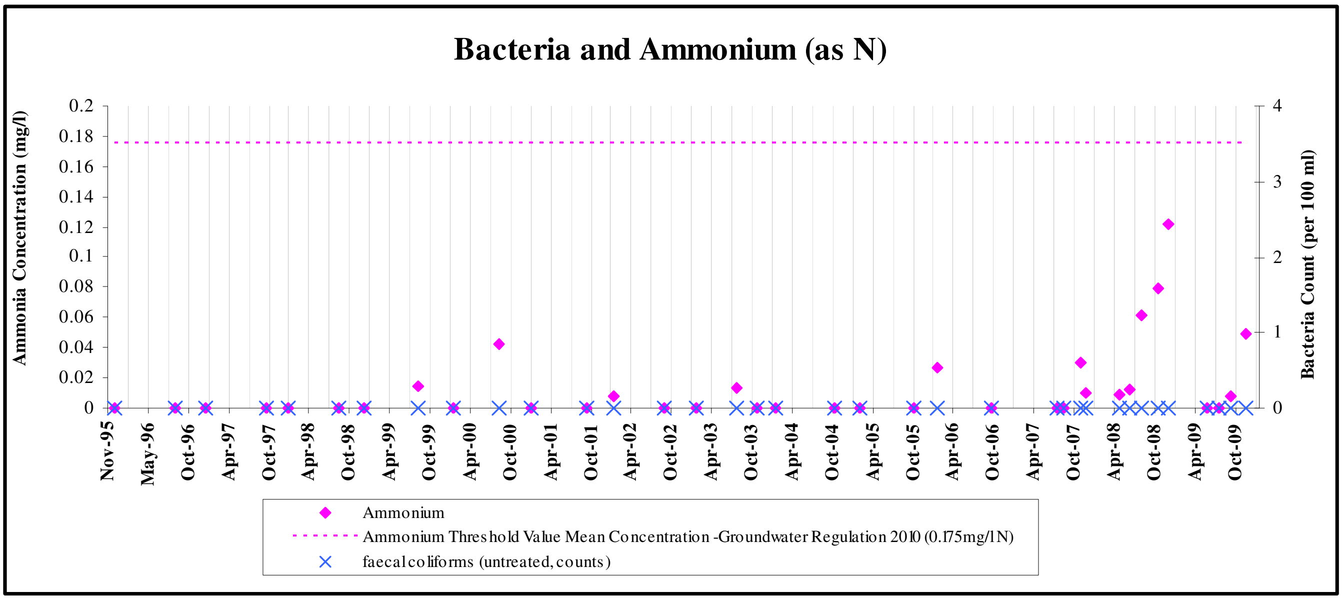


**Figure 6: Key indicators of agricultural and domestic contamination: bacteria and ammonium graph**

- The nitrate levels range from 1.0 mg/l to 5.1 mg/l, with a mean of 4.mg/l (as $NO_3$). The levels have not exceeded the EU Drinking Water Directive maximum admissible concentration (MAC) of 50 mg/l, or the Groundwater Regulations Threshold Value of 37.5 mg/l.
- Chloride can be a constituent of organic wastes and levels higher than the Threshold Value of 24 mg/l may indicate contamination, with levels higher than the MAC value 250 mg/l usually indicating significant contamination. Chloride concentrations range from 9.7 mg/l to 16 mg/l, with a mean of 12.9 mg/l which is below the Threshold Value.

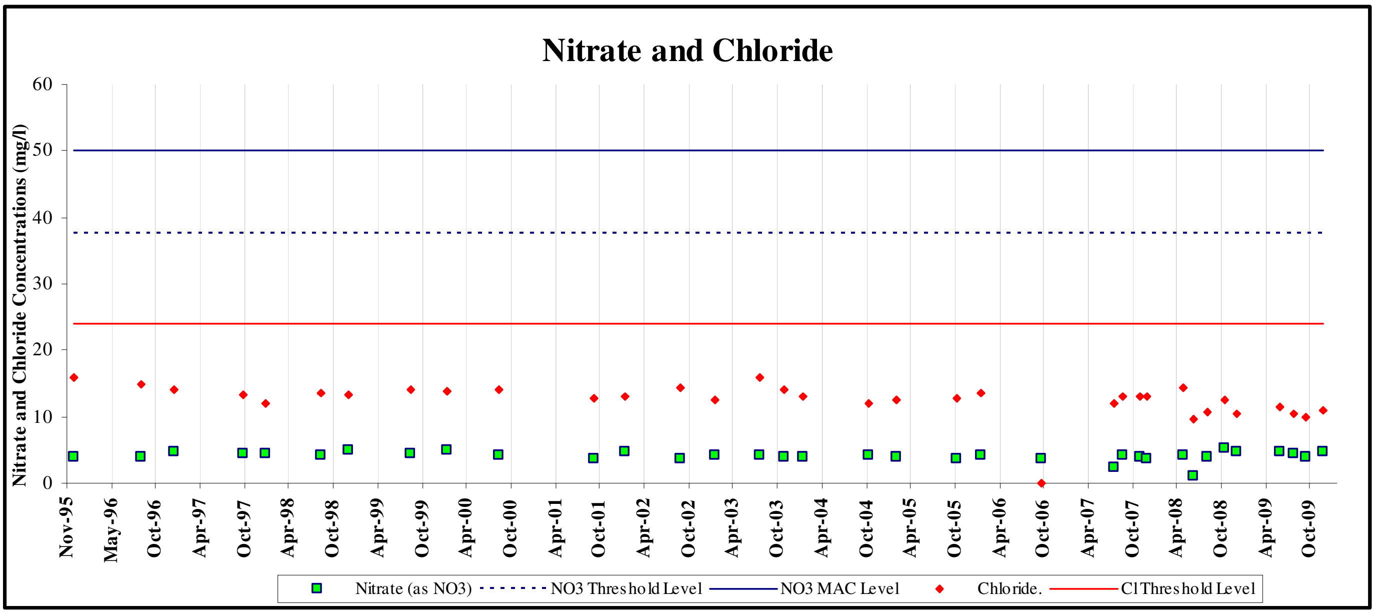


**Figure 7: Key indicators of agricultural and domestic contamination: Nitrate and Chloride graph**

- The concentration of sulphate, potassium, sodium, magnesium and calcium are within normal ranges. The potassium: sodium ratio has never exceeded the threshold of 0.35.

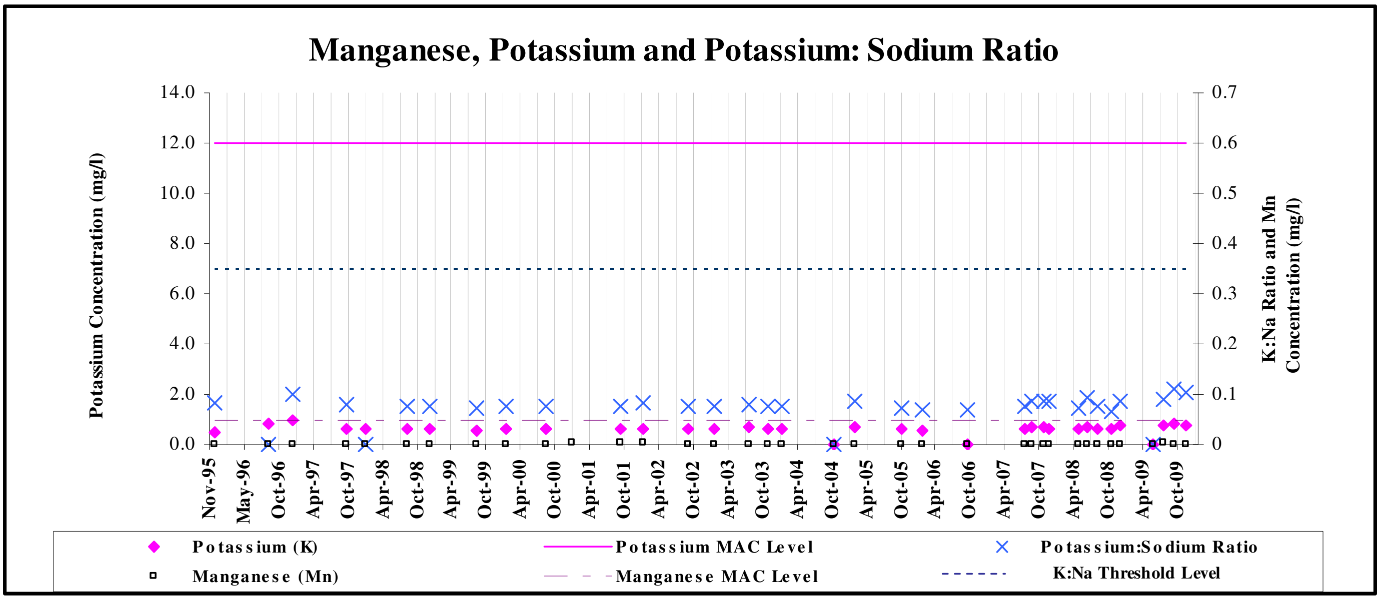


**Figure 8: Key indicators of agricultural and domestic contamination: Manganese, Potassium and K/Na ratio**

- The turbidity was above the MAC limit on three occasions, 25/6/2008, 30/10/2008 and 16/12/2008 at levels of 1.9, 2.8 and 1.6 NTU, respectively. This is likely due to the presence of very fine clay particles.
- The concentrations of iron and manganese are within normal ranges for groundwater.
- Trace metals were within either within the normal range for good quality drinking water or were not detected. Similarly organic compounds and herbicides have not been detected.

In summary, the water quality is generally good, which is likely to be a function of the aquifer vulnerability and the limited pressures in the zone of contribution to the well.

Water quality data were also obtained for the Ballinvreena Spring Group Water Supply Scheme. These are included in Appendix 2. While generally the water quality is similar to the Martinstown Well, higher nitrate levels (12–18mg/l NO3) have been recorded. This may be indicative of a higher direct contribution from shallow groundwater, which is more likely to reflect the limited agricultural activity in the spring catchment.

Land use up hydraulic gradient of the supply is dominated by forestry, where typically pesticides are used to control weed growth. In 1997, monitoring for pesticides was undertaken, but none were detected. However additional data are required to establish if there is any impact associated with their use in the catchment.

Field chemistry monitoring was undertaken in the stream located 150 m east of the well, and at the Ballinvreena Spring located 450 m to the east (Table 8-2). The results show as expected that the spring and groundwater well have a similar hydrochemical signature. The lower conductivity and pH in the stream is due to the short residence time of surface run-off from the higher ground around Slievereagh to the south.

**Table 9-2: Groundwater and surface water quality**

| | BH1 | Ballinvreena Spring | Unnamed Stream (was almost dry) |
|---|---|---|---|
| **Location** | On site | 450 m to the east | 150 m to the east |
| **pH** | Ave 6.9<br>Range: 6.5-7.9 | Ave 6.8<br>Range: 6.5-7.1 | 4.5 |
| **Conductivity (µS/cm)** | Ave 340<br>Range: 253-407 | Ave 291<br>Range: 251-329 | 50 |

## 9.4 Aquifer Characteristics

The available data indicate that the borehole abstracts water from several different water bearing zones. Groundwater most likely flows northwards from the Devonian Old Red Sandstones up hydraulic gradient. Water reaches the well from the heavily weathered and fractured Thrust Zone immediately beneath and to the east and west of the compund. .Both the Devonian Sandstone and Namurian Shales are classified as a Locally Important aquifer which is moderately productive only in Local Zones (Ll) as indicated in Figure 9. The sustainable yield from the borehole is 408 $m^3$/d. Normally these aquifers sustain much lower volumes (c<100$m^3$/d) than that from this borehole, unless a well is situated along a major fault or fracture zone. It is likely therefore that the high yield derives substantially from the Thrust Zone, which comprises a mix of rock types that have been broken up into a rubble zone along the thrust with high secondary porosity and permeability. During the long term pumping tests undertaken in 1993 and 2000-2001 the drawdown did not stabilize. This indicates that the fractures network may be of limited extent along the thrust zone.

The aquifer(s) beneath the borehole are considered to be unconfined, though a small portion of flow may derive from the Namurian shales at depth, which are likely to be confined beneath the sandstone and the thrust zone.

A pumping test was undertaken from October 9th – 12th 1990 using a 4 inch pump set at 150 ft below the top of the casing (c.46 mbgl). The starting water level was 50 ft bgl (c.15 mbgl) and the water level did not fall during the test. A yield of 2000 gallons per hour (c.9 $m^3$/hr) was sustained for the duration of the test. Based on the outcome of the test a Production borehole was drilled in 1993.

Upon completion of the production borehole, a 72 hour pumping test was undertaken, although the full recovery was not measured. The constant pumping rate was 65 $m^3$/h, or 1560 $m^3$/d. The water level dropped from 12.0 mbgl to 18.58 mbgl over the duration of the test. It did not stabilize and was still falling at the end of the test. In the next 1240 minutes (20.6 hours), the water recovered to 13.52 m bgl.

The assessment undertaken by Mr Ball included two pumping tests that were completed in 2000 and 2001. The purpose of the testing was to determine if increased pumping rates to allow the expansion of the water supply scheme was sustainable. During the first test, lasting 15 days, the pumping rate was 34 $m^3$/h (816 $m^3$/d). The water level did not stabilize and decreased significantly after 1000 minutes.

A second, longer, test was undertaken using a higher capacity pump, at 68 $m^3$/h (1608 $m^3$/d). Mr. Ball concluded that while the borehole was high yielding, expansion of the scheme should only occur in small increments and should include monitoring to ensure sustainability with increased pumping rates. He also concluded that the pumping rate of 68 $m^3$/hour was not sustainable long term.

The Cooper-Jacob approximation was used to calculate the transmissivity based on the data from the pumping test completed in January 2001. Given the drawdown is < 0.3 of the thickness of the aquifer, the CE Jacob Formula can be applied for unconfined conditions:

$$\text{Transmissivity (T)} = 0.183Q / \Delta s$$

Where Q=discharge and ΔS= change in the drawdown over 1 log cycle.

The calculated transmissivity value is around 53 $m^2$/d and is based on a very long duration pumping test (53 days). The transmissivity range described by GSI for this area of the GWB is 40-100 $m^2$/d, which is consistent with the calculated transmissivity at this borehole.

The Ballinvreena Group Water Scheme, which is a spring source, is located 450 m east of the borehole. The spring is also in the Thrust Fault Zone and is the most likely natural discharge point for water entering the fault zone from the Devonian Sandstone on the high ground to the south.

Bedrock permeability for an LI aquifer is expected to be low to moderate. The permeability is highest in the upper few metres, but generally decreases rapidly with depth. The permeability can be calculated by dividing the transmissivity by the saturated thickness of the aquifer. Given the lack of information on the production borehole (e.g. a borehole or well construction log), the saturated thickness of the aquifer has been assumed as the depth of the main water strike encountered in the exploration borehole i.e. around 130 ft (c.40 m) as very little flow is expected beneath this depth in the Namurian Shale. Therefore the bulk permeability (K) is estimated as follows:

**Table 9-3: Permeability range for BH1 and BH2**

| | Local Assumption |
|---|---|
| **Transmissivity ($m^2$/d)** | 53 |
| **Aquifer Thickness (m)** | 40 |
| **Permeability (m/d)** | 1.3 |

The permeability for the aquifer is 1.3 m/d, which is calculated by dividing transmissivity by the assumed aquifer thickness. However, this permeability is an average and it is likely that the groundwater velocity will be significantly higher in fault zone.

The velocity of water moving through this aquifer to the borehole was estimated using Darcy's Law:

Velocity (V) = (K x Groundwater Gradient(i)) / porosity (n)

The natural gradient is estimated at 0.16 (described in section 9.2). The typical effective porosity (n) range for Old Red Sandstones (ORS) in Ireland, based on previous source protection zone reports, is 1–5%, with an average of 2.5%. It is likely that the porosity along the Thrust Zone is much higher than in the ORS to the south. As this Zone is a major contributor to the groundwater entering the borehole, a higher effective porosity value of 3% has been selected.

**Table 9-4: Velocity range**

| | **Velocity (m/d)** |
|---|---|
| **Local Minimum Effective Porosity (3%)**<br>**Local K Assumption (1.3 m/d)** | 7 |

The velocity is estimated to be 7 m/d. The aquifer parameters are summarized in Table 8–6.

**Table 9-5: Indicative parameters for the thrust zone and Old Red Sandstone**

| **Parameters** | **Source of Data** | **BH1** |
|---|---|---|
| **Transmissivity ($m^2$/d)** | Estimated from pumping test data | 53 $m^2$/d |
| **Permeability (m/d)** | Estimated from T value and the depth to the inflow zone | 1.3 m/d |
| **Effective Porosity** | Assumed (based on other ORS sources) | 3% |
| **Groundwater gradient** | Estimated based on topography | 0.16 |
| **Velocity (m/d)** | Assumed (calculated based on above) | 7 m/d |

# 10 Zone Of Contribution

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

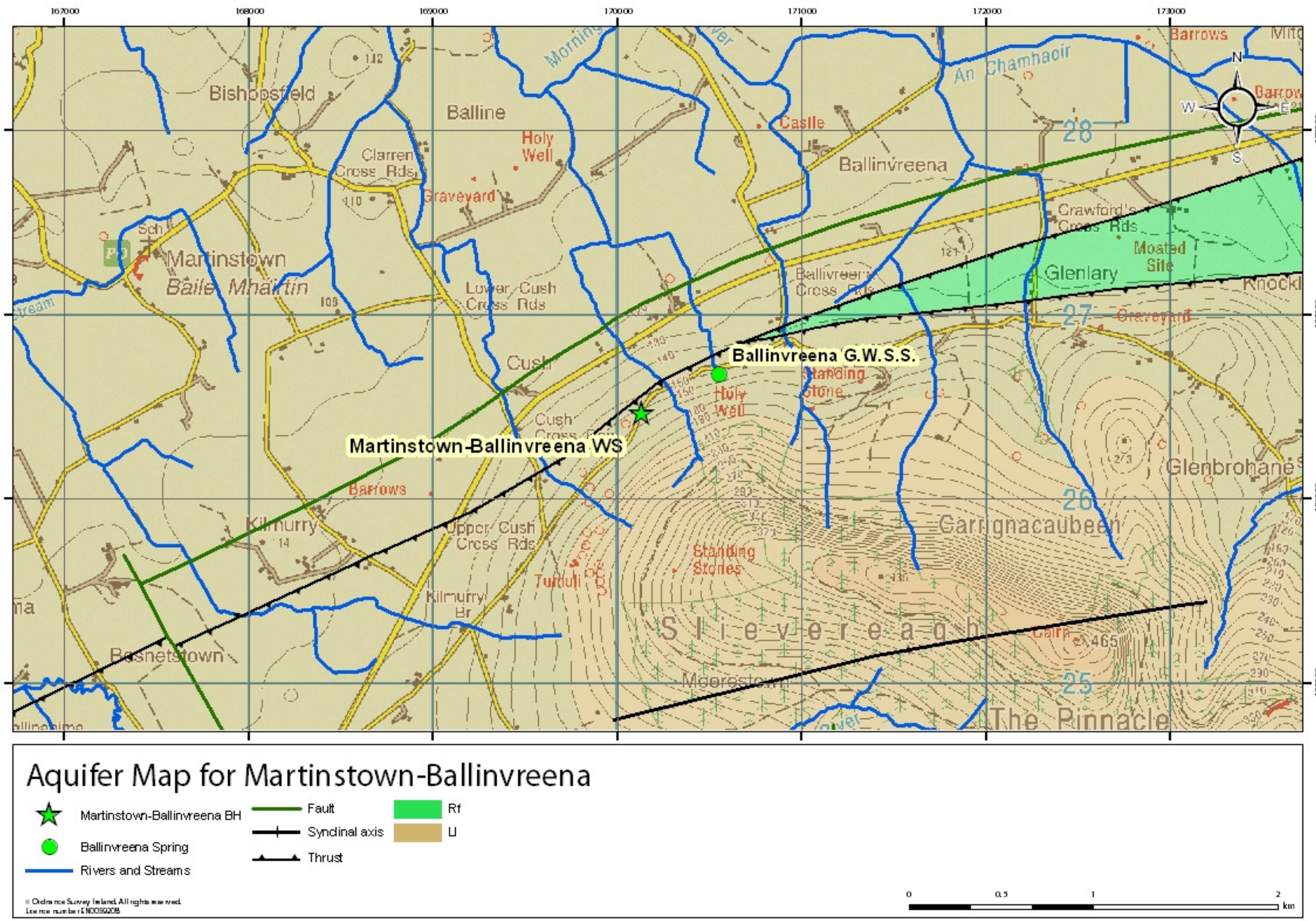


**Figure 9: Aquifer map**

## 10.1 Conceptual Model

The Martinstown Public Water Supply Scheme consists of a single borehole, which abstracts an average of 408 $m^3$/d, largely from a Thrust Fault Zone at approximately 40 m depth in the well. The zone extends laterally to the east and west of the borehole and is also likely to be supplying the nearby Ballinvreena Group Water Scheme Spring Supply. The thrust fault zone is recharged by groundwater which infiltrates directly to the bedrock to the south and southeast of the borehole and which flows to a northerly direction, down slope from the high ground along Slievereagh into the thrust fault zone. The extent of groundwater flow to the well along the thrust fault zone is likely to be controlled by topography. Water is unlikely to reach the well for elevations along the thrust fault lower than the pumping level of the well. This assumption has been used below to define the extent of the ZOC. The rocks in this area comprise the Old Red Sandstones which are classified as a Locally Important aquifer which is moderately productive only in Local Zones (Ll). The majority of the ZOC is mapped as extreme vulnerability, although there is some low vulnerability in the vicinity of the source and overlying the thrust fault. The water quality of the supply is however, good, which may in part reflect the low pollution pressures in the area. A schematic representation of the conceptual model is shown in Figure 10. This model is an adaptation of one initially developed by Mr. Ball as part of his assessment of the water supply in 2001.

## 10.2 Boundaries of the ZOC

The boundaries of the area contributing to the source are illustrated on Figure 11. The boundaries, along with associated uncertainties and limitations are based on interpretations of the available data, field observations and advice from David Ball as follows. As indicated above flow to the well along the thrust fault is considered to be topographically controlled. The average drawdown in the well is approximately 15 m bgl. During the long term pumping test undertaken in 2000-2001 the drawdown, pumping at twice the current pumping rate, was 19 m bgl. While the drawdown did not stabilize given that the pumping rate was twice the normal pumping rate the pump test drawdown has been used in this assessment to determine how far along the thrust zone that water can flow to the well. Ground level at the well is 163 mOD. Assuming a drawdown of 19 m, water in the thrust zone below 144 mOD is unlikely to reach the well.

**The Northern Downgradient** boundary is defined by the contact between the Thrust Fault and the Namurian Shales to the north of the well, which are considered to inhibit groundwater flow to the north causing groundwater preferentially to discharge via the Ballinvreena Spring.

As outlined above **the Western and Eastern Boundaries** are defined by the distance along the thrust fault that water is likely to reach the well.

**The Southern Boundary** is based on conceptualised groundwater flow-lines, which are themselves defined by the topography of the area.

## 10.3 Recharge and Water Balance

The term ‘recharge’ refers to the amount of water replenishing the groundwater flow system. The recharge rate is generally estimated on an annual basis, and assumed to consist of input (i.e. annual rainfall), less water loss prior to entry into the groundwater system (i.e. annual evapotranspiration and runoff). The estimation of a realistic recharge rate is important in source protection delineation, as it will dictate the size of the ZOC to the source (and therefore the outer Source Protection Area).

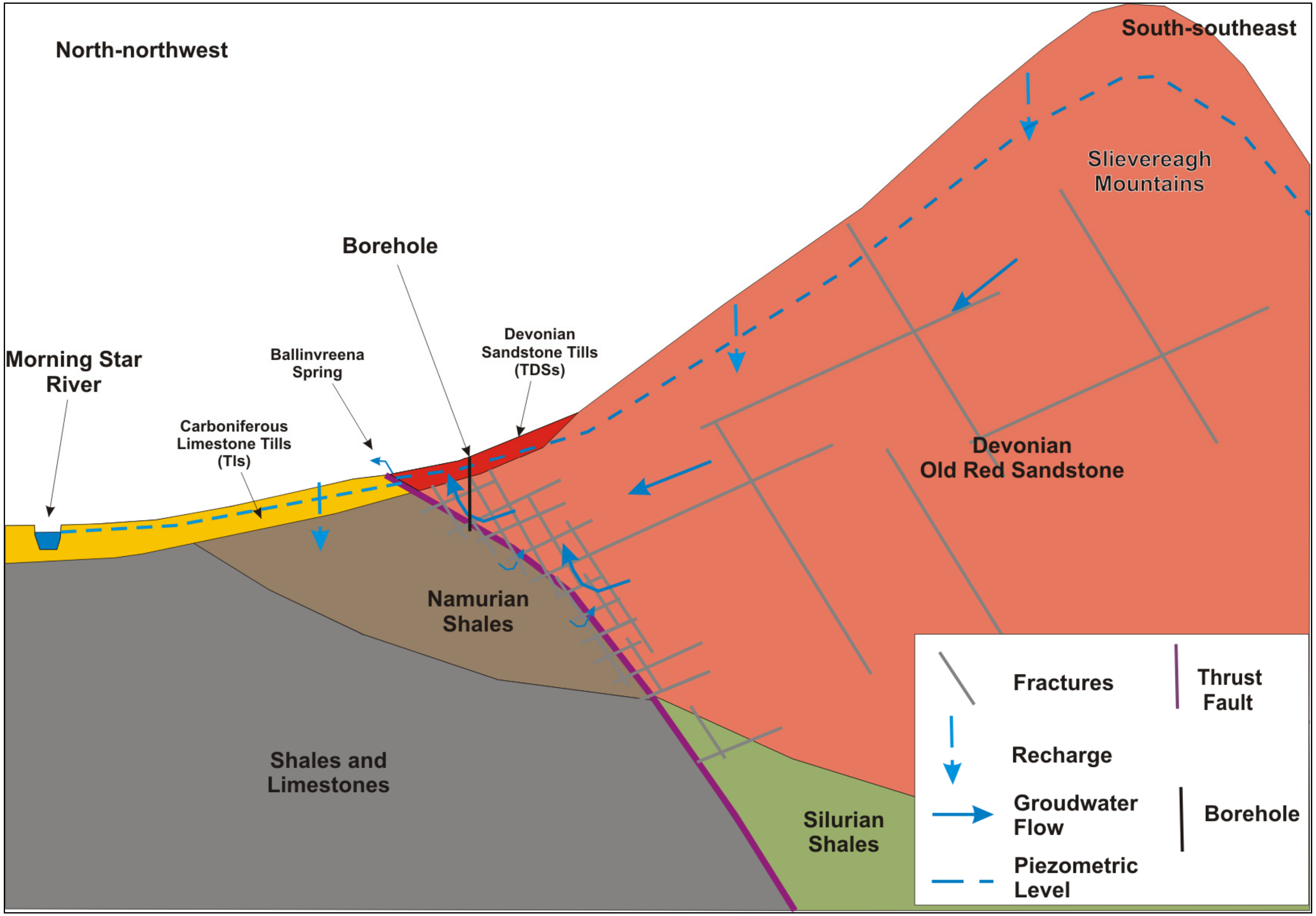


**Figure 10: Conceptual Model (after D. Ball, 2001)**

At Martinstown, the main parameters involved in recharge rate estimation are: annual rainfall; annual evapotranspiration and a recharge coefficient. The recharge is estimated as follows.

**Potential recharge:** equivalent to 649 mm/year i.e. (Annual Effective Rainfall as outlined in Section 6.

**Recharge Cap:** 200 mm/yr. The Slievenamuck Conglomerate Formation (conglomerate and purple sandstone) from the Devonian ORS is classified as a moderately productive only in Local zones (Ll). Applying the aquifer cap (GWG 2008), the recharge is estimated to be 200 mm/yr. The recharge cap is applicable, as across the majority of the catchment of the borehole (around 70%) the bedrock outcrops or is overlain by thin subsoil. The bulk recharge coefficient for the area is estimated to be 31%.

**Runoff losses**: 449 mm. Runoff losses are assumed to be 69% of potential recharge.

These calculations are summarised as follows:

| | |
|---|---|
| Average annual rainfall (R) | 1157 mm |
| Estimated P.E. | 508 mm |
| Estimated A.E. (95% of P.E.) | 535 mm |
| Effective rainfall | 649 mm |
| Potential recharge | 649 mm |
| Recharge cap | 200 mm |
| Run off losses | 449 mm |
| Runoff losses | 69% |
| Bulk recharge coefficient | 31% |
| **Assumed Recharge** | **200 mm** |

The water balance calculations indicate that at a recharge of 200 mm/yr, an average discharge of 408 $m^3$/day would require a recharge area of 0.74 $km^2$.

The ZOC to the source shown in Figure 11 is slightly larger (0.82 $km^2$) than that required to supply the abstraction, because the groundwater comes primarily from a long linear Thrust Fault that collects water from a large catchment area. Locally, the discharge point for the Thrust Zone is the Ballinvreena Spring, located 400 m to the east of the Martinstown well.

To allow for daily variations in abstraction and to allow for expansion of ZOC during dry weather periods, the GSI usually increases the ZOC by a factor of safety of 50%. However, in this case it would be unrealistic in terms of the hydrogeological limitations of the boreholes and the topography of the catchment.

## 11 Source Protection Zones

The Source Protection Zones are a landuse planning tool which enable an objective, geoscientific assessment of the risk to groundwater to be made. The zones are based on an amalgamation of the source protection areas and the aquifer vulnerability. The source protection areas represent the horizontal groundwater pathway to the source, while the vulnerability reflects the vertical pathway. Two source protection areas have been delineated, the Inner Protection Area and the Outer Protection Area.

The Inner Protection Area (SI) is designed to protect the source from microbial and viral contamination and it is based on the 100-day time of travel to the supply (DELG/EPA/GSI 1999). Based on the indicative aquifer parameters presented in Section 9.4, the groundwater velocity in the Old Red Sandstone up gradient of the source is 7 m/d, and hence the 100-day time of travel distance in that direction is 700 m. This relatively large distance is a function of the steep topography and the inferred hydraulic gradient to the south of the borehole. The Inner Protection Area is illustrated in Figure 12.

The Outer Protection Area (SO) encompasses the entire zone of contribution to the source.

The groundwater Source Protection Zones (SPZs) are shown in Figure 13 and are listed in Table 11-1. The SPZs include SI/X, SI/E, SI/H, SI/M and SI/L. The majority of the area is designated SO/L.

**Table 11-1 Source Protection Zones**

| **Source Protection Zone** | | **% of total area ($km^2$)** |
|---|---|---|
| SI/X | Inner Source Protection area / ≤1 m subsoil | 40.24% (0.330 $km^2$) |
| SI/E | Inner Source Protection area / <3 m subsoil | 4.88% (0.040 $km^2$) |
| SI/H | Inner Source Protection area / High vulnerability | 13.41% (0.110 $km^2$) |
| SI/M | Inner Source Protection area / Moderate vulnerability | 6.10% (0.050 $km^2$) |
| SI/L | Inner Source Protection area / Low vulnerability | 24.39% (0.200 $km^2$) |
| SO/X | Outer Source Protection area / ≤1 m subsoil | 10.98%(0.820 $km^2$) |

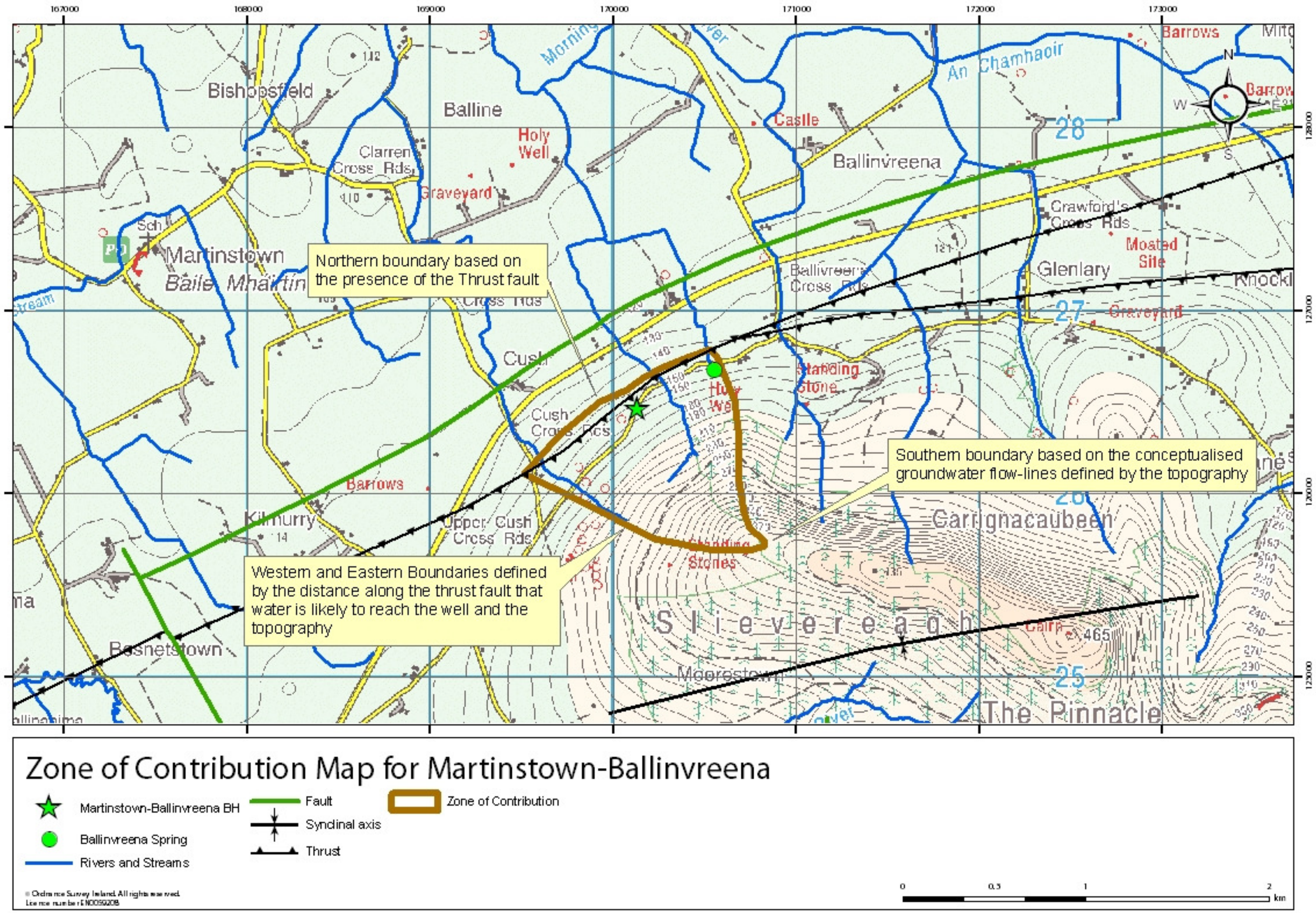


**Figure 11: Zones of Contribution**

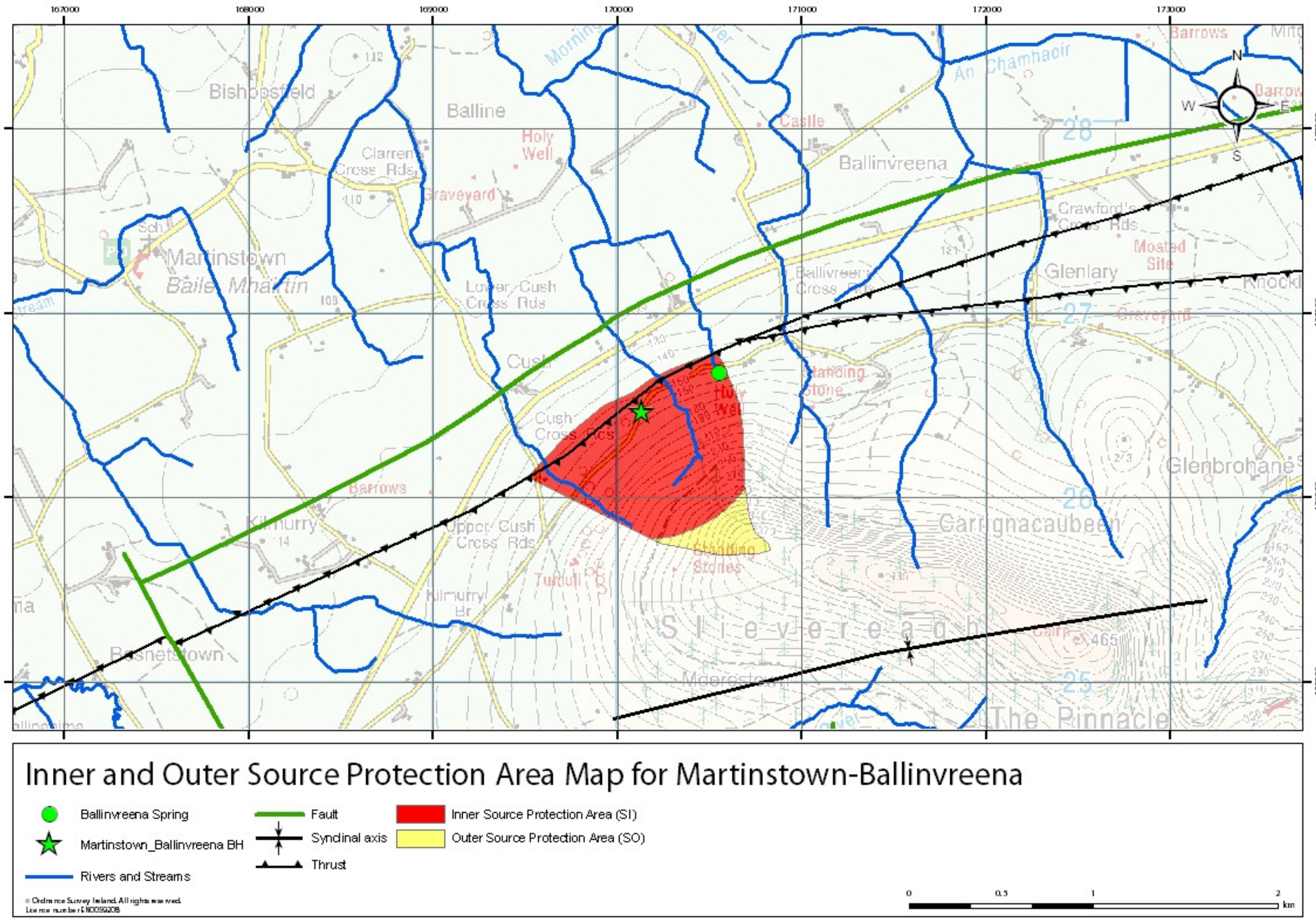


**Figure 12 Inner and Outer Source Protection Areas**

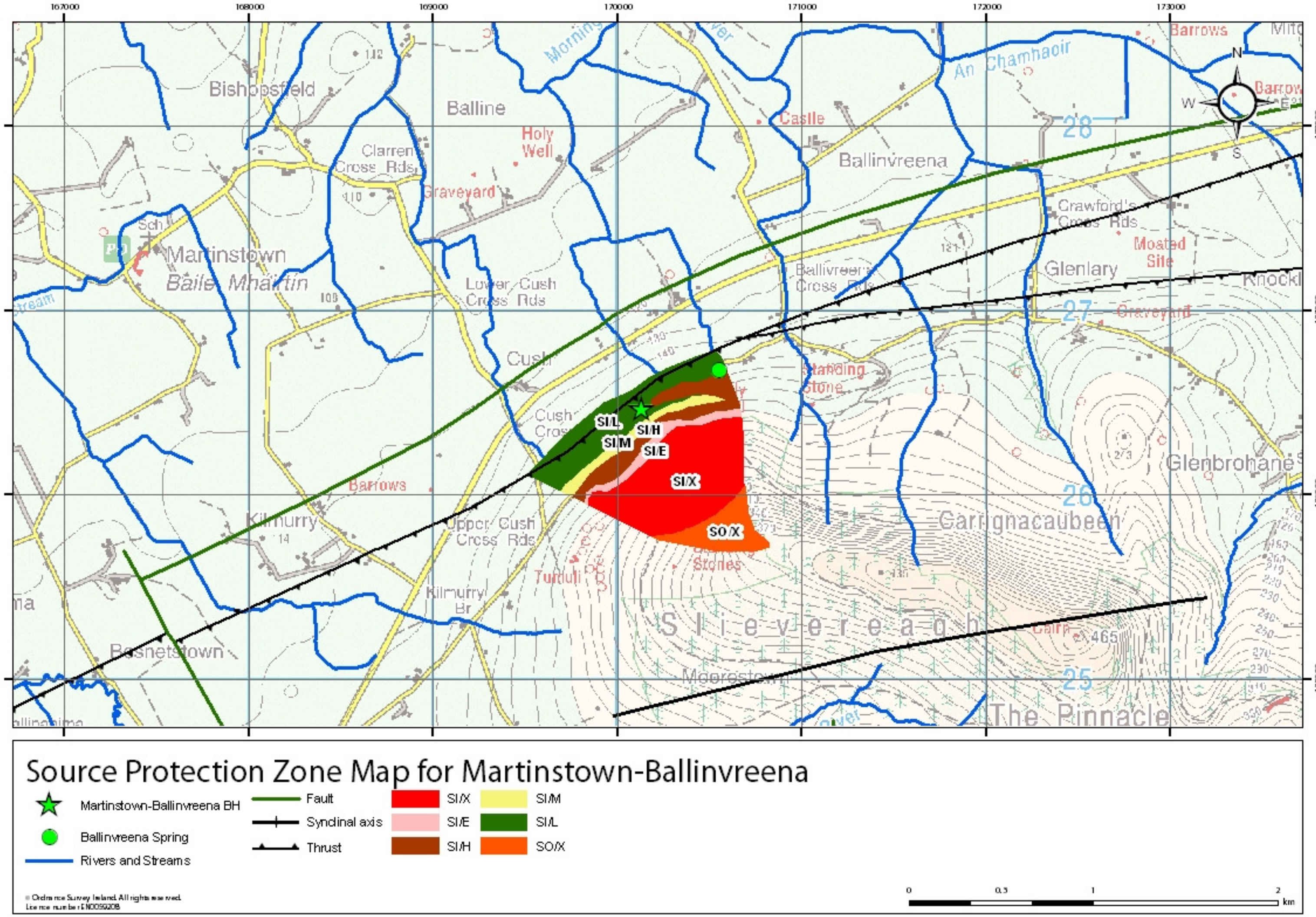


**Figure 13 Source Protection Zones**

# 12 Potential Pollution Sources

The well head is in a concrete block manhole chamber (c2 m by 0.8 m) fitted with two large, lockable, steel covers. The internal chamber walls are not rendered. It appears that surface run-off or shallow subsurface flows could enter the chamber, although the steel casing rises 0.40 m above the bottom of the chamber. The borehole is not capped and there no details (e.g. a borehole or well construction log) to establish whether or not it is adequately sealed to prevent shallow subsurface inflow or to determine the precise depths of inflow to the well. However, given the protection of the boreholes and their location, the potential risk for contamination as a result of surface spills in the vicinity of the well head is low.

The land within the SI is primarily forestry and scrub land, with small areas of pasture (Photograph 4).


**Photo 4: Land within the SI**

A public third class road runs from west to east, approximately 10 m down-gradient of the production well. The road is approximately 1m lower than the well compound, therefore there is no potential risk of a diesel or petrol spill from the road directly entering the well head.

The land use in the SO is dominated by forestry, and pasture used for grazing cattle, sheep and horses. There are no dwellings or farms up hydraulic gradient of the compound. The highest risk of pollution in the outer protection zone is most likely to originate from the use of pesticides to control weed growth in the forestry although there is no evidence of this in the water quality at the well at present. Given the current landuse within the outer zone, the potential risk for contamination is low.

# 13 Conclusions

The Martinstown GWS comprises a single borehole, situated in a compound adjacent to the public road in the townland of Cush. Water is pumped from the well between 6-12 hours per day at a reliable rate of 34 $m^3$/h, giving a maximum daily abstraction rate of 408 $m^3$/d. Yield tests carried out by David Ball suggest that the sustainable yield is of the order of 545 $m^3$/d.

The borehole is supplied by a major Thrust Fault at depth which also supplies the Ballinvreena Group Water Scheme Spring, located 400 m to the east of the Martinstown well. The fault is recharged by groundwater flowing northwards down slope through the Old Red Sandstones on Slievereagh. The ZOC to the source is slightly larger than that required to supply the abstraction, because the fault collects water from a large catchment area. The groundwater vulnerability over much of the ZOC is Extreme, however near the well and the overlying the thrust fault, the vulnerability is low. The water quality is good, reflecting the low pollution pressures present within the ZOC. However, pesticide monitoring has only been conducted once (January 1997) and more frequent monitoring should be considered to determine the impact from the likely application of pesticides in the large areas of forestry in the ZOC.

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

# 14 Recommendations

It is recommended that the water quality monitoring programme be amended to include pesticides on an annual basis.

# 15 References

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# APPENDIX 1

**Report “Yield testing of the Martinstown source borehole”**

**(M. David Ball, 2001)**

David M. Ball
Hydrogeologist
Emmet Bridge House
38 Upper Clanbrassil Street
Dublin 8, Ireland

**telephone**:- Ø353-Ø1-4530-310/-320/-330
**fax**: Ø353-Ø1-4530331
**email**:- davidbal@indigo.ie

James O'Callaghan
Kilmallock Area Office
Limerick County Council
Kilmallock
Co. Limerick

9th April 2001

**re: Martinstown Water Scheme - Cush Townland, Co. Limerick**

Dear James,

The following is my report on the yield testing of the Martinstown source Borehole. Some of the information on the history of the source is given for the record

**1. Introduction**

The borehole was drilled in 1993 for the Martinstown Group Water Scheme. It was a production borehole based upon the results of an exploration borehole 5 metres away drilled in 1990. The County Council took over the Martinstown scheme in 1999. The exploration borehole and the production borehole both indicated that groundwater resources at the site were copious. The Martinstown Group Water Scheme committee had availed of assistance from the County Council and had constructed and managed an exemplary rural water supply project. In late 1999 adjacent water schemes requested a connection to the Martinstown Group Water Scheme because they needed more water and there appeared to be a surplus capacity in the Martinstown source. The original testing of the exploration borehole and the production borehole had been carried out in 1990 and 1993. The testing was not exhaustive because it was clear from these preliminary results that there was more than sufficient water to meet the needs of just the Martinstown Group Water Scheme. The testing was therefore appropriate for, at that time, the expected demand.

General experience of water supplies in Limerick, and elsewhere, since 1993 has shown that simple tests carried out just after a borehole has been drilled have often given results that are misleadingly optimistic. In 1993, and still to this day, there was a belief that if a source will sustain a certain yield for 72 hours that this yield can be sustained for evermore. A 72 hour test had become a standard, whereas originally it was promulgated as a guide, to encourage people to do more than just test a hole for one or two hours. 72 hours for a pump test is really an arbitrary compromise. Some boreholes, in say a very extensive permeable gravel aquifer, may reach equilibrium in less than 12 hours and therefore a 24 hour test may be sufficient and appropriate. Other boreholes tapping a bedrock containing two productive fractures, may appear to sustain a certain yield for 72 hours, but during subsequent extensive operation, as a production borehole, fail to sustain the yield, because one upper fracture becomes dewatered, as the drawdown extends outwards through the aquifer. Sometimes the final sustainable yield turns out to be just 20% of the yield sustained during the 72 hour test. If the drilling and construction of the borehole was supervised and directed by a hydrogeologist, it is probable that the position and relative yield of the different fractures would be noted. The hydrogeologist running the subsequent pump test would probably extend the test if drawdown was still continuing at 72 hours, and if there was a chance that a major fracture could become dewatered. Unfortunately, for the Martinstown Group Water Scheme, neither the exploration borehole, nor the production borehole, were supervised or tested by a hydrogeologist. There are only partial records of the design of the holes, and no information on the geology encountered during drilling. In 2000 with the benefit of experience, it was realised that it would not be wise or prudent to make a decision based on the partial information obtained in 1993. It was decided to re-test the borehole at the end of the summer, or early autumn, in 2000 when the water table would be at its lowest.

The principal objective of the tests was to determine the long term sustainable yield before making a decision on whether the source could provide a supply for an extended scheme. A Secondary objective was to try to assess whether intensive pumping would be likely to have an impact on the adjacent Ballinvreena water supply source, which is a spring.

## 2. Background Information

The following is the available background information on the two boreholes drilled for the Martinstown Group Water Scheme.

Exploration Borehole

Drilled in August 1990 by John Dunne of Mallow. Hole Depth 200 feet. Drilled at probably 10inch diameter and a 6inch steel liner or casing was installed to 80 feet below ground. The installation of a liner sometimes indicates that the driller was concerned about the stability of the hole to this depth. This could have been because the overburden was thick and unstable or because the bedrock was soft and crumbly. There is no record of why 80 feet of liner were installed. This information would have been very useful. Apparently the main yield of water was obtained in the bedrock at a depth of 130 feet. The drilling continued to 200 feet which suggests that the inflow of water at 130 feet was not excessive and did not swamp the Down-the-hole-hammer used to drill the hole. The borehole was tested from the 9th to the 12th of October 1990 with a 4 inch pump yielding 2,000 gph set at a depth of 150 feet. Apparently the initial water level was 50 feet below ground level and the water level did not fall during the test. There are good meter readings of the volume pumped but there are no records of direct measurements of the water levels. It appears that a pressurised airline was used to monitor whether the water level changed. It appears to have changed falling from 40 to 33 psi and then somehow rising again to 40 psi in the last 3 hours of the test.

Production Borehole

Drilled in 1993 by John Dunne of Mallow. There appear to be no records of the drilling and design. I understand that John Dunne essentially replicated the exploration borehole, but at a wider diameter, and used a high quality PVC borehole liner or casing. This casing is 8 inch diameter, around it there is 12 inch steel casing. This is probably a short length of ‘conductor casing’ installed to stabilise the borehole at the surface during drilling. This indicates that the borehole was drilled at 12 inch diameter, but the depth of the casing and the depth and diameter of the uncased borehole is not known. The records for the subsequent pump test are excellent. A high yielding pump was installed. The hole was pumped from the 8th November to the 11th November1993. Hourly measurements were made of the flow meter and the water level in the pumping borehole. When the test finished, Jenny Deakin from the GSI measured the recovery of the water levels for 24 hours. The average yield of the borehole during the 72 hour test was 14,626 gallons per hour. The static water level was 12 metres below the top of the casing and it was drawn down to 18.58 metres at the end of the test. The water level recovered to 13.52 metres within the next 1240 minutes.

## 3. Operation of the Martinstown Group Water Scheme Borehole

The production borehole has been equipped with a pump that can produce 7,513 gallons per hour or 34.15 m3/h or about 180,300 gallons per day. However the consumption of water is only about 70,000 gallons per day in winter rising to 80,000 gallons per day in summer. Therefore the borehole is only pumped for 12 hours per day or less. The water is pumped to the adjacent 20,000 gallon reservoir and this maintains a gravity feed to all the connections to the scheme.

The borehole has therefore not been has not been pumped at a rate of 180,300 gallons for each day. This volume is therefore just theoretical output of the pump and not the proven, sustainable, long term yield of the borehole. Therefore it would be dangerous to assume that there are about 100,000 extra gallons of water a day that could be provided for other schemes.

## 4. Results of Work

### 4.1. Initial Long Pump Test October 2000

The initial tests were expected to provide the information required to meet the main objectives of the work. As the borehole was in use for supply it was not possible to turn off the pump and allow time for the groundwater levels to fully recover. Also it was decided to use the existing pump, rather than remove this pump, and re-install another, with a probable disruption of the supply to the scheme.

A recovery of water levels was measured from 1320 hrs on the 9th October 2000 until 1120 hrs the following day when the reservoir was empty and houses had begun to run out of water. The pumping level had been at 16.55 m below the top of the casing in the production borehole and 15.91 metres below the top of the casing in the adjacent exploration borehole. These water levels recovered very slowly over the next 22 hours and respectively reached 15.035 and 14.67 metres below the reference points at the top of the casing. Therefore the start of the subsequent pumping test did not begin from a static or equilibrium water level. The low water level after 22 hours recovery when compared with the water levels in November 1993 indicated that the groundwater was at summer/autumn levels and that the test had been started before the effective onset of the autumn rains..

The initial long pumping test was carried out from 11.30 hrs on the 10th October 2000. Numerous readings were taken on the first day and night but thereafter readings were taken daily for the next 8 days and then the pump was left running for a further week with one final water level reading on the 25th October. The reason for the infrequent readings after the first day was that I was simultaneously directing and supervising exploration drilling 28 miles away near Doon.

The water levels fell slowly during the first 200 minutes of the test. Thereafter the decline steepened and remained relatively constant for the next three days. It rained heavily and persistently during the two weeks of the test. Eventually on the 6th day of pumping water levels started to rise slightly indicating that the heavy rain had begun to recharge the aquifer. The lowest water level in the pumping borehole before the impact of the rain was 17.27 metres (i.e. a drawdown of 2.235 metres below the starting water level). This was monitored for the next two days and the water levels rose 12 cms. A final reading taken by Jim Finn (18.80m) on the 25th just before returning the borehole to the normal operating regime, showed that the water levels had fallen in the interim and the impact of the heavy rainfall had been overcome. This period of rainfall was a part of one of the wettest autumn periods for several decades.

The data from the initial test was analysed and it was decided that a higher capacity pump was necessary in order to carry out a thorough test under winter conditions.

The data and the interpretation will be discussed in section 5 below.

### 4.2. Long Term Pumping Test at a higher Pumping Rate

A high capacity test pump was installed. It appears that it was probably the same pump that had been used for the original test in 1993. The test began on the 5th December 2000 at 1455 hrs. The static water level was 8.52 m below the top of the borehole. It was predicted from the 1993 test, which finished after 72 hours, that the pumping water levels would have started to fall more rapidly after about a week. The test in 2000 was designed to last at least a week in order to replicate the original test and determine whether high yields could be sustained. The initial pumping rate was 14,700 gallons per hour or $67m^3$/hour.

Pumping water levels declined at a gentle rate for 6 days but thereafter started to fall at an increasingly rapid rate. It was decided to continue the test in order to observe whether and when the water levels stopped falling and an equilibrium was reached between the aquifer and the pumping rate. This equilibrium was never reached, and when it became clear that the borehole could not sustain the pumping rate the test was stopped on the 29th January 2001. This test was one of the longer pumping tests carried out in the state. In total it was pumped at a relatively constant rate for 78,955 minutes or 54.8 days. The recovery was not measured because the pump had to return to service within 12 hours because of the limited storage in the reservoir. Two sets of recovery data had been previously obtained.

In order to restrain costs; I measured water levels during the first 1700 minutes, and thereafter the readings were taken diligently every day by the pump superintendent. Having plotted and interpreted these data I am satisfied that the data obtained was accurate.

The data and the interpretation will be discussed in section 5 below.

# 5. Interpretation and Assessment

## 5.1. Topography, Drainage and Geology

An understanding of the drainage and geology of the site is essential for an interpretation of the pumping test results.

Figure 1 shows the location of the source borehole on the north western slope of Slievereagh at an altitude of 500 feet above Poolbeg Ordnance Datum. To the north east of the borehole there is a spring described on the latest 1:50,000 Discovery series maps as a 'Holy Well' that is the source for the Ballinvreena Group Water Supply Scheme. Figure 1 also shows the relative position of Elton, Knocklong, Bulgaden Kilfinnane and Hospital that will be referred to in the assessment and conclusions. The surface drainage system for the Morningstar River is highlighted in blue on Figure 1. Extending to the south of both the spring and the borehole is a rough representation of the surface water catchment area up gradient of each groundwater source. As you can see, if this surface catchment area also represented the groundwater catchment, then the area receiving recharge that could be drawn upon by the borehole or spring would be very small.

Each catchment area is about 0.5 square kilometres. Assuming roughly that 350 mm of rainfall percolates into this area to replenish the groundwater system, then the total renewable water resource would be about 175,000 $m^3$ per annum (500,000$m^2$ x 0.35m). If this rough quantity is divided equally throughout the year to represent an average hourly volume it works out as an average of 20$m^3$ per hour or about 4,400 gallons per hour. These assumptions and calculations are very rough, but they give an idea of the available water resources if the zone of contribution to the borehole is only based upon topography. It is salutary to note that given the steep gradients it is unlikely that the equivalent of say 4,400 gallons per hour would be held in storage after the winter recharge period until the water was needed in the summer. Groundwater drainage and discharge to springs lower down the slope would take place during the winter and this water would be lost from the zone of contribution or catchment area above the borehole. It is also of note that the total of approximately 4,000 gallons per hour is approximately the same as the present daily abstraction rate. This indicates that to maintain even present abstraction rates the borehole is likely to be drawing upon water from a much larger area than the limited catchment area shown on figure 1.

An understanding of the catchment area or zone of contribution can be achieved by a consideration of the geology and in particular the structural geology of the area.

Figure 2 shows the bedrock geology from the 1996 GSI 1:100,000 scale map of the area transcribed onto the 1/2" scale topographic map. The geological units are not labelled on this figure but are labelled on Figure 3, which is an illustrative geological cross section through the site.

Figure 2 shows a large blue grey area of Ballysteen limestone north of Elton and Knocklong with an small anticlinal dome of older 'Kiltorcan' beds and a core of Old Red Sandstone near Kilfrush. South of this the beds of Waulsortian limestone and upper Carboniferous or younger shales and limestones dip gently southwards below the youngest layer called the Namurian shales (often referred to as "Pincil" in west Limerick). South of the area shown dark brown for the Namurian shales, there is a white line, with arrow points on its southern side. This line denotes a major thrust fault. South of this line there is a confusion of rock types and faults and folds. The thrust is the northern edge of a major collision and folding zone. The geological upheavals that took place south of this thrust are on a world wide scale. It was the Hercynian Mountain building period that involved the collision of continents. The Martinstown Group Water Scheme boreholes are sited on the zone of crushing at the northern edge of this great earth movement, therefore it is not surprising that a high yielding borehole should be found in this location.

Figure 3 shows the gentle dip of the limestones in the north and the way that the older Devonian sandstones and the underlying even Older Silurian shales have been shoved up and over the younger carboniferous rocks. A thrust zone was a zone of high compression and shattering. It is probably not a clean break but a zone of rubble. When the thrust occurred the rocks were compressed, but since that time, other earth movements have reversed the compression, and tried to pull the rocks apart. Therefore a zone of low permeability compressed crushed rock has probably become an open zone of high permeability.

On Figure 3, which I stress is a schematic section for illustrative purposes, I have shown a possible layer of overburden, scree or glacial deposits on the lower northern slopes of Slievereagh. I do not know whether these materials exist in this position because we don't have any geological log from the drilling, but I am suggesting that there may be unstable sands gravels and clays above the bedrock because John Dunne used 80 feet of casing in the upper part of the exploration borehole. It would appear likely that he justified using this length of casing because he needed to support loose material that would otherwise have fallen into the borehole. It may not have been sands, gravels and clays. It could have been partly such deposits and a thick upper zone of very soft, weathered, unstable bedrock. On the cross section, I have shown the borehole penetrating deposits that required support, then going into a small thickness of Old Red Sandstone, then going through the thrust zone, and finishing in the Namurian Shales. I have shown it thus because of the report of the major yield at 130 feet which is, I assume, the thrust zone.

The Namurian shales are a notoriously poor aquifer. The yields are often minuscule and the water is often iron rich and sulphurous. There is no evidence from the borehole water chemistry that a significant amount of water is derived from this formation. The old Red sandstone is also not a prolific aquifer. The solid rock is impermeable but good yields can be obtained when it is heavily fractured. Therefore neither of the rock types encountered by the borehole should lead to a high yielding source. It is evident that the main productive zone is the thrust fault zone.

Turning back to figure 2 it can be seen that the thrust extends roughly east to west. The thrust is shown to pass directly under the 'holy well' source for the Ballinvreena group Water Scheme before passing just north of the boreholes. The coincidence of the spring and the thrust probably explains the origin of the spring, but also has significant consequences for the future exploitation of the Martinstown Group Water Scheme borehole. Given that the two rock types are not major aquifers and given that the catchment area above the boreholes is small it is reasonable to infer that the main productive zone that has potential to sustain a yield from the borehole is the thrust and that the borehole must draw water from the thrust in an east and west direction on either side. This means that the Martinstown Group Water Scheme borehole and the Ballinvreena Group Water Scheme Spring are both reliant on the same zone of high permeability. The implications for interference and negative impacts from this deduction are obvious.

## 5.2. Pumping Tests and Borehole Yields

I attach 5 graphs, some of which I have already sent you with interim reports. I have not given figure numbers to the graphs. I will provide an interpretation of the graphs and compare them.

Three of the graphs show the response of the groundwater system to pumping at different rates and times.

> The first graph shows the drawdown of the water levels in the pumping borehole during the 72 hour test in 1993.
>
> The second graph shows the drawdown in the pumping borehole during the long test in October 2000.
>
> The third graph shows the drawdown in the observation borehole (exploration borehole) about 5 metres from the pumping borehole during the long test from December 2000 to January 2001. It was found that the water levels changed in the observation borehole at the same rate as the change in the pumping borehole, but it was easier for the pump superintendent to take reliable measurements in the observation borehole.
>
> The fourth graph shows the change in pumping rate during the long test between December 2000 and January 2001.
>
> The fifth graph shows the same data as the third graph but on a different scale of time and depth.

If you study the first three graphs and the curves and straight lines formed by the data points, you will see that the shapes are similar. Looking at the first 100 minutes of pumping it can be seen that the water level falls relatively quickly and then the rate of decline diminishes. This pattern shows that the pump initially takes water from the column of water in the borehole. After about 0.5 -1.0 minutes the drop in water level in the borehole stimulates water to flow from the 'aquifer' into the borehole. This release of water from the aquifer is principally made up of pressure release of water from open fractures and fissures directly adjacent to the borehole. The release of water from these conduits tries to keep pace with the rate at which the water is being removed from the hole by the pump. The fact that the water level continues to fall indicates that the release of water cannot keep pace with the pumping.

For the first 100 minutes or so, the fractures nearly keep pace with the pump and the impact of the pumping spreads outwards through the open fracture systems. Water begins moving in towards the borehole from further and further away. Eventually after about 100 - 200 minutes the storage of water in the easily accessible open fracture system (in this case presumably the high permeability thrust zone and perhaps the upper zone of sands, gravels or soft weathered bedrock behind the casing), is depleted and the water level starts to fall again more rapidly. This continues for the next 1000 -2000 minutes.

In the first test in 1993 the rate of decline of the water levels slowly, and almost inexorably, increases from about 100 minutes until the end of the test after 4200 minutes.

The graphs showing the two tests in 2000 show a common but different pattern after about 1000 minutes for different reasons. The first test in 2000 started with a deep water level at around 15 metres but after about 1000 minutes appears to have received some rainfall recharge. The rate of water level decline decreases and eventually after 5000 minutes the decline stops, and water levels start to rise.

The third graph showing the long test from December to January shows a similar pattern after 1500 minutes (the small drop at around 1400 minutes is just a slight increase in pumping rate because a valve controlling the flow to waste was fully opened). Disregarding this small drop it is evident that the water levels begin to fall less rapidly from 1,500 minutes to about 9,000 minutes. The 'aquifer' at the start of the test was relatively full. The static water level was at about 8.5 metres below ground level or about 7.5 metres higher than the level at the start of the test in October. What is probably happening during the 1,500 to 9,000 minute period is that the permeable thrust zone is tapping, or drawing in, water held in the saturated overburden or weathered old red sandstone bedrock above the thrust zone. The release of water from the pore spaces in these materials means that the thrust zone fractures and cavities are nearly able to keep pace with the pumping rate. After about 9,000 minutes the water levels start to fall more rapidly again. This is the point at which even the release of recent rainfall water soaked up by the overburden and upper bedrock was still not able to keep pace with the pumping rate. Finding this point was one of the objectives of the test, because beyond this point the drawdown begins to reflect the storage and permeability of the 'aquifer' that can be drawn upon by the borehole in summer.

The long test in the third graph shows that the bedrock aquifer, which is a combination of both the high permeability thrust zone and the less broken up Old Red Sandstone and Namurian Shales above and below it, cannot release and transmit water to the borehole commensurate with the rate of withdrawal by the pump. In other words, it began to look as if the groundwater system could not reach equilibrium or steady state, with water being taken out of it at this rate of around 15,000 gallons per hour.

We carried on pumping at this rate for a further 70,000 minutes because the results of the test were so important, and we wanted to find out if there was any chance that steady state could be reached. Unfortunately, with just a slight 'wobble' just after Christmas (around 35,000 - 40,000 minutes), the water levels continued to fall consistently, and the rate of decline increased. The slight apparent decrease in the rate of decline towards the end appears to correspond to a decline in the pumping rate shown in the fourth graph. The pumping rate declined slightly at the end because the pump was struggling to lift the water from greater and greater depths. It is important in these tests to try to maintain a constant pumping rate. It was this fall in pumping rate after about 40 -50,000 minutes that eventually convinced me that we could not obtain further useful information, and the pump was turned off.

Therefore, though it is evident that  the Martinstown Group Water Scheme borehole can provide a short-term high yield, because it is an efficient borehole that has encountered a very permeable fracture zone, it is also evident that the borehole and fracture system cannot sustain a high yield indefinitely.

The recent test ending in January 2001 was conducted when there were high water table conditions after the heavy autumn rains. The fifth graph shows the pump test data on an extended scale of up to 1,000,000 minutes and 28 metres depth.

I have made a dangerous extrapolation of the late drawdown data excluding the end of the test when the pumping rate declined. It shows that under winter conditions the pumping water level would fall to about 20 metres below the static water level within a year. The reason why this extrapolation is dangerous is that we know so little about the borehole geology and construction. If, in the summer, the starting water level were at say 18 metres, and if there were a productive fissure at say 25 metres, it is possible that this fracture could be dewatered within say 3 weeks and the water level would plummet to the pump intake in a matter of days. I am assuming that John Dunne did not provide a full cement grout seal in the annulus behind the 8 inch PVC casing.

I provide this 'dangerous graph' merely so that someone with additional information in the future can use it for comparison.

The conclusion of my interpretation, of the several pumping tests, is that the Martinstown Group Water Scheme borehole **cannot** maintain a pumping rate of 15,000 gallons per hour, in perpetuity through all seasons. The accessible storage in the bedrock above and below the thrust zone is insufficient, even in winter when the storage is being replenished by recharge.

It also does not appear that it will be able to sustain a rate of only 8,000 gallons per hour, though this interpretation depends greatly on the final measurement made before the pump was turned off in October.

### 5.3. Assessment of the Potential for further Extension of the Martinstown Group Water Scheme and Conclusions

In your faxed letter of the 25th January you provide information on the current water usage in adjacent water schemes. I summarise your figures below.

| Scheme | Connections | Summer consumption estimate |
|---|---|---|
| Martinstown | 150 | 80,000 gallons per day |
| Ballinvreena | 72 | ? but pro rata 40,000 gallons per day |
| Proposed Elton Extension | | 11,000 gallons per day |
| Kilfinnane hinterland extension | | 40,000 gallons per day |
| Bulgaden private scheme source replacement | 50 | ? but pro rata say 30,000 gallons per day |
| Hospital | 467 | 132,000 gallons per day |
| Knocklong | 333 | 92,000 gallons per day |

I understand that there are problems of either yield, extra capacity or quality in all the above except Martinstown. The estimated consumption for the above schemes combined would be about 425,000 gallons per day. This total in gallons per hour would be about 18,000 gallons per hour, 24 hours a day. It is obvious from the recent tests that Martinstown Group Water Scheme cannot, in either winter or summer, meet this total demand. Therefore, I suggest that any consideration of Martinstown replacing, or even augmenting Hospital or Knocklong, is dropped. It is perhaps useful to add that, though I do not have information on the sources for either of these big schemes, the recent drilling results from Bruff, Knockainey and Doon areas would indicate that additional or replacement water sources could easily be located in the 'Kiltorcan' sandstones that occur below a protective layer of Ballysteen limestone near both these villages. Suitable hydrogeological sites could be found on either side of the main road between them.

The Ballinvreena Scheme source is on the major thrust that is also tapped by the Martinstown Group Water Scheme borehole. Therefore any large increase in abstraction from Martinstown, is very likely to reduce the flow from the Ballinvreena spring particularly in the summer. I therefore recommend that you consider taking over the Ballinvreena scheme and linking it to, or replacing it with, water from Martinstown Group Water Scheme. It basically would be the same water but from a much better protected source. The reservoir at Cush is above the Ballinvreena spring.

The addition of the Ballinvreena scheme would increase the demand on Martinstown Group Water Scheme to 120,000 gpd or the equivalent of 5,000 gph, 24 hours a day. This total is coming close to a reasonable expectation of the sustainable yield of Martinstown at the end of a dry summer.

The possible increased demand in the Kilfinnane hinterland and the need to maintain pressure in the town is another 40,000 gallons per day. Adding this total, in full, would increase the demand on the Martinstown borehole to the equivalent of 6,660 gph for 24 hours a day. In my opinion, on the basis of the existing information, I think that this extra demand could just be met by Martinstown for most of the year, but for only a short period in mid or late summer.

The Elton extension, if it is limited to 11,000 gallons per day, would impose only a small extra demand on Martinstown. If the extra demand was to be limited to just the Elton extension, then I think that Ballinvreena would probably be able to survive as a private scheme.

**In conclusion:**

The tests have shown that the Martinstown borehole is a high yielding borehole structure that is fed by a limited groundwater resource.

It is therefore important to make cautious decisions regarding the extension of the water supply scheme. From the results obtained so far, I suggest that any expansion or extension is limited to a maximum total volume equivalent to 5,500 gallons per hour continuous pumping, or 132,000 gallons per day.

I strongly suggest that extensions to the scheme occur in small increments, with thorough monitoring of performance before the next extension, rather than an immediate, large scale, ambitious expansion.

I do not know all the details regarding the engineering difficulties in making connections to Elton, Ballinvreena and Kilfinnane, but I suggest that it would be safe to provide the Elton extension, and a qualified connection to both Ballinvreena and Kilfinnane. The purpose of the latter two connections would be to have the capacity to supply additional water when either pressure, or a short term surge in demand occurs. However, I would not recommend that the latter two connections are regarded as a permanent additional supply, that is then used as a basis for granting planning permission for a significant increase in housing.

One of the reasons for urging caution is that the Martinstown source is just one borehole. There is no standby borehole. Therefore, it is not wise to make a commitment to stretch the output without monitoring the impact, and without an alternative borehole to fall back upon in emergencies.

I suggest that at least two years (particularly summers) water level and abstraction volume monitoring data is collected daily before any long term or permanent commitment is made to supply Kilfinnane.

I draw your attention to Figure 2 which shows that the major thrust zone and a major NW - SE fault occur next to Kilfinnane, and that the 'Kiltorcan' sandstone outcrops just below Kilfinnane and dips below a protective layer of Ballysteen limestone to the north. In my opinion, finding either an additional groundwater source for Kilfinnane or a standby source for both Martinstown and Kilfinnane would be, from a hydrogeological perspective, very easy. A site in the town land of Bosnetstown north of Kilfinnane, just east of the road and the river Loobagh would appear attractive.

There is no shortage of either groundwater or aquifer targets in Limerick. Therefore all hopes for improving water supplies do not need to depend on taking more water from existing sources.

I hope this helps clarify the situation.

**Figure 1 Martinstown Group Water Scheme Source Topography and Drainage**

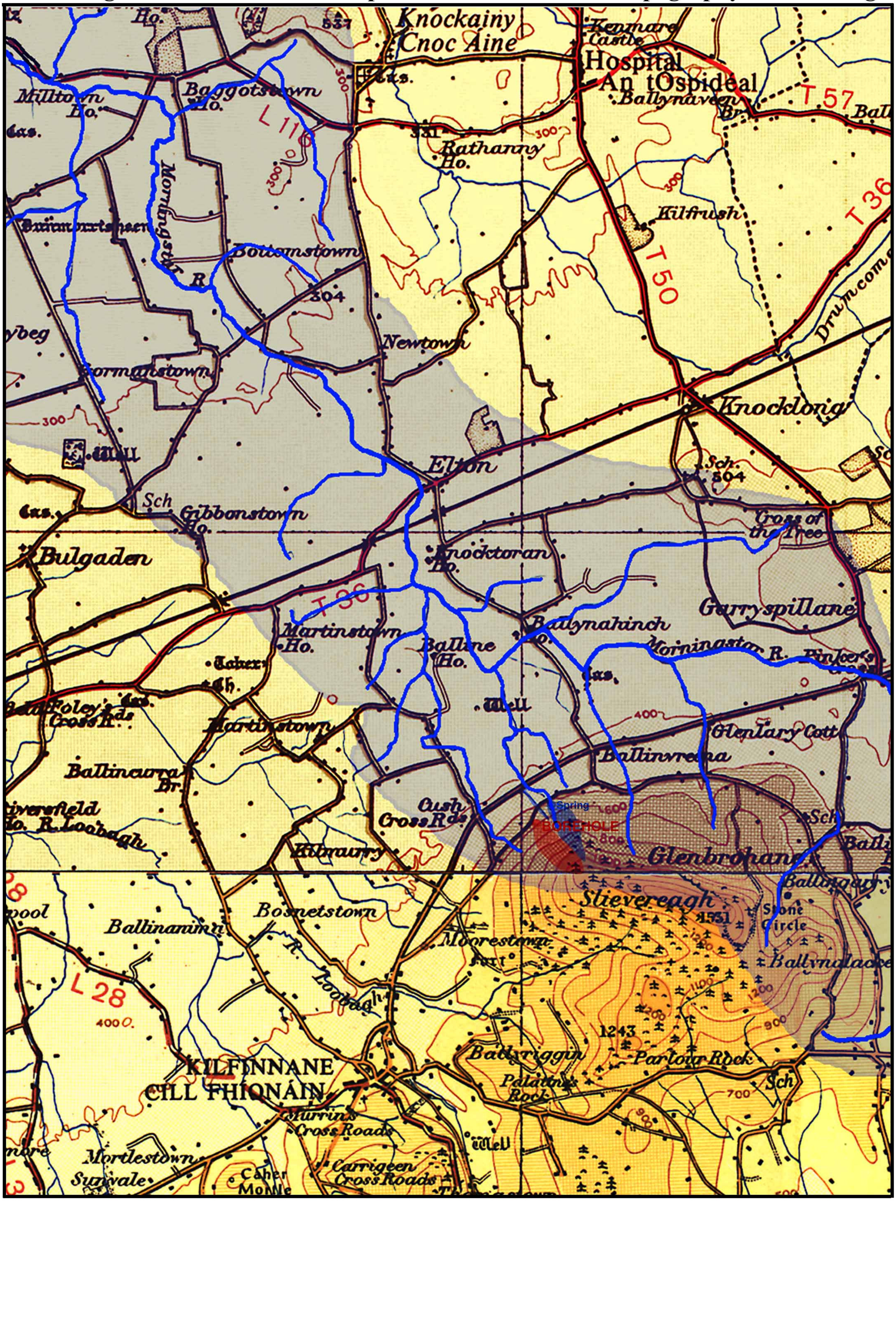
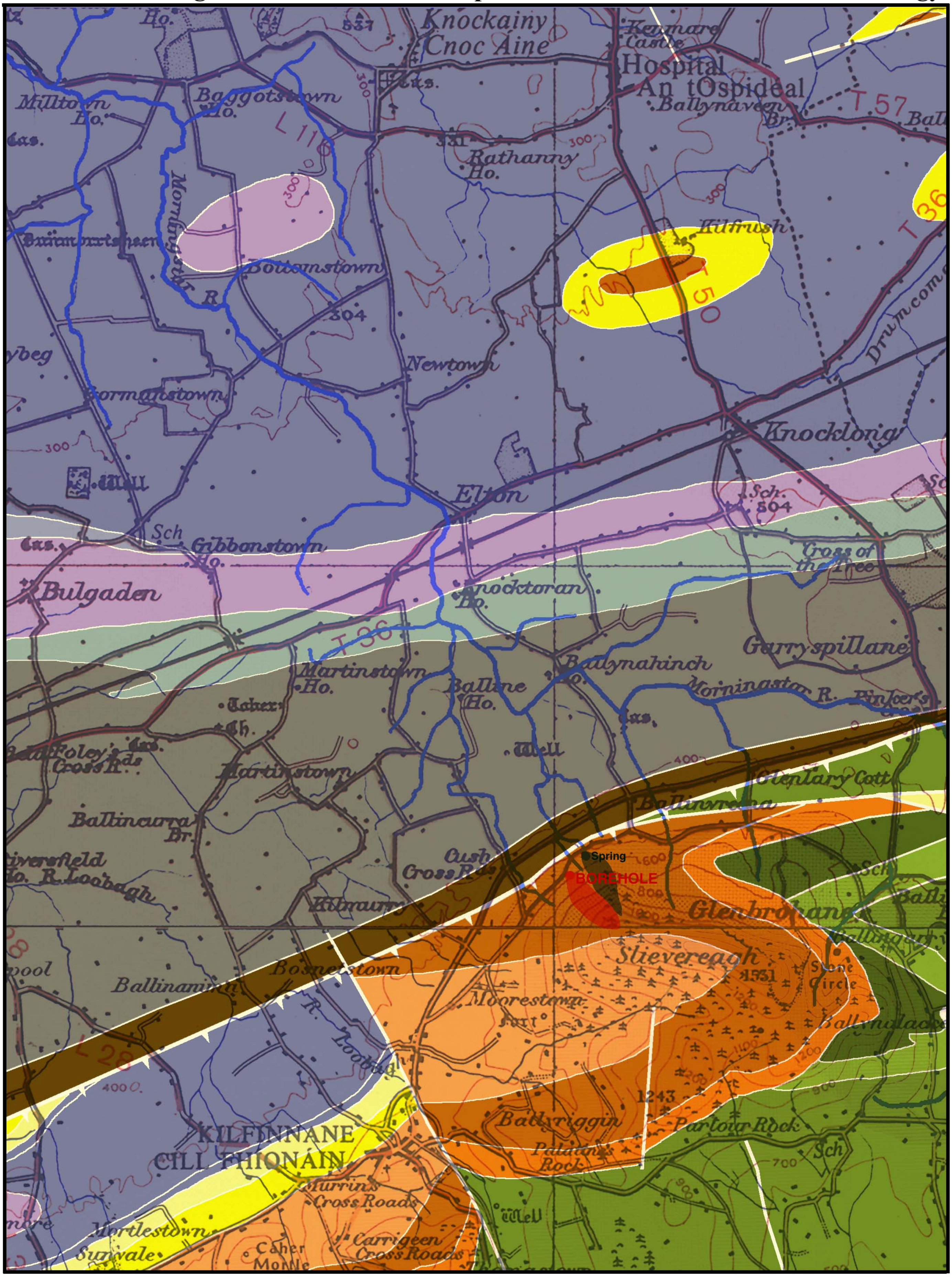


**Figure 2 Martinstown Group Water Scheme Source - Bedrock Geology**



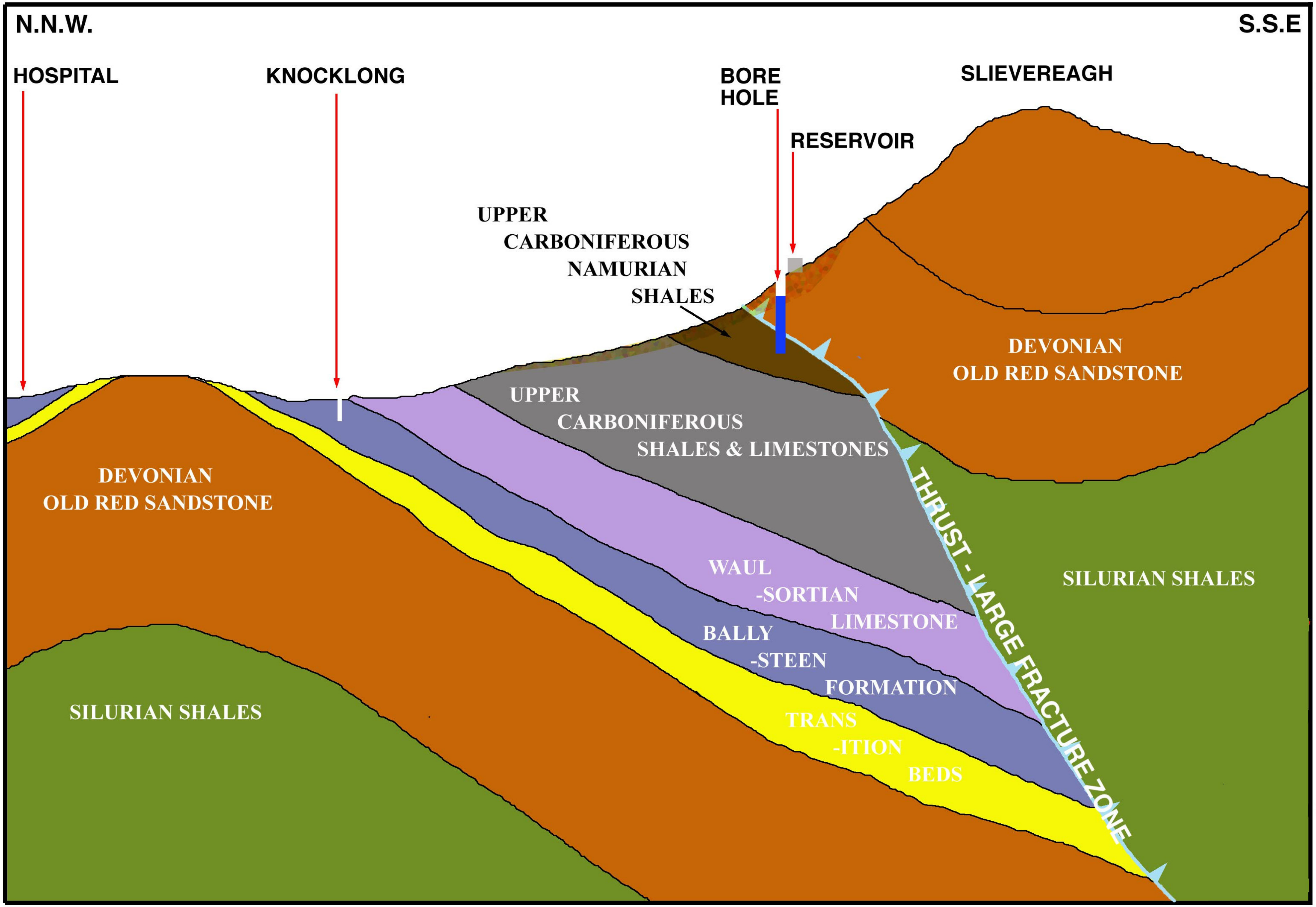
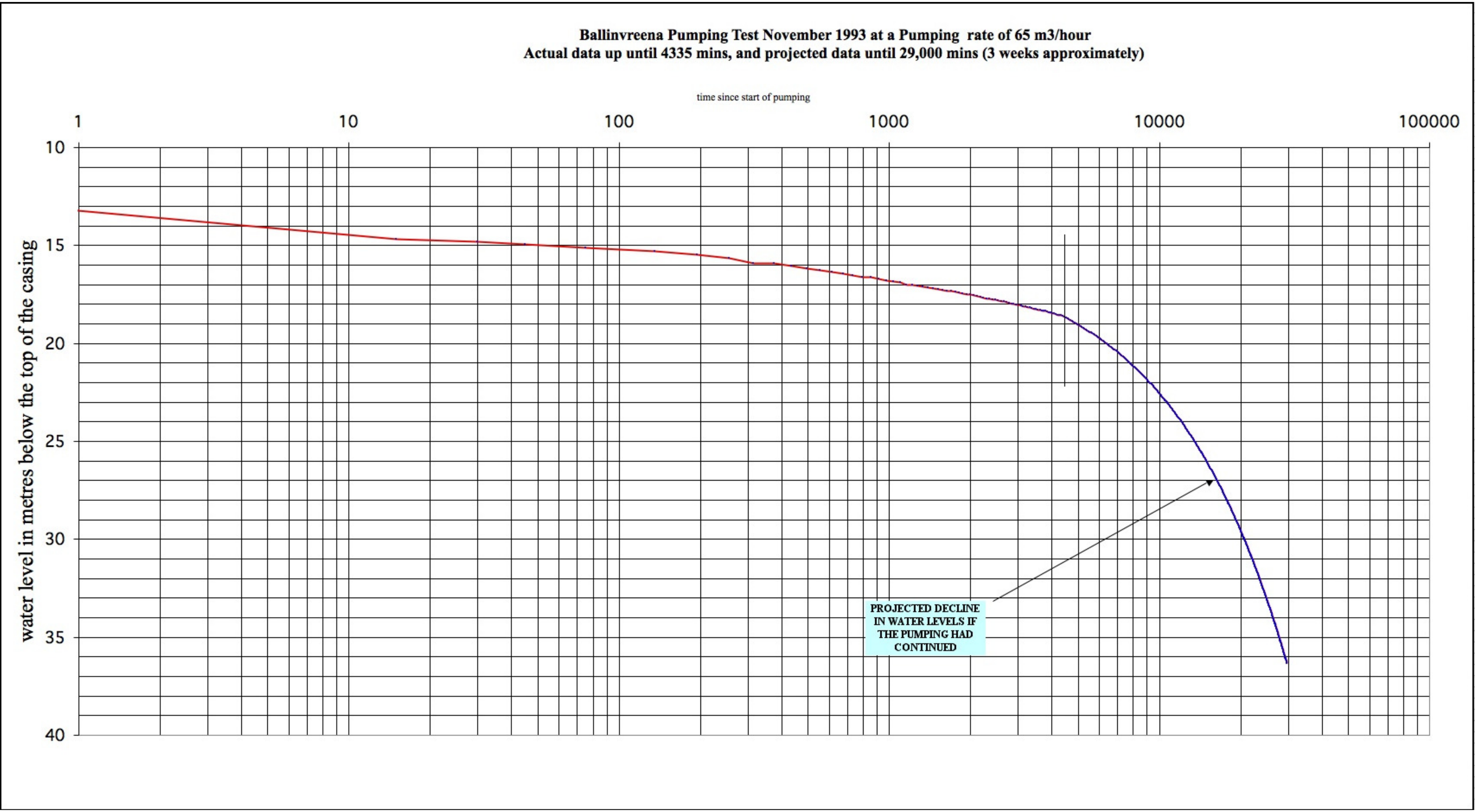
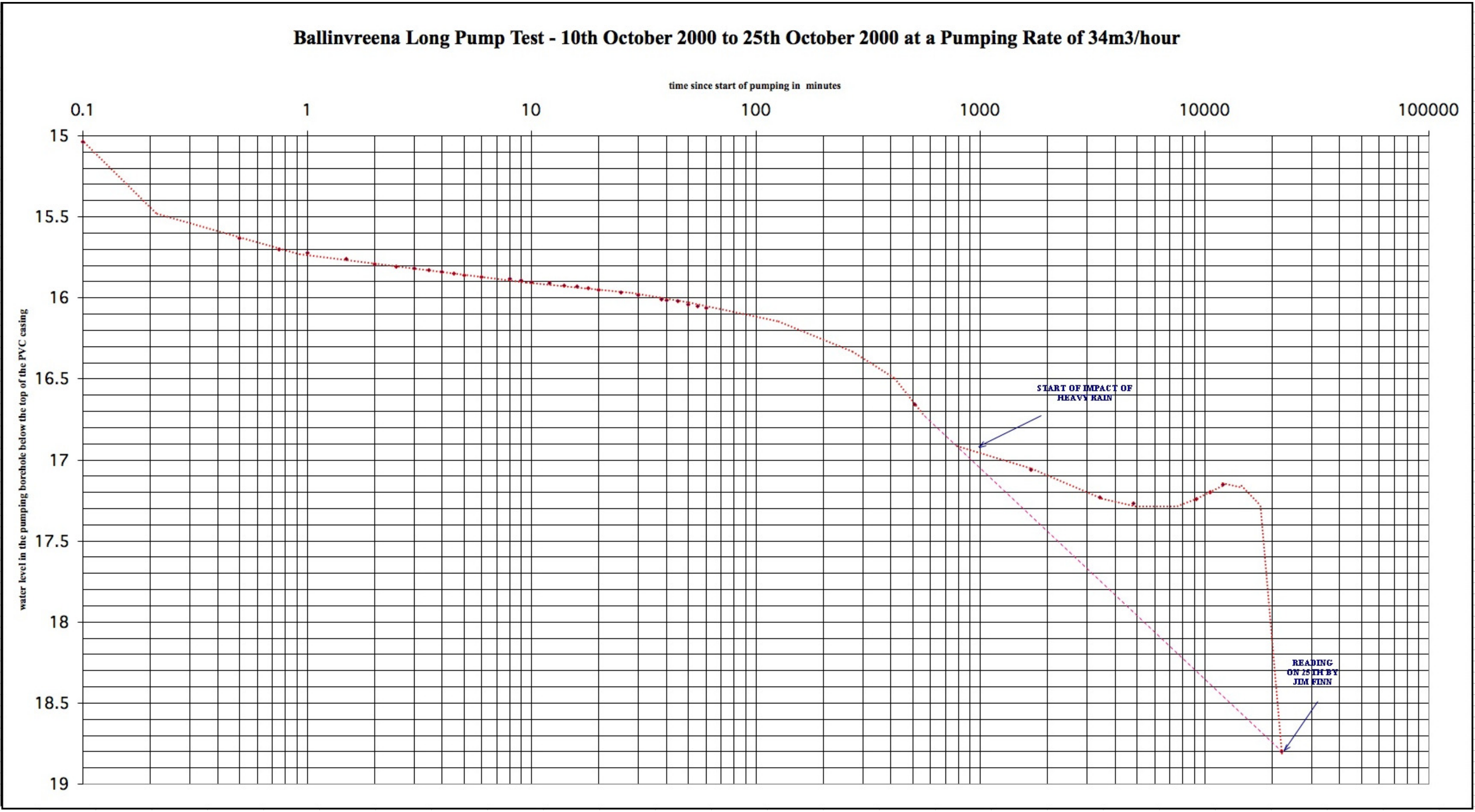
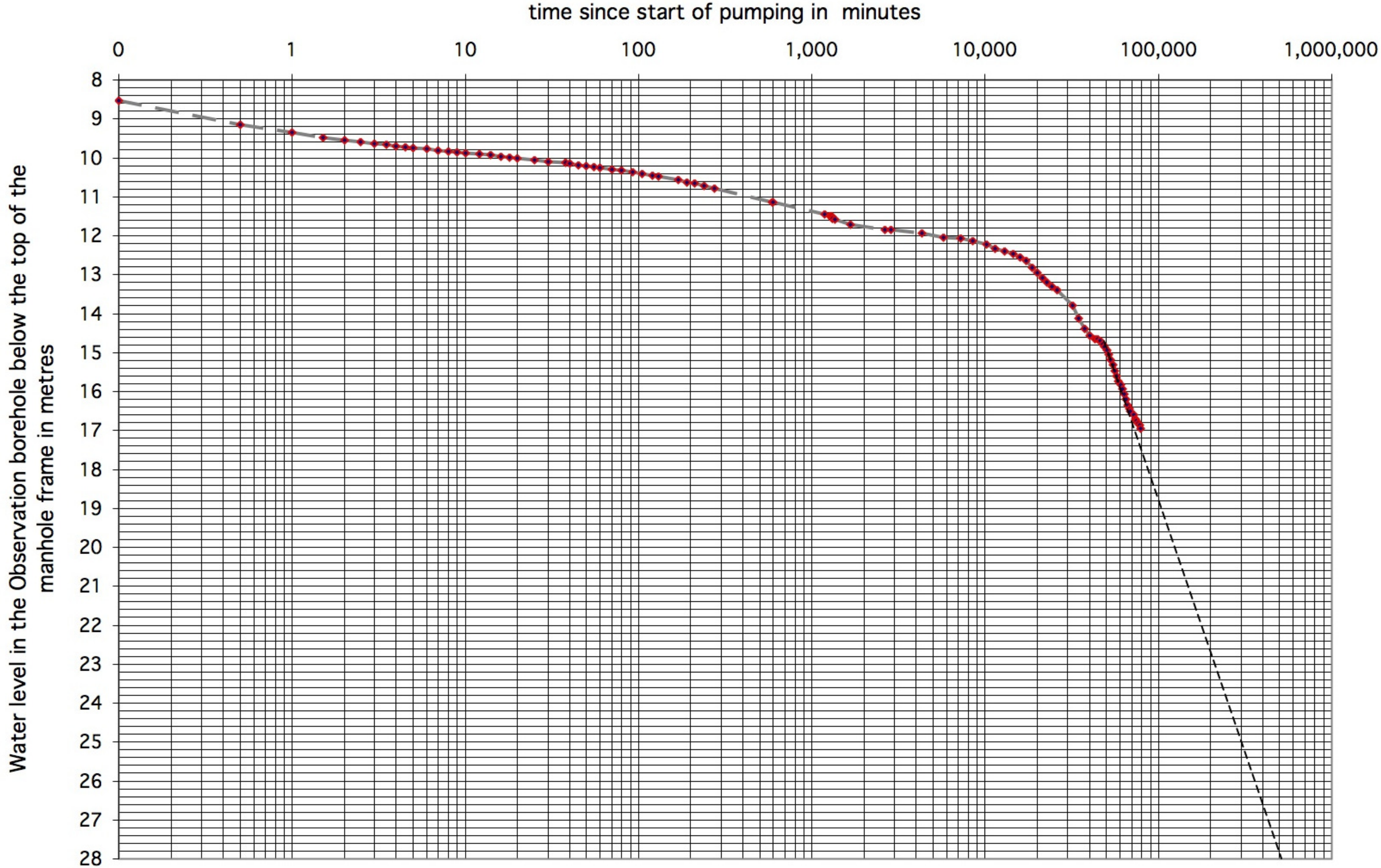


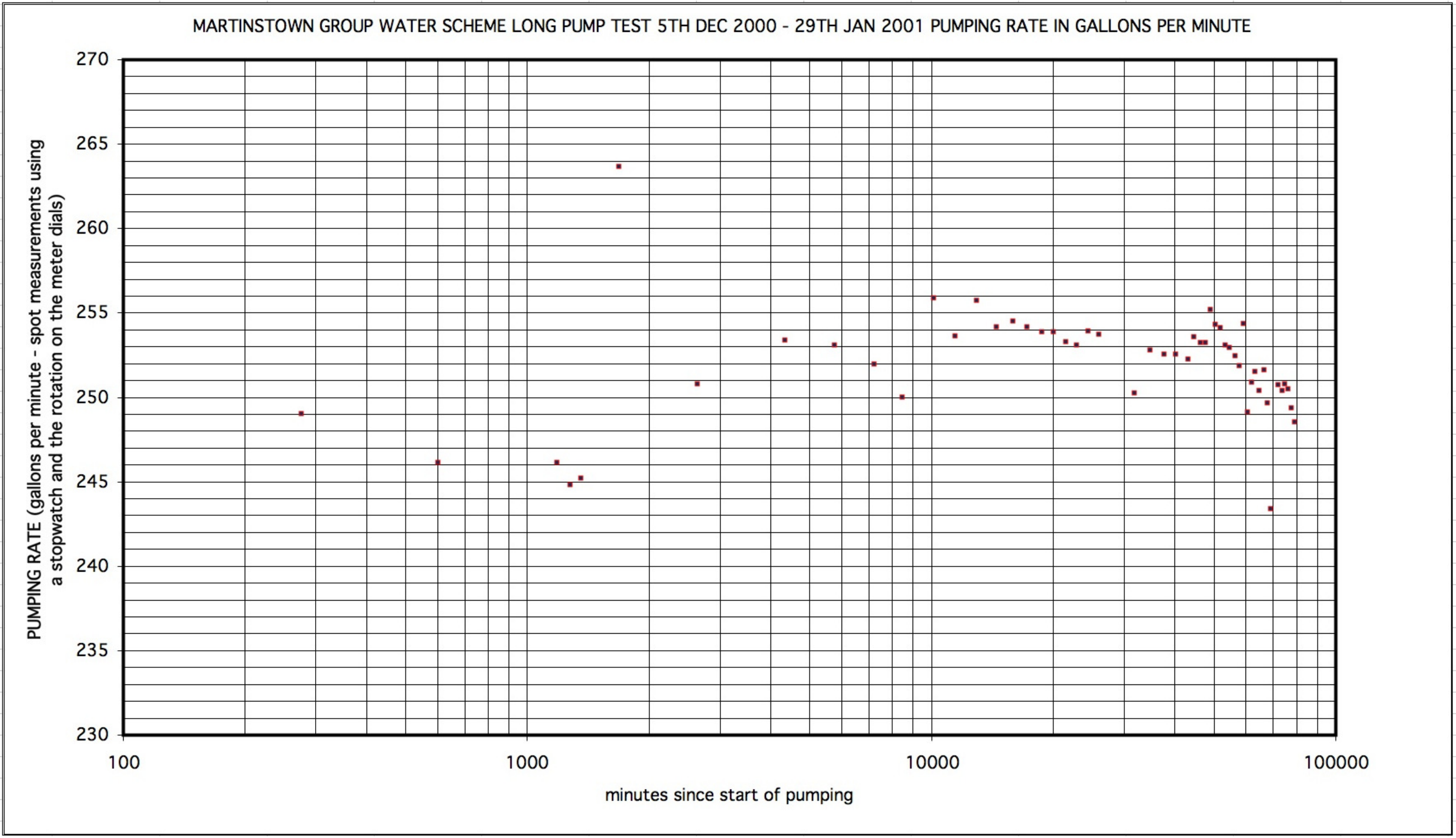

Figure 3 Martinstown Group Water Scheme Source - Schematic Geology Section


Ballinvreena Pumping Test November 1993 at a Pumping rate of 65 m3/hour
Actual data up until 4335 mins, and projected data until 29,000 mins (3 weeks approximately)
time since start of pumping
1
10
100
1000
10000
100000
10
15
20
25
30
35
40
water level in metres below the top of the casing
PROJECTED DECLINE IN WATER LEVELS IF THE PUMPING HAD CONTINUED

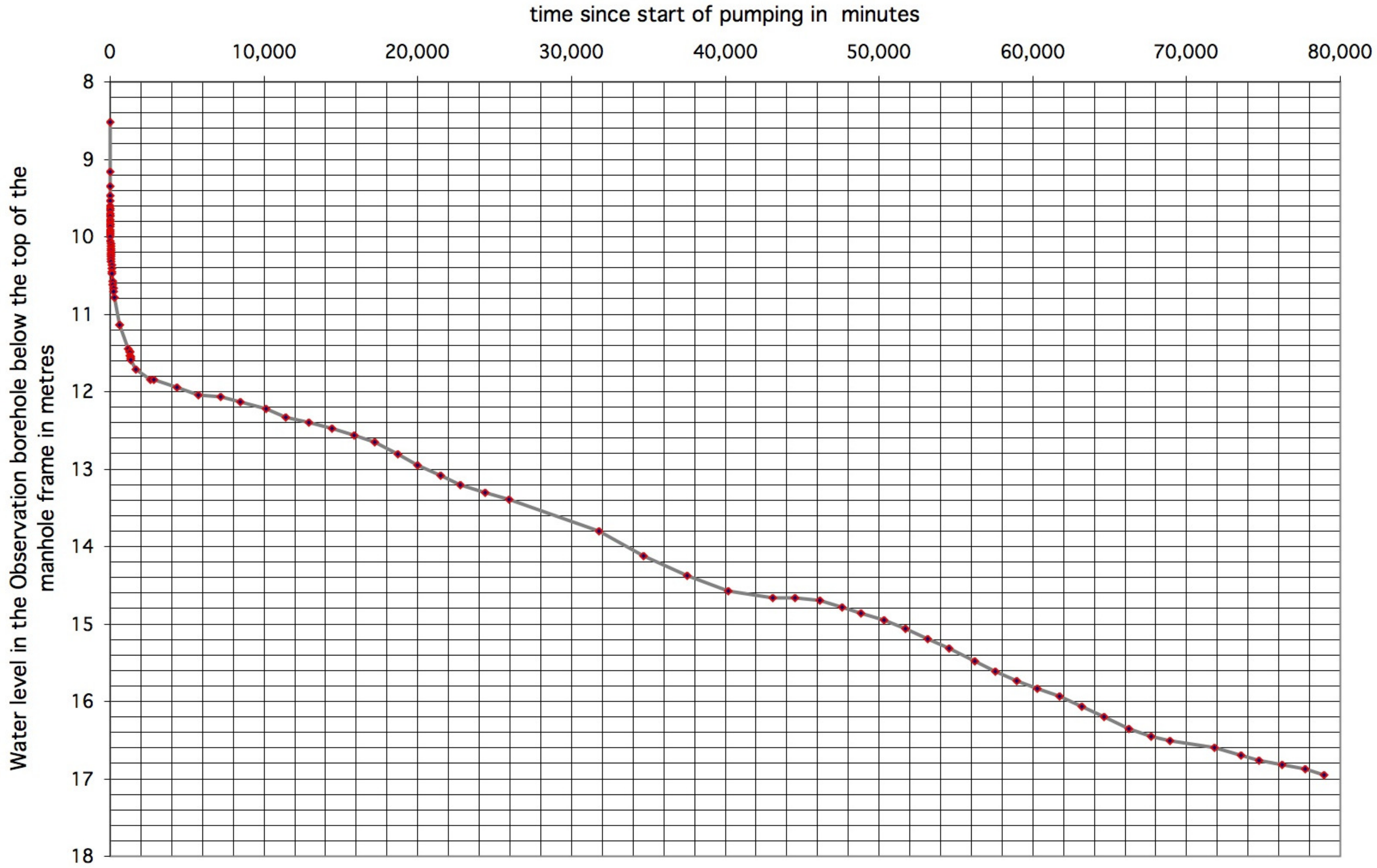

Ballinvreena Long Pump Test - 10th October 2000 to 25th October 2000 at a Pumping Rate of 34m3/hour
time since start of pumping in minutes
0.1
1
10
100
1000
10000
100000
water level in the pumping borehole below the top of the PVC casing
15
15.5
16
16.5
17
17.5
18
18.5
19
START OF IMPACT OF HEAVY RAIN
READING ON 25TH BY JIM FINN

**Martinstown Group Water Scheme Long Pump Test - 5th December 2000 to 29th January 2001 at a varying Pumping Rate ranging from 14,750 to 15,250 gallons/hour (@ 21st January 2001 rate is declining slightly and is around 15000 gallons per hour )**




MARTINSTOWN GROUP WATER SCHEME LONG PUMP TEST 5TH DEC 2000 - 29TH JAN 2001 PUMPING RATE IN GALLONS PER MINUTE
PUMPING RATE (gallons per minute - spot measurements using a stopwatch and the rotation on the meter dials)
270
265
260
255
250
245
240
235
230
100
1000
10000
100000
minutes since start of pumping

**Martinstown Group Water Scheme Long Pump Test - 5th December 2000 to 29th January 2001 at a varying Pumping Rate ranging from 14,750 to 15,250 gallons/hour (@ 21st January 2001 rate is declining slightly and is around 15,000 gallons per hour )**



# APPENDIX 2

**Water Quality Data for Ballinvreena Spring Group Water Scheme**

**Bodycote** CONSULTUS laboratories

Health Sciences www.healthsciences.bodycote.com www.bodycote.com

Bodycote Consultus Ltd, Glanmire Industrial Estate, Glanmire, Co.Cork, Ireland
Tel: +353 (0)21 48 222 88 Fax +353 (0)21 48 663 42 Email: info.consultus@bodycote.com

**Client ID** : EPS

MS SUSAN MC GRATH
EPS ELECTRICAL PUMP SERVICES
QUARTERTOWN IND, ESTATE, MALLOW
CO CORK

**No. of Samples** : 1
**Sample Type** : Water
**Order Number** : B'VREENA

**Report No.** : 6187Q
**Date of Receipt** : 04/10/07
**Delivery Mode** : Refrigerated Van
**Date Test Initiated** : 04/10/07
**Date of Report** : 09/11/07
**Sample Condn on Receipt** Satisfactory
**Page** : 1 of 6

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# TEST REPORT

**Sample No** : 6187Q1
**Client Reference** : SAMPLE REF . BALLINVREENA GWS OP 029 – 04/10/07

The water was analysed for the parameters stated in SI No 278 of 2007, EU directive 98/83/EC. Non conforming results are highlighted in **bold**.

## Part A
## Microbiological Parameters

| Test | Test Result | P.Value | Unit | Method |
|---|---|---|---|---|
| Escherichia Coli (E.Coli) | 0 | 0 | 100ml | MT4201/ISO 9308-1:2000 |
| Enterococci | 0 | 0 | 100ml | ISO 7899/2 2000 |

SEE REVERSE FOR CONDITIONS

Continued.......

Bodycote CONSULTUS laboratories
Health Sciences www.healthsciences.bodycote.com www.bodycote.com
Bodycote Consultus Ltd, Glanmire Industrial Estate, Glanmire, Co.Cork, Ireland
Tel: +353 (0)21 48 222 88 Fax +353 (0)21 48 663 42 Email: info.consultus@bodycote.com

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**Order Number** : B'VREENA

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**Sample Condn on Receipt** Satisfactory


## TEST REPORT

**Sample No** : 6187Q1
**Client Reference** : SAMPLE REF . BALLINVREENA GWS OP 029 – 04/10/07

### Part B - Chemical Parameters

| Test | | Test Result | P. Value | Unit | Method |
|---|---|---|---|---|---|
| Acrylamide | | Not Tested | 0.1 | µg/l | SUBCONTRACTED |
| Antimony (Sb) | | <0.12 | 5.0 | µg/l | SUBCONTRACTED |
| Arsenic (As) | | <0.37 | 10.0 | µg/l | SUBCONTRACTED |
| Benzene | | <0.1 | 1.0 | µg/l | SUBCONTRACTED |
| Boron (B) | | <0.017 | 1.0 | mg/l | SUBCONTRACTED |
| Bromate as BrO3 | | <0.6 | 25 | µg/l | SUBCONTRACTED |
| Cadmium (Cd) | | <0.06 | 5.0 | µg/l | APHA 1998 3111:B |
| Chromium (Cr) | | <0.7 | 50 | µg/l | SUBCONTRACTED |
| Copper (Cu) | | <0.0027 | 2.0 | mg/l | APHA 1998 3111:B |
| Cyanide (CN) | | <0.7 | 50 | µg/l | SUBCONTRACTED |
| 1,2-Dichloroethane | | <0.1 | 3.0 | µg/l | SUBCONTRACTED |
| Epichlorohydrin | | Not Tested | 0.1 | µg/l | SUBCONTRACTED |
| Fluoride (F) | | <0.1 | 0.8* | mg/l | ETC981/APHA 1998S 4110:B |
| Lead (Pb) | | <0.5 | 25 | µg/l | SUBCONTRACTED |
| Mercury (Hg) | | <0.012 | 1.0 | µg/l | SUBCONTRACTED |
| Nickel (Ni) | | <0.9 | 20 | µg/l | APHA 1998 3111:B |
| Nitrate Nitrogen ($NO_3$ as $NO_3$) | | 18.2 | 50 | mg/l | ET0443/APHA98 4500NO3:I |
| Nitrite Nitrogen ($NO_2$ as $NO_2$) | | <0.03 | 0.5** | mg/l | ET0432/APHA98 4500NO3:I |
| Nitrate/50 + Nitrite/3 | | <1 | <1 | mg/l | |
| Total Pesticides | Appendix I | <0.014 | 0.5 | µg/l | SUBCONTRACTED |
| PAH | Appendix II | <0.006 | 0.1 | µg/l | SUBCONTRACTED |
| Selenium (Se) | | <0.22 | 10 | µg/l | SUBCONTRACTED |
| Tetrachloroethene and Trichloroethene (sum) | | <0.2 | 10 | µg/l | SUBCONTRACTED |
| Trihalomethanes(see App III) | | 0.8 | 150 | µg/l | SUBCONTRACTED |
| Vinyl Chloride | | <0.1 | 0.5 | µg/l | SUBCONTRACTED |

* P. Value for supplies with naturally occurring fluoride = 1.5 mg/l
** Nitrite Limit for Waterworks is <0.1mg/l

SEE REVERSE FOR CONDITIONS

Continued.......

Bodycote CONSULTUS laboratories

Health Sciences www.healthsciences.bodycote.com www.bodycote.com

Bodycote Consultus Ltd, Glanmire Industrial Estate, Glanmire, Co.Cork, Ireland
Tel: +353 (0)21 48 222 88 Fax +353 (0)21 48 663 42 Email: info.consultus@bodycote.com

**Client ID** : EPS

MS SUSAN MC GRATH
EPS ELECTRICAL PUMP SERVICES
QUARTERTOWN IND, ESTATE, MALLOW
CO CORK

**No. of Samples** : 1
**Sample Type** : Water
**Order Number** : B'VREENA

**Report No.** : 6187Q
**Date of Receipt** : 04/10/07
**Delivery Mode** : Refrigerated Van
**Date Test Initiated** : 04/10/07
**Date of Report** : 09/11/07
**Sample Condn on Receipt** Satisfactory


## TEST REPORT

**Sample No** : 6187Q1
**Client Reference** : SAMPLE REF . BALLINVREENA GWS OP 029 – 04/10/07

**Part C**
**Indicator Parameters**

| Test | Test Result | P. Value | Unit | Method |
|---|---|---|---|---|
| Aluminium | <11 | 200 | µg/l | APHA 1998 3111:D |
| Ammonia Nitrogen as $NH_4$ | 0.15 | 0.3 | mg/l | ET0383/MEWAM1981 |
| Chloride (Cl) | 16 | 250 | mg/l | ETC981/APHA 1998S 4110:B |
| *Clostridium perfringens* | 0 | 0 | 100ml | MTD731 |
| Colour (filtered) | <2 | Acceptable | Hazen | ET2992/MEWAM 1981 C&T |
| Conductivity @ 20°C | 329 | 2500 | µS/cm | ET0561/APHA1998:2510:B |
| Hydrogen Ion Concentration (pH) | 6.9 | 6.5 ≤ pH≥ 9.5 | pH units | ET1241/APHA1998:4500H:B |
| Iron (Fe) | 13 | 200 | µg/l | APHA 1998 3111:B |
| Manganese (Mn) | <1.5 | 50 | µg/l | APHA 1998 3111:B |
| Odour | Acceptable | Acceptable | | APHA 1998 2170 |
| Sulphate (SO4) | 4 | 250 | mg/l | ETC981/APHA 1998S 4110:B |
| Sodium | 9.0 | 200 | mg/l | APHA 1998 3111:B |
| Taste | Acceptable | Acceptable | | APHA 1998 2150 |
| Colony Count 22°C | 0 | * | CFU/ml | MTC921/ISO 6222:1999 |
| Coliform Bacteria | 0 | 0 | CFU/100ml | MT4201/ISO 9308-1:2000 |
| TOC as NPOC | 1.2 | * | mg/l | APHA1998 5310:B |
| Turbidity | 0.3 | Acceptable | NTU | APHA 1998 2130:B |
| Radioactivity - Total Indicative Dose | <ID | 0.1 | mSv/year | SUBCONTRACTED |

* No abnormal change

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Continued.......

Bodycote CONSULTUS laboratories

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Tel: +353 (0)21 48 222 88 Fax +353 (0)21 48 663 42 Email: info.consultus@bodycote.com

**Client ID** : EPS

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QUARTERTOWN IND, ESTATE, MALLOW
CO CORK

**No. of Samples** : 1
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**Date of Receipt** : 04/10/07
**Delivery Mode** : Refrigerated Van
**Date Test Initiated** : 04/10/07
**Date of Report** : 09/11/07
**Sample Condn on Receipt** Satisfactory


---

# TEST REPORT

**Sample No** : 6187Q1
**Client Reference** : SAMPLE REF . BALLINVREENA GWS OP 029 – 04/10/07

**Appendix I – Pesticides**

| Test | Test Result | ParametricValue | Unit |
|---|---|---|---|
| **Organohalide Pesticides** | | | |
| Aldrin | <0.001 | 0.03 | µg/l |
| Chlordane-α | <0.002 | 0.1 | µg/l |
| Chlorothalonil | <0.003 | 0.1 | µg/l |
| Cyfluthrin | <0.003 | 0.1 | µg/l |
| Cypermethrin | <0.004 | 0.1 | µg/l |
| Deltamethrin | <0.005 | 0.1 | µg/l |
| Dichlobenil | <0.001 | 0.1 | µg/l |
| Dieldrin | <0.002 | 0.03 | µg/l |
| Endosulphan-α | <0.002 | 0.1 | µg/l |
| Endosulphan-ß | <0.002 | 0.1 | µg/l |
| Endrin | <0.002 | 0.03 | µg/l |
| Fenvalerate | <0.003 | 0.1 | µg/l |
| HCH-α | <0.001 | 0.1 | µg/l |
| HCH-ß | <0.001 | 0.1 | µg/l |
| HCH-δ | <0.002 | 0.1 | µg/l |
| HCH-γ (Lindane) | <0.001 | 0.1 | µg/l |
| Heptachlor | <0.001 | 0.1 | µg/l |
| Heptachlor Epoxide | <0.002 | 0.1 | µg/l |
| Hexachlorobenzene | <0.001 | 0.1 | µg/l |
| Isodrin | <0.001 | 0.03 | µg/l |
| Methoxychlor | <0.001 | 0.1 | µg/l |
| op-DDE | <0.001 | 0.1 | µg/l |
| op-DDT | <0.003 | 0.1 | µg/l |
| op-TDE | <0.001 | 0.1 | µg/l |
| Permethrin, cis | <0.002 | 0.1 | µg/l |
| Permethrin, trans | <0.002 | 0.1 | µg/l |
| pp-DDE | <0.001 | 0.1 | µg/l |
| pp-DDT | <0.001 | 0.1 | µg/l |
| pp-TDE | <0.002 | 0.1 | µg/l |
| **Total Organohalides** | <0.005 | | µg/l |

SEE REVERSE FOR CONDITIONS

Continued.......

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Health Sciences www.healthsciences.bodycote.com www.bodycote.com
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Tel: +353 (0)21 48 222 88 Fax +353 (0)21 48 663 42 Email: info.consultus@bodycote.com

| | | | | | |
|---|---|---|---|---|---|
| **Client ID** | : | EPS | **Report No.** | : | 6187Q |
| | | MS SUSAN MC GRATH<br>EPS ELECTRICAL PUMP SERVICES<br>QUARTERTOWN IND, ESTATE, MALLOW<br>CO CORK | **Date of Receipt** | : | 04/10/07 |
| | | | **Delivery Mode** | : | Refrigerated Van |
| | | | **Date Test Initiated** | : | 04/10/07 |
| **No. of Samples** | : | 1 | **Date of Report** | : | 09/11/07 |
| **Sample Type** | : | Water | **Sample Condn on Receipt** | | Satisfactory |
| **Order Number** | : | B'VREENA | **Page** | : | 5 of 6 |

## TEST REPORT

**Sample No** : 6187Q1
**Client Reference** : SAMPLE REF . BALLINVREENA GWS OP 029 – 04/10/07

### Appendix I – Pesticides

| Test | Test Result | ParametricValue | Unit |
|---|---|---|---|
| **Organophosphorus Pesticides** | | | |
| Azinphos-methyl | <0.006 | 0.1 | µg/l |
| Carbophenothion | <0.007 | 0.1 | µg/l |
| Chlorfenvinphos | <0.009 | 0.1 | µg/l |
| Demeton-s-methyl | <0.008 | 0.1 | µg/l |
| Diazinon | <0.005 | 0.1 | µg/l |
| Dichlorvos | <0.006 | 0.1 | µg/l |
| Dimethoate | <0.008 | 0.1 | µg/l |
| Fenitrothion | <0.005 | 0.1 | µg/l |
| Malathion | <0.009 | 0.1 | µg/l |
| Mevinphos | <0.007 | 0.1 | µg/l |
| Parathion ethyl | <0.005 | 0.1 | µg/l |
| Phorate | <0.005 | 0.1 | µg/l |
| Phosalone | <0.008 | 0.1 | µg/l |
| Pirimiphos methyl | <0.005 | 0.1 | µg/l |
| Propetamphos | <0.004 | 0.1 | µg/l |
| Triazophos | <0.008 | 0.1 | µg/l |
| **Total Organophosphorous** | <0.009 | | µg/l |
| **Total Pesticides** | <0.014 | | µg/l |

SEE REVERSE FOR CONDITIONS

Continued......

Bodycote CONSULTUS laboratories

Health Sciences www.healthsciences.bodycote.com www.bodycote.com

Bodycote Consultus Ltd, Glanmire Industrial Estate, Glanmire, Co.Cork, Ireland
Tel: +353 (0)21 48 222 88 Fax +353 (0)21 48 663 42 Email: info.consultus@bodycote.com

**Client ID** : EPS

MS SUSAN MC GRATH
EPS ELECTRICAL PUMP SERVICES
QUARTERTOWN IND, ESTATE, MALLOW
CO CORK

**No. of Samples** : 1
**Sample Type** : Water
**Order Number** : B'VREENA

**Report No.** : 6187Q
**Date of Receipt** : 04/10/07
**Delivery Mode** : Refrigerated Van
**Date Test Initiated** : 04/10/07
**Date of Report** : 09/11/07
**Sample Condn on Receipt** Satisfactory


# TEST REPORT

**Sample No** : 6187Q1
**Client Reference** : SAMPLE REF . BALLINVREENA GWS OP 029 – 04/10/07

## Appendix II
## Polycyclic Aromatic Hydrocarbons (PAH)

| Test | Test Result | Unit |
|---|---|---|
| Benzo(b)fluoranthene | <0.001 | µg/l |
| Benzo –a-pyrene | <0.001 | µg/l |
| Benzo(g,h,i)perylene | <0.001 | µg/l |
| Benzo(k)fluoranthene | <0.001 | µg/l |
| Indeno(123-cd)pyrene | <0.002 | µg/l |
| **Total PAH** | <0.006 | µg/l |

## Appendix III
## Trihalomethanes (THM)

| Test | Test Result | Unit |
|---|---|---|
| Bromodichloromethane | <0.1 | µg/l |
| Bromoform | 0.5 | µg/l |
| Chloroform | <0.1 | µg/l |
| Dibromochloromethane | 0.3 | µg/l |
| **Total THM** | 0.8 | µg/l |

SEE REVERSE FOR CONDITIONS

Authorised By:
Teresa Twomey /Peter Piggott
Env Serv Manager/Micro Manager

**Customer:** EPS Limited

**Customer Address:** IDA Industrial Estate
Mallow
Co. Cork

**Customer Contact:** Susan McGrath

**Report Reference:** 08-01861-EPS

**Report Date:** 17/12/2008

**Customer PO No.:**
**Chain of Custody No.:** 1217



# Re-Issued Certificate Of Analysis

**Reason for Re-issue:** To remove Taste and Odour results
Analysis of 1 sample(s) submitted on 06/11/2008 is now complete.
We have the pleasure of enclosing your certificate of analysis.

Should you have any queries regarding the report or require any further services, we would be happy to discuss your requirements. For additional information about the company please log-on to our web site at the above address.

Thank you for choosing City Analysts Limited. We look forward to assisting you again.

**Authorised By:** ______________________ **Date:** __________

**Authorised Signatories:**
**Dublin :** Miriam Byrne, Niamh McIntyre, Jenny Pender, Adriana Przekazinska
**Limerick**: Dr. Ann Sullivan, Hugh O'Donnell. Eimear Carney, Donal Morrissey
**Note:** Information on methods of analysis and performance characteristics is available on request.

Note: Results relate only to the items tested.
Test report shall not be reproduced except in full or with written approval of City Analysts Ltd.

Template 1146
Revision 008

# Certificate of Analysis

**Customer:** EPS Limited

**Report Reference:** 08-01861-EPS
**Date Received:** 06/11/2008

**Customer Address:** IDA Industrial Estate
Mallow
Co. Cork

**Customer Contact:** Susan McGrath



**Sample Description:** Ballinvreena GWS
**Sample Type:** Treated Water
**Date Sampled:** 06/11/2008
**Lab Reference Number:** 52838

| Site/Method Ref. | Analysis Start Date | Parameter | Result | Units | PV Value | Accreditation Status |
|---|---|---|---|---|---|---|
| L/1041 | 06/11/2008 | pH | 7.14 | pH Units | 6.5 - 9.5 | INAB |
| L/3010 | 10/11/2008 | Colour | <5 | Hazen | NAC + ATC | INAB |
| L/3054 | 10/11/2008 | Turbidity | 0.08 | NTU | NAC + ATC | NON |
| L/1201 | 06/11/2008 | E.coli | <1.00 | MPN/100ml | 0/100mls | INAB |
| L/1201 | 06/11/2008 | Total Coliforms | <1.00 | MPN/100ml | 0 / 100mls | INAB |
| L/3000 | 10/11/2008 | Nitrite as NO2 | <0.07 | mg/l | 0.50 mg/l | NON |
| L/3000 | 10/11/2008 | Nitrate as NO3 | 19.27 | mg/l | 50 mg/l | NON |
| D/3001 | 12/11/2008 | Iron, Total | <20 | ug/l | 200 µg/l | INAB |
| D/3001 | 12/11/2008 | Manganese, Total | <5 | ug/l | 50 µg/l | INAB |
| L/3000 | 10/11/2008 | Ammonia as NH4 | 0.30 | mg/l | 0.30 mg/l | NON |
| L/3000 | 10/11/2008 | Chloride | 12.63 | mg/l | 250 mg/l | NON |
| L/3011 | 07/11/2008 | Conductivity | 254 | µs/cm at 20ºC | 2500 µs/cm | NON |
| L/3000 | 10/11/2008 | Sulphate | <20 | mg/l | 250 mg/l | NON |
| L/1214 | 06/11/2008 | Clostridium perfringens | <1 | cfu/100ml | 0 / 100mls | INAB |
| L/1208 | 06/11/2008 | TVC @ 22 ºC (72 Hours) | 6 | cfu/ml | NAC | INAB |
| SUB C | | Cyanide, Total | <0.7 | ug/l | 50 µg/l | UKAS |
| SUB C | | Bromate as Br03 | <0.6 | ug/l | 25 µg/l | UKAS |
| SUB C | | Selenium, Total as Se | <0.2200 | ug/l | 10.0 µg/L | UKAS |
| SUB C | | Mercury, Total as Hg | <0.015 | ug/l | 1.0 µg/l | UKAS |
| Sub C | | 1,2-Dichloroethane | <1.00 | ug/l | 3.0 µg/l | UKAS |
| SUB C | | Benzene | <0.06 | ug/l | 1.0 µg/l | UKAS |
| SUB C | | Tritium H-3 (as HTO) | <2.9 | Bq/l | 100 Bq/l | UKAS |
| SUB C | | Gross Alpha (as Am-241) | 0.105 | Bq/kg | 0.1 mSv/year | UKAS |

Note:

NAC & ATC - No abnormal change and acceptable to customers.
PV Value is the parametric value, taken from European Communities, (Drinking Water) (No. 2) Regulations, 2007. S.I. No. 278 of 2007, and relates only to drinking water samples.
Site D = Analysed at City Analysts Dublin. Site L = Analysed at City Analysts Limerick

# Certificate of Analysis

**Customer:** EPS Limited

**Report Reference:** 08-01861-EPS
**Date Received:** 06/11/2008

**Customer Address:** IDA Industrial Estate
Mallow
Co. Cork

**Customer Contact:** Susan McGrath



**Sample Description:** Ballinvreena GWS
**Sample Type:** Treated Water
**Date Sampled:** 06/11/2008
**Lab Reference Number:** 52838

| Site/Method Ref. | Analysis Start Date | Parameter | Result | Units | PV Value | Accreditation Status |
|---|---|---|---|---|---|---|
| SUB C | | Gross Beta (as K-40) | 0.036 | Bq/kg | | UKAS |
| SUB C | | Vinyl Chloride | <1.0 | ug/l | 0.50 µg/l | UKAS |
| SUB C | | Chloroform | <0.58 | ug/l | | UKAS |
| SUB C | | Bromodichloromethane | <0.17 | ug/l | | UKAS |
| SUB C | | Chlorodibromomethane | <0.17 | ug/l | | UKAS |
| SUB C | | Bromoform | <0.16 | ug/l | | UKAS |
| SUB C | | Total THM | 0 | ug/l | 150 µg/l | UKAS |
| **Pesticides (OCP):** | | | | | | |
| SUB C | | 124 TCB | <0.002 | ug/l | 0.5µg/L (Total) | UKAS |
| SUB C | | Aldrin | <0.003 | ug/l | 0.030 µg/L | UKAS |
| SUB C | | Chlordane-Alpha | <0.002 | ug/l | 0.5µg/L (Total) | UKAS |
| SUB C | | Alpha HCH | <0.002 | ug/l | 0.5µg/L (Total) | UKAS |
| SUB C | | Beta HCH | <0.002 | ug/l | 0.5µg/L (Total) | UKAS |
| SUB C | | Chlorothalonil | <0.003 | ug/l | 0.5µg/L (Total) | UKAS |
| SUB C | | Cyfluthrin | <0.003 | ug/l | 0.5µg/L (Total) | UKAS |
| SUB C | | Cypermethrin | <0.003 | ug/l | 0.5µg/L (Total) | UKAS |
| SUB C | | Delta HCH | <0.002 | ug/l | 0.5µg/L (Total) | UKAS |
| SUB C | | Deltamethrin | <0.004 | ug/l | 0.5µg/L (Total) | UKAS |
| SUB C | | Dichlobenil | <0.001 | ug/l | 0.5µg/L (Total) | UKAS |
| SUB C | | Dieldrin | <0.002 | ug/l | 0.030 µg/L | UKAS |
| SUB C | | EndosulfanA (alpha-Endosulfan) | <0.003 | ug/l | 0.5µg/L (Total) | UKAS |
| SUB C | | EndosulfanB (beta-Endosulfan) | <0.003 | ug/l | 0.5µg/L (Total) | UKAS |
| SUB C | | Endrin | <0.003 | ug/l | 0.5µg/L (Total) | UKAS |

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# Certificate of Analysis

**Customer:** EPS Limited

**Report Reference:** 08-01861-EPS

**Date Received:** 06/11/2008

**Customer Address:** IDA Industrial Estate
Mallow
Co. Cork

**Customer Contact:** Susan McGrath



**Sample Description:** Ballinvreena GWS
**Sample Type:** Treated Water
**Date Sampled:** 06/11/2008
**Lab Reference Number:** 52838

| Site/Method Ref. | Analysis Start Date | Parameter | Result | Units | PV Value | Accreditation Status |
|---|---|---|---|---|---|---|
| SUB C | | Fenvalerate | <0.003 | ug/l | 0.5µg/L (Total) | UKAS |
| SUB C | | Hexachlorobenzene | <0.002 | ug/l | 0.5µg/L (Total) | UKAS |
| SUB C | | Hexachlorobutadiene | <0.002 | ug/l | 0.5µg/L (Total) | UKAS |
| SUB C | | Gamma-HCH (Lindane) | <0.002 | ug/l | 0.5µg/L (Total) | UKAS |
| SUB C | | Heptachlor | <0.002 | ug/l | 0.030 µg/L | UKAS |
| SUB C | | Heptachlor Epoxide | <0.002 | ug/l | 0.030 µg/L | UKAS |
| SUB C | | Isodrin | <0.003 | ug/l | 0.5µg/L (Total) | UKAS |
| SUB C | | Methoxychlor | <0.003 | ug/l | 0.5µg/L (Total) | UKAS |
| SUB C | | op`-DDE | <0.002 | ug/l | 0.5µg/L (Total) | UKAS |
| SUB C | | op`-DDT | <0.002 | ug/l | 0.5µg/L (Total) | UKAS |
| SUB C | | op`-DDD (TDE) | <0.002 | ug/l | 0.5µg/L (Total) | UKAS |
| SUB C | | PCB - Arochlor 1254 | <0.018 | ug/l | 0.5µg/L (Total) | UKAS |
| SUB C | | Permethrin-cis | <0.003 | ug/l | 0.5µg/L (Total) | UKAS |
| SUB C | | Permethrin-trans | <0.004 | ug/l | 0.5µg/L (Total) | UKAS |
| SUB C | | pp`-DDE | <0.002 | ug/l | 0.5µg/L (Total) | UKAS |
| SUB C | | pp`-DDD (TDE) | <0.003 | ug/l | 0.5µg/L (Total) | UKAS |
| SUB C | | pp`-DDT | <0.002 | ug/l | 0.5µg/L (Total) | UKAS |
| Sub C | | Trichloroethene | <1.000 | ug/l | 10 µg/l | UKAS |
| Sub C | | Tetrachloroethene | <1.000 | ug/l | 10 µg/l | UKAS |
| **PAH (Polycyclic Aromatic Hydrocarbons):** | | | | | | |
| SUB C | | Fluoranthene | <0.002 | ug/l | 0.1µg/L (Total) | UKAS |
| SUB C | | Benzo(b)fluoranthene | <0.001 | ug/l | 0.1µg/L (Total) | UKAS |

Note:

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# Certificate of Analysis

**Customer:** EPS Limited

**Report Reference:** 08-01861-EPS
**Date Received:** 06/11/2008

**Customer Address:** IDA Industrial Estate
Mallow
Co. Cork

**Customer Contact:** Susan McGrath



**Sample Description:** Ballinvreena GWS
**Sample Type:** Treated Water
**Date Sampled:** 06/11/2008
**Lab Reference Number:** 52838

| Site/Method Ref. | Analysis Start Date | Parameter | Result | Units | PV Value | Accreditation Status |
|---|---|---|---|---|---|---|
| SUB C | | Benzo(k)fluoranthene | <0.001 | ug/l | 0.1µg/L (Total) | UKAS |
| SUB C | | Benzo (a) pyrene | <0.001 | ug/l | 0.01µg/L | UKAS |
| SUB C | | Benzo(ghi)perylene | <0.001 | ug/l | 0.1µg/L (Total) | UKAS |
| SUB C | | Indeno(1 2 3cd)pyrene | <0.002 | ug/l | 0.1µg/L (Total) | UKAS |
| SUB C | | Total PAHs 6 Constituents | 0 | ug/l | 0.10 µg/L | UKAS |
| SUB C | | Antimony, Total as Sb | 0.13 | ug/l | 5.0 µg/l | UKAS |
| SUB C | | Arsenic, Total as As | <0.370 | ug/l | 10 µg/l | UKAS |
| D/3001 | 07/11/2008 | Boron, Total | <100 | ug/l | 1000 µg/l | INAB |
| D/3001 | 12/11/2008 | Cadmium, Total | <0.5 | ug/l | 5.0 µg/l | INAB |
| D/3001 | 12/11/2008 | Chromium, Total | <5 | ug/l | 50 µg/l | INAB |
| D/3001 | 12/11/2008 | Copper, Total | <20 | ug/l | 2.0 mg/l | INAB |
| D/3001 | 12/11/2008 | Lead, Total | <2.5 | ug/l | 25 µg/l | INAB |
| D/3001 | 12/11/2008 | Nickel, Total | <2 | ug/l | 20 µg/l | INAB |
| D/3001 | 12/11/2008 | Aluminium, Total | <20 | ug/l | 200 µg/l | INAB |
| D/3001 | 07/11/2008 | Sodium | 9.967 | mg/l | 200 mg/l | INAB |
| **Pesticides (OPP):** | | | | | | |
| SUB C | | Azinphos methyl | <0.004 | ug/l | 0.5µg/L (Total) | UKAS |
| SUB C | | Carbophenothion | <0.012 | ug/l | 0.5µg/L (Total) | UKAS |
| SUB C | | Chlorfenvinphos | <0.005 | ug/l | 0.5µg/L (Total) | UKAS |
| SUB C | | Demeton-S-Methyl | <0.006 | ug/l | 0.5µg/L (Total) | UKAS |
| SUB C | | Diazinon | <0.006 | ug/l | 0.5µg/L (Total) | UKAS |
| SUB C | | Dichlorvos | <0.008 | ug/l | 0.5µg/L (Total) | UKAS |

Note:

NAC & ATC - No abnormal change and acceptable to customers.
PV Value is the parametric value, taken from European Communities, (Drinking Water) (No. 2) Regulations, 2007. S.I. No. 278 of 2007, and relates only to drinking water samples.
Site D = Analysed at City Analysts Dublin. Site L = Analysed at City Analysts Limerick

# Certificate of Analysis

**Customer:** EPS Limited

**Report Reference:** 08-01861-EPS

**Date Received:** 06/11/2008

**Customer Address:** IDA Industrial Estate
Mallow
Co. Cork

**Customer Contact:** Susan McGrath



**Sample Description:** Ballinvreena GWS
**Sample Type:** Treated Water
**Date Sampled:** 06/11/2008
**Lab Reference Number:** 52838

| Site/Method Ref. | Analysis Start Date | Parameter | Result | Units | PV Value | Accreditation Status |
|---|---|---|---|---|---|---|
| SUB C | | Dimethoate | <0.005 | ug/l | 0.5µg/L (Total) | UKAS |
| SUB C | | Fenitrothion | <0.004 | ug/l | 0.5µg/L (Total) | UKAS |
| SUB C | | Malathion | <0.004 | ug/l | 0.5µg/L (Total) | UKAS |
| SUB C | | Mevinphos | <0.004 | ug/l | 0.5µg/L (Total) | UKAS |
| SUB C | | Parathion ethyl | <0.006 | ug/l | 0.5µg/L (Total) | UKAS |
| SUB C | | Phorate | <0.009 | ug/l | 0.5µg/L (Total) | UKAS |
| SUB C | | Phosalone | <0.007 | ug/l | 0.5µg/L (Total) | UKAS |
| SUB C | | Pirimiphos methyl | <0.009 | ug/l | 0.5µg/L (Total) | UKAS |
| SUB C | | Propetamphos | <0.007 | ug/l | 0.5µg/L (Total) | UKAS |
| SUB C | | Triazophos | <0.003 | ug/l | 0.5µg/L (Total) | UKAS |
| SUB C | | Chlorpyriphos Ethyl | <0.010 | ug/l | 0.5µg/L (Total) | UKAS |
| L/3200 | 31/12/2008 | Enterococci | <1.0 | MPN/100ml | | NON |
| D/3015 | 24/11/2008 | Fluoride | 0.1 | mg/l | 0.8 mg/l | INAB |
| L/WEF 7.1 | 28/11/2008 | TOC | <0.4 | mg/l | NAC | NON |

Analysts Comments:

Gross beta result +/- 0.016 Bq/kg.

Note:

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Site D = Analysed at City Analysts Dublin. Site L = Analysed at City Analysts Limerick

| | |
|---|---|
| **Customer:** | EPS Operations Division |
| **Customer Address:** | IDA Industrial Estate<br>Mallow<br>Co. Cork |
| **Customer Contact:** | Susan Mc Grath |
| **Report Reference:** | 09-01746- |
| **Report Date:** | 13/11/2009 |
| **Customer PO No.:** | |
| **Chain of Custody No.:** | paperwork supplied |



# Certificate Of Analysis

Analysis of 1 sample(s) submitted on 07/10/2009 is now complete.
We have the pleasure of enclosing your certificate of analysis.

Should you have any queries regarding the report or require any further services, we would be happy to discuss your requirements. For additional information about the company please log-on to our web site at the above address.

Thank you for choosing City Analysts Limited. We look forward to assisting you again.

**Authorised By:** ______________________________ **Date:** ____________

**Authorised Signatories:**
**Dublin :** Miriam Byrne, Niamh McIntyre, Jenny Pender, Adriana Przekazinska
**Limerick**: Hugh O'Donnell. Eimear Carney, Colleen O'Hara, Maurice Daffy, Sylwia Wojtowicz.
**Note:** Information on methods of analysis and performance characteristics is available on request.

Note: Results relate only to the items tested.
Test report shall not be reproduced except in full or with written approval of City Analysts Ltd.

# Certificate of Analysis

**Customer:** EPS Operations Division

**Report Reference:** 09-01746-

**Date Received:** 07/10/2009

**Customer Address:** IDA Industrial Estate
Mallow
Co. Cork

**Customer Contact:** Susan Mc Grath



**Sample Description:** Ballinvreena GWS Audit
**Sample Type:** Treated Water
**Date Sampled:** 07/10/2009
**Lab Reference Number:** 70202

| Site/Method Ref. | Analysis Start Date | Parameter | Result | Units | PV Value | Accreditation Status |
|---|---|---|---|---|---|---|
| L/1201 | 07/10/2009 | Total Coliforms | <1.00 | MPN/100ml | 0 / 100mls | NON |
| L/1201 | 07/10/2009 | E.coli | <1.00 | MPN/100ml | 0/100mls | NON |
| L/3200 | 07/10/2009 | Enterococci | <1.0 | MPN/100ml | | NON |
| L/1214 | 07/10/2009 | Clostridium perfringens | <1 | cfu/100ml | 0 / 100mls | NON |
| L/1208 | 24/09/2009 | TVC @ 22 ºC (72 Hours) | <1 | cfu/ml | NAC | NON |
| L/1041 | 07/10/2009 | pH | 6.78 | pH Units | 6.5 - 9.5 | NON |
| SUB C | | Benzene | <0.06 | ug/l | 1.0 µg/l | UKAS |
| D/3001 | 14/10/2009 | Boron, Total | <100 | ug/l | 1000 µg/l | INAB |
| D/3001 | 15/10/2009 | Cadmium, Total | <0.5 | ug/l | 5.0 µg/l | INAB |
| D/3001 | 15/10/2009 | Chromium, Total | <5 | ug/l | 50 µg/l | INAB |
| D/3001 | 15/10/2009 | Copper, Total | <20 | ug/l | 2.0 mg/l | INAB |
| SUB C | | Cyanide, Total | <0.7 | ug/l | 50 µg/l | UKAS |
| D/3001 | 15/10/2009 | Lead, Total | <2.5 | ug/l | 25 µg/l | INAB |
| D/3001 | 15/10/2009 | Nickel, Total | <2 | ug/l | 20 µg/l | INAB |
| D/3000 | 12/10/2009 | Nitrate as NO3 | 15.86 | mg/l | 50 mg/L | INAB |
| D/3000 | 12/10/2009 | Nitrite as NO2 | <0.07 | mg/l | 0.50 mg/L | INAB |
| D/3001 | 15/10/2009 | Aluminium, Total | <20 | ug/l | 200 µg/l | INAB |
| D/3054 | 09/10/2009 | Turbidity | <0.5 | NTU | NAC & ATC | INAB |
| D/3000 | 12/10/2009 | Ammonia as NH4 | <0.13 | mg/l | 0.30 mg/l | INAB |
| D/3000 | 12/10/2009 | Chloride | 14.51 | mg/l | 250 mg/l | INAB |
| D/3011 | 09/10/2009 | Conductivity | 251 | µs/cm at 20ºC | 2500 µS/cm at 20ºC | NON |
| D/3001 | 15/10/2009 | Iron, Total | <20 | ug/l | 200 µg/l | INAB |
| D/3001 | 15/10/2009 | Manganese, Total | <5 | ug/l | 50 µg/l | INAB |

Note:

NAC & ATC - No abnormal change and acceptable to customers.
PV Value is the parametric value, taken from European Communities, (Drinking Water) (No. 2) Regulations, 2007. S.I. No. 278 of 2007, and relates only to drinking water samples.
Site D = Analysed at City Analysts Dublin. Site L = Analysed at City Analysts Limerick

# Certificate of Analysis

**Customer:** EPS Operations Division

**Report Reference:** 09-01746-

**Date Received:** 07/10/2009

**Customer Address:** IDA Industrial Estate
Mallow
Co. Cork

**Customer Contact:** Susan Mc Grath



**Sample Description:** Ballinvreena GWS Audit
**Sample Type:** Treated Water
**Date Sampled:** 07/10/2009
**Lab Reference Number:** 70202

| Site/Method Ref. | Analysis Start Date | Parameter | Result | Units | PV Value | Accreditation Status |
|---|---|---|---|---|---|---|
| D/3000 | 12/10/2009 | Sulphate | <20 | mg/l | 250 mg/l | INAB |
| D/3001 | 13/10/2009 | Sodium | 9.342 | mg/l | 200 mg/l | INAB |
| SUB C | | Chloroform | <0.9 | ug/l | | UKAS |
| SUB C | | Bromodichloromethane | 0.11 | ug/l | | UKAS |
| SUB C | | Chlorodibromomethane | 0.17 | ug/l | | UKAS |
| SUB C | | Bromoform | 0.30 | ug/l | | UKAS |
| SUB C | | Total THM | 0.58 | ug/l | 100 µg/l | UKAS |
| SUB C | | Vinyl Chloride | <1.0 | ug/l | 0.50 µg/l | UKAS |
| D/3010 | 09/10/2009 | Colour, True | <5 | Hazen | NAC & ATC | INAB |
| **Pesticides (OCP):** | | | | | | |
| SUB C | | 124 TCB | <0.002 | ug/l | 0.5µg/L (Total) | UKAS |
| SUB C | | Aldrin | <0.003 | ug/l | 0.030 µg/L | UKAS |
| SUB C | | Chlordane-Alpha | <0.002 | ug/l | 0.5µg/L (Total) | UKAS |
| SUB C | | Alpha HCH | <0.002 | ug/l | 0.5µg/L (Total) | UKAS |
| SUB C | | Beta HCH | <0.002 | ug/l | 0.5µg/L (Total) | UKAS |
| SUB C | | Chlorothalonil | <0.003 | ug/l | 0.5µg/L (Total) | UKAS |
| SUB C | | Cyfluthrin | <0.003 | ug/l | 0.5µg/L (Total) | UKAS |
| SUB C | | Cypermethrin | <0.003 | ug/l | 0.5µg/L (Total) | UKAS |
| SUB C | | Delta HCH | <0.002 | ug/l | 0.5µg/L (Total) | UKAS |
| SUB C | | Deltamethrin | <0.004 | ug/l | 0.5µg/L (Total) | UKAS |
| SUB C | | Dichlobenil | <0.001 | ug/l | 0.5µg/L (Total) | UKAS |
| SUB C | | Dieldrin | <0.002 | ug/l | 0.030 µg/L | UKAS |
| SUB C | | EndosulfanA (alpha-Endosulfan) | <0.003 | ug/l | 0.5µg/L (Total) | UKAS |

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# Certificate of Analysis

**Customer:** EPS Operations Division

**Report Reference:** 09-01746-

**Date Received:** 07/10/2009

**Customer Address:** IDA Industrial Estate
Mallow
Co. Cork

**Customer Contact:** Susan Mc Grath



**Sample Description:** Ballinvreena GWS Audit
**Sample Type:** Treated Water
**Date Sampled:** 07/10/2009
**Lab Reference Number:** 70202

| Site/Method Ref. | Analysis Start Date | Parameter | Result | Units | PV Value | Accreditation Status |
|---|---|---|---|---|---|---|
| SUB C | | EndosulfanB (beta-Endosulfan) | <0.003 | ug/l | 0.5µg/L (Total) | UKAS |
| SUB C | | Endrin | <0.003 | ug/l | 0.5µg/L (Total) | UKAS |
| SUB C | | Fenvalerate | <0.003 | ug/l | 0.5µg/L (Total) | UKAS |
| SUB C | | Hexachlorobenzene | <0.002 | ug/l | 0.5µg/L (Total) | UKAS |
| SUB C | | Hexachlorobutadiene | <0.002 | ug/l | 0.5µg/L (Total) | UKAS |
| SUB C | | Gamma-HCH (Lindane) | <0.002 | ug/l | 0.5µg/L (Total) | UKAS |
| SUB C | | Heptachlor | <0.002 | ug/l | 0.030 µg/L | UKAS |
| SUB C | | Heptachlor Epoxide | <0.002 | ug/l | 0.030 µg/L | UKAS |
| SUB C | | Isodrin | <0.003 | ug/l | 0.5µg/L (Total) | UKAS |
| SUB C | | Methoxychlor | <0.003 | ug/l | 0.5µg/L (Total) | UKAS |
| SUB C | | op`-DDE | <0.002 | ug/l | 0.5µg/L (Total) | UKAS |
| SUB C | | op`-DDT | <0.002 | ug/l | 0.5µg/L (Total) | UKAS |
| SUB C | | op`-DDD (TDE) | <0.002 | ug/l | 0.5µg/L (Total) | UKAS |
| SUB C | | PCB - Arochlor 1254 | <0.018 | ug/l | 0.5µg/L (Total) | UKAS |
| SUB C | | Permethrin-cis | <0.003 | ug/l | 0.5µg/L (Total) | UKAS |
| SUB C | | Permethrin-trans | <0.004 | ug/l | 0.5µg/L (Total) | UKAS |
| SUB C | | pp`-DDE | <0.002 | ug/l | 0.5µg/L (Total) | UKAS |
| SUB C | | pp`-DDD (TDE) | <0.003 | ug/l | 0.5µg/L (Total) | UKAS |
| SUB C | | pp`-DDT | <0.002 | ug/l | 0.5µg/L (Total) | UKAS |
| **Pesticides (OPP):** | | | | | | |
| SUB C | | Azinphos methyl | <0.004 | ug/l | 0.5µg/L (Total) | UKAS |
| SUB C | | Carbophenothion | <0.012 | ug/l | 0.5µg/L (Total) | UKAS |

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**Sample Description:** Ballinvreena GWS Audit
**Sample Type:** Treated Water
**Date Sampled:** 07/10/2009
**Lab Reference Number:** 70202

| Site/Method Ref. | Analysis Start Date | Parameter | Result | Units | PV Value | Accreditation Status |
|---|---|---|---|---|---|---|
| SUB C | | Chlorfenvinphos | <0.005 | ug/l | 0.5µg/L (Total) | UKAS |
| SUB C | | Demeton-S-Methyl | <0.006 | ug/l | 0.5µg/L (Total) | UKAS |
| SUB C | | Diazinon | <0.006 | ug/l | 0.5µg/L (Total) | UKAS |
| SUB C | | Dichlorvos | <0.008 | ug/l | 0.5µg/L (Total) | UKAS |
| SUB C | | Dimethoate | <0.005 | ug/l | 0.5µg/L (Total) | UKAS |
| SUB C | | Fenitrothion | <0.004 | ug/l | 0.5µg/L (Total) | UKAS |
| SUB C | | Malathion | <0.004 | ug/l | 0.5µg/L (Total) | UKAS |
| SUB C | | Mevinphos | <0.004 | ug/l | 0.5µg/L (Total) | UKAS |
| SUB C | | Parathion ethyl | <0.006 | ug/l | 0.5µg/L (Total) | UKAS |
| SUB C | | Phorate | <0.009 | ug/l | 0.5µg/L (Total) | UKAS |
| SUB C | | Phosalone | <0.007 | ug/l | 0.5µg/L (Total) | UKAS |
| SUB C | | Pirimiphos methyl | <0.009 | ug/l | 0.5µg/L (Total) | UKAS |
| SUB C | | Propetamphos | <0.007 | ug/l | 0.5µg/L (Total) | UKAS |
| SUB C | | Triazophos | <0.003 | ug/l | 0.5µg/L (Total) | UKAS |
| SUB C | | Chlorpyriphos Ethyl | <0.010 | ug/l | 0.5µg/L (Total) | UKAS |
| Sub C | | Tetrachloroethene | <0.060 | ug/l | 10 µg/l | UKAS |
| Sub C | | Trichloroethene | <0.100 | ug/l | 10 µg/l | UKAS |
| SUB C | | Antimony, Total as Sb | 0.17 | ug/l | 5.0 µg/l | UKAS |
| SUB C | | Arsenic, Total as As | <0.370 | ug/l | 10 µg/l | UKAS |
| **PAH (Polycyclic Aromatic Hydrocarbons):** | | | | | | |
| SUB C | | Fluoranthene | <0.002 | ug/l | 0.1µg/L (Total) | UKAS |
| SUB C | | Benzo(b)fluoranthene | <0.001 | ug/l | 0.1µg/L (Total) | UKAS |

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**Customer:** EPS Operations Division

**Report Reference:** 09-01746-

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**Sample Description:** Ballinvreena GWS Audit
**Sample Type:** Treated Water
**Date Sampled:** 07/10/2009
**Lab Reference Number:** 70202

| Site/Method Ref. | Analysis Start Date | Parameter | Result | Units | PV Value | Accreditation Status |
|---|---|---|---|---|---|---|
| SUB C | | Benzo(k)fluoranthene | <0.001 | ug/l | 0.1µg/L (Total) | UKAS |
| SUB C | | Benzo (a) pyrene | <0.001 | ug/l | 0.01µg/L | UKAS |
| SUB C | | Benzo(ghi)perylene | <0.001 | ug/l | 0.1µg/L (Total) | UKAS |
| SUB C | | Indeno(1 2 3cd)pyrene | <0.002 | ug/l | 0.1µg/L (Total) | UKAS |
| SUB C | | Total PAHs 6 Constituents | 0 | ug/l | 0.10 µg/L | UKAS |
| SUB C | | Bromate as Br03 | <0.6 | ug/l | 10 µg/l | UKAS |
| SUB C | | Selenium, Total as Se | <0.2200 | ug/l | 10.0 µg/L | UKAS |
| SUB C | | Total organic carbon | 0.46 | mg/l | | UKAS |
| SUB C | | Mercury, Total as Hg | <0.015 | ug/l | 1.0 µg/l | UKAS |
| Sub C | | 1,2-Dichloroethane | <1.00 | ug/l | 3.0 µg/l | UKAS |
| D/3015 | 15/10/2009 | Fluoride | <0.1 | mg/l | 0.8 mg/l | INAB |
| SUB C | | Odour (Dilution No.) | 0 | - | NAC & ATC | UKAS |
| SUB C | | Odour (Nature) | Ok | - | NAC & ATC | UKAS |
| SUB C | | Taste (dilution No.) | 0 | - | NAC & ATC | UKAS |
| SUB C | | Taste (Nature) | Ok | - | NAC & ATC | UKAS |

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