A REVIEW OF THE CONTRIBUTORY FACTORS AFFECTING WATER QUALITY IN THE DRUMCLIFF SPRINGS, CO. CLARE

By

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Submitted in part fulfilment of the HETAC requirements of the award of

Master of Science in Environmental Protection

at

Institute of Technology, Sligo

June 2005

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Abstract

The water supply for Ennis town and its environs is taken from Drumcliff Springs whose recharge area is a karst aquifer. Previous studies have indicated that due to the geology of the catchment, the varying thickness in the overlying soils and fast travel time in the groundwater flow regime, there is minimal attenuation of contaminants, both natural and anthropogenic, thereby making the groundwater and the Drumcliff Springs supply well extremely vulnerable to pollution. In addition to the known contributory factors resulting from the geological nature of the catchment, there are significant hazards associated with anthropogenic activities occurring within the catchment that are giving rise to risks of contamination of the supply.

The objective of this study is to review data generated during the past seven years, within the context of the above. The evaluation of this analytical water quality data available indicates that there has been no deterioration in water quality suggesting that the groundwater protection plan in place for the catchment is effective to some degree. The lack of correlation observed between rainfall and the parameters colour, turbidity and iron, leaves the water supply very vulnerable to a wide variation in water quality in the supply until such time as increased treatment is put in place. Nutrient levels observed are low. Risk of elevated nutrient levels can arise from septic tanks, wastewater treatment systems for single houses, municipal and commercial facilities and from the landspreading of organic waste. A link was observed between rainfall and elevated microbial levels and because of the karst nature of the catchment, a real danger still exists of contamination of the supply, in particular from microbial pathogens entering the groundwater, as a result of both agricultural activities and single house developments and municipal activities. In addition a similarly significant danger exists from hazardous materials, i.e. from hydrocarbons and other hazardous substances that are in use within the catchment, whether they are used as part of commercial operational processes, or in the storage of the hazardous materials, e.g. in petrol stations or in fuel tanks on farms or for home heating, or as a result of a large road-side spillage, resulting in a major emergency event.

It will be difficult to control the water quality in the supply unless proposed developments are planned in a sustainable manner and good practice is adopted in the management of waste materials arising in the catchment. Public awareness of the groundwater vulnerability is required to maintain good water quality status. The implications for the water supply and the associated public health issues remains a serious concern. Ongoing and indeed increased monitoring of the water quality within the catchment, together with sustainable management, landuse planning of activities that generate wastes and public co-operation is required if the risk of contamination from the various hazards existing is to be minimised.

Acknowledgements

I would like to express my sincere appreciation and gratitude to my project supervisor, Mr. Eamonn Grennan, whose interest, guidance and encouragement in relation to this thesis was invaluable.

My sincere appreciation and gratitude also to the many people who assisted me in completion of this thesis, in particular my employer, Clare County Council and my work colleagues who supported and assisted me along the way.

A special thank you to my husband, Neil and daughter Gráinne, without whose support, understanding and encouragement I would not have managed. Thank you also to my family and friends for their all their support and encouragement.

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1 INTRODUCTION

1.1. Background

The water supply source for Ennis town and its environs is taken from the Drumcliff Springs, which are located on the Western bank of the River Fergus, near Drehidnagower bridge. The supply serves a population of approximately 22,000 people. The surface and ground hydrology within the catchment is complex due to the predominant karst nature of the underlying limestone bedrock and the catchment is characterised by sinking streams and rivers. Activities at the land surface, i.e. farming activities, housing and commercial/industrial developments all have the potential to significantly impact on the quality of the groundwater as a high proportion of the rainfall within the catchment, in particular where impermeable sandstones and shales predominate, feeds quickly into the groundwater system. The ground water flow within the catchment is fast thereby permitting minimal attenuation of contaminants within the system. In light of this, and the main objectives of the Water Framework Directive 2000/60/EEC, which is to achieve "good status" for all waters, including groundwaters, by 2015, and in order to reverse any significant and sustained upward trend in concentration of any pollutant resulting from the impact of human activity, there is an onus on Ennis Town Council to protect the good water status in provision of a water supply that is suitable for human consumption and that is in accordance with the European Communities (Drinking Water) Regulations, 2000.

1.2. Catchment Area

The land catchment for Drumcliff springs, extends over an approximate area of 63 square kilometres, and has been mapped in previous studies carried out on the catchment by K. T. Cullen and the Geological Survey of Ireland (GSI). The catchment boundary is delineated on the west by topography where the catchment overlies Carboniferous Namurian sandstones and shales of relatively low permeability. The bedrock geology in the low lying areas is of the Lower Carboniferous Visean age with two dominant limestone formations present, namely the Burren Limestone Formation and the Slievenaglasha Limestone Formation, the former being the more dominant. The limestones have faulted in both north-south and east-west directions. Jointing is common parallel to the main fault trends and some may be solutionally enlarged (Deakin, 1999).

1.3. Water Quality

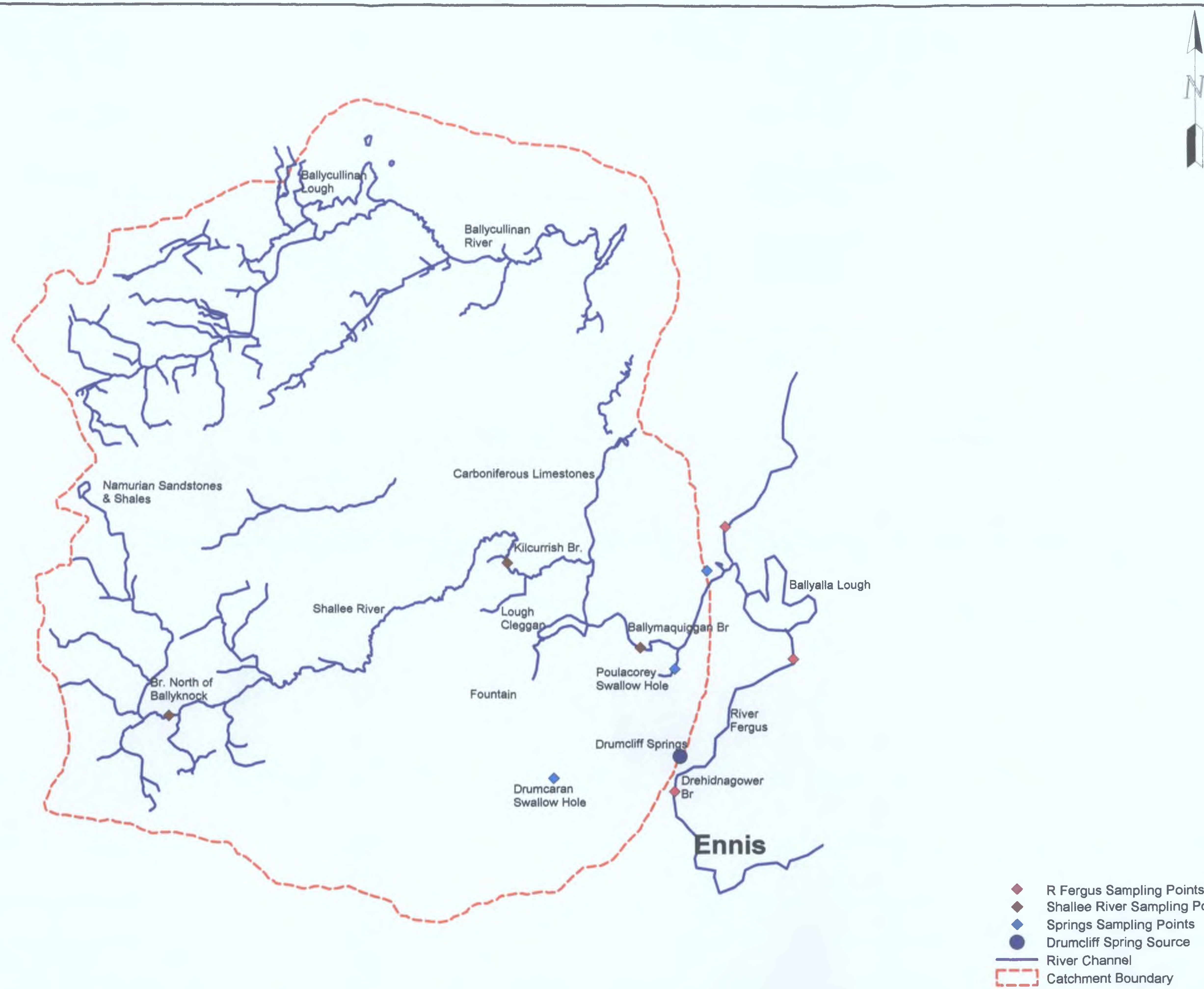
Water quality issues have arisen in the past with regard to the Drumcliff Springs supply source, resulting in the commissioning of a number of studies/investigations, whose objective was to identify the contributory factors, which are affecting water quality and to develop a groundwater protection plan for the catchment. The studies concluded that fluctuations in colour and turbidity are typically the result of a vulnerable limestone source, with a "flashy response" to rainfall events (Cullen, 1990 and 1991, and Deakin, 1999). Another water quality issue identified was that of high iron levels in the supply, and this has been attributed to the presence of iron in the sandstones and shales along the outer perimeter of the catchment and in the dissolution of iron at the sandstone limestone interface.

While water quality is a function of both natural and human influences, the previous studies identified the natural influences as the principle contributory factor to water quality (Deakin, 1999). However account must also be taken of the potential impact arising from anthropogenic activities and their associated hazards that may be contributing to the water quality, e.g, from agricultural, municipal and commercial activities and also in light of pressures from the increased level of housing development within the catchment due to it's proximity to Ennis.

1.4. Objective

This study will evaluate the anthropogenic influences on the water quality within the catchment. It will identify the existing hazards in map form, so as to provide a more comprehensive understanding in the management of the potential risks to water quality. The study will also critically review and evaluate new analytical data available from Ennis Town Council and Clare County Council for the raw water at the Drumcliff Water Treatment Plant, the Drumcliff Springs, the two principle inflows to the springs and the Shallee River. The review will provide a more comprehensive understanding of the contributory factors affecting the water quality, it will identify if there has been any change or deterioration in the water quality of the supply source and will highlight any trends emerging in the water quality, which may confirm or identify a different focus or contributory factor that has not been previously observed. Once all potential hazards are identified, the water quality problems encountered in provision of a potable water can be addressed. In as far as is practicable the risks to the supply source can be removed or minimised through the implementation of the groundwater plan and through sustainable planning.

Map i Showing Drumcliff Springs Catchment, River Channel and Sampling Points



Extract from Ordinance Survey of Ireland Discovery Series Map No. 57 ap Scale: 1cm = 0.62Km

2 PREVIOUS REPORTS

Elevated levels for the parameters iron, colour and turbidity, which exceed the European Community drinking water standards, have been recorded periodically in the Drumcliff Springs water supply and as the major water supply source for Ennis town and its environs, both Ennis Town Council and Clare County Council required that significant factors affecting the water quality of the supply source be investigated. A review was carried out on previous studies, that had been carried out on the Drumcliff Springs catchment.

2.1. Geology

Cullen (1989) describes how the Drumcliff Springs discharge area is within a karst limestone aquifer, which is characterised by disappearing rivers, swallow holes and springs. The geology is defined as being predominantly Lower Carboniferous Limestone with varying thickness in the overlying soils, containing well drained grey-brown podzolics, brown earths and rendzinas. The impact on groundwater vulnerability depends on the thickness and permeability of the glacial deposits. To the west of the catchment, the bedrock is the younger Upper Carboniferous Sandstones and Shales, which are covered by surface water gleys and glacial tills. These soil types have a high percentage clay content resulting in poor drainage. Finch (1971) indicates that the gley soils developed on the Upper Carboniferous Shales contain the highest iron content, typically 4% free iron. Due to the low permeability of the bedrock on the western boundary, there is a high percentage of rainfall run-off to surface waters (Deakin, 1999).

2.2. Water Flows

Cullen (1989) states that water tracing demonstrated how water from the Ballygriffey River sinking at Poulacorey swallow hole, travels underground to Drumcliff springs, in less than 24 hours, indicating fast travel times. A second potential source to Drumcliff springs, Drumcaranmore swallow hole, was also identified. This link between Drumcaranmore Swallow hole and Drumcliff Springs was confirmed by Cullen (1990). Like Poulacorey Swallow hole, the travel time was fast indicating "*the flow is in* *solutionally widened fissures or cave passages, therefore the degree of purification is minimal.*" Deakin (1999) found that the majority of the flow is from Poulacorey Swallow hole, with Drumcaranmore Swallow hole contributing only during wet weather.

Five main inflows to the springs were identified namely: -

1. Ballycullinan System, to the north of the catchment, which incorporates Lough Reagh. It is traced southwards to the east of Lough Cleggan and to the Poulacorey River near Ballygriffey Castle. The system eventually joins the River Fergus north of Ennis near Ballyalla Lough.
2. Shallee/Ballygriffey system, meets Ballycullinan River to the north of Lough Clegan.
3. Lough Clegan system including the lake and its tributary, which rises at Fountain Cross.
4. Magowna System, which flows underground at Magowna and has been traced to the Ballygriffey system.
5. Greenpark System to the south of the catchment, which sinks at Drumcarronmore and re-emerges at Drumcliff springs. This system can be dry on occasion.

The two most significant inflows to the springs are Poulacorey and Drumcaranmore swallow holes. c.f. Map 1.

2.3. Meteorology

Cullen (1990) found the relationship between the contaminant variables and rainfall was not close enough to allow for prediction.

2.4. Water Quality

In assessing the water quality, Cullen (1989) identifies the source of elevated iron levels at Drumcliff springs as being "*from surface water, both natural and artificial sources, and also from groundwater flow, from the transition boundary between the Limestone or interbedded Limestones and Shales on the western boundary.*" Cullen (1990) suggests that *colour and turbidity contamination incidents are related somewhat to rainfall perhaps as a result of the wash out of organic matter from the soils into sinking streams.*

Iron contamination incidents are not related to rainfall hence the iron contamination is arising from a different source." Cullen (1991) states *"the source of contaminants as being from a) the Shale bedrock and b) the degree of purification due to conduit flow and lack of thick overburden within the catchment. Consequently, the catchment is highly vulnerable to contamination from septic tanks and agricultural effluents if a protection plan is not in place."* Deakin (1999) states that the springs respond rapidly to recharge and have a highly variable water quality, which is likely to be dependent on the water quality in the rivers. Deakin also indicates that the link between Drumcliff Springs and Drumcaranmore Swallow hole is significant in that the water quality at Drumcaranmore swallow hole has been identified as the poorest quality of all site locations analysed. Deakin further states that the analytical data showed that the contaminants are primarily due to natural diffuse sources, i.e. from iron in the bedrock thus *"the water quality issue at Drumcliff springs cannot be resolved"* and *"fluctuations in the contaminants recorded are typical of a karst environment where there is a rapid response to rainfall events and short residence times. Bacterial contamination can originate from anywhere in the catchment. The Namurian rock, on the western boundary, is the likely origin of the suspended matter."*

2.5. Groundwater Protection Plans

Cullen (1991) developed a draft Protection Plan for the Drumcliff Catchment. The plan included a set of maps showing the geology, rock outcrop and depth to bedrock, soils, Quaternary deposits for the catchment and a groundwater vulnerability map for the Drumcliff catchment, which was to be used as a guide in planning decisions. A source protection map for Drumcliff springs was also compiled. The maps were accompanied by explanatory text outlining the controls on proposed developments that should be implemented to safeguard the supply. The catchment was divided into four source protection zones, dependant on the vulnerability risk assigned. The plan was developed in accordance with the aquifer protection policy proposed by the Geological Survey of Ireland in 1986.

Deakin (1999), developed a Groundwater Protection Plan for the Drumcliff Springs catchment, which took into account the previous reports by Cullen, together with additional information, and formatted it in a manner which was consistent with the national source protection guidelines as set out in the joint document by the DOE, EPA and GSI, in 1999.

Deakin (1999) considered that all of the catchment fell within the inner protection area if the 100-day travel time to the supply source criteria was applied as per national guidelines. However, Deakin (1999) proposed that all limestone areas, within the catchment, be included within the inner source protection area, plus an additional 100m buffer zone over the Namurian rocks. The remainder of the catchment (i.e. the area to the west of the catchment, over Namurian rocks) to be included in the outer protection zone.

As in the previous Cullen draft protection plan, a response matrix and appropriate controls on development and differing activities accompanied the report, which are dependant on the combining of the source protection areas with the vulnerability categories to arise with groundwater protection zones, Map ii.

Pouladower spring was identified as a possible alternative water supply for Ennis. A Groundwater Source Protection Plan was compiled for Pouladower spring also, which defined the catchment area, the main inflows and identified the geology, soils, depth to bedrock and vulnerability risk to groundwater in the catchment area (Deakin, 2000).

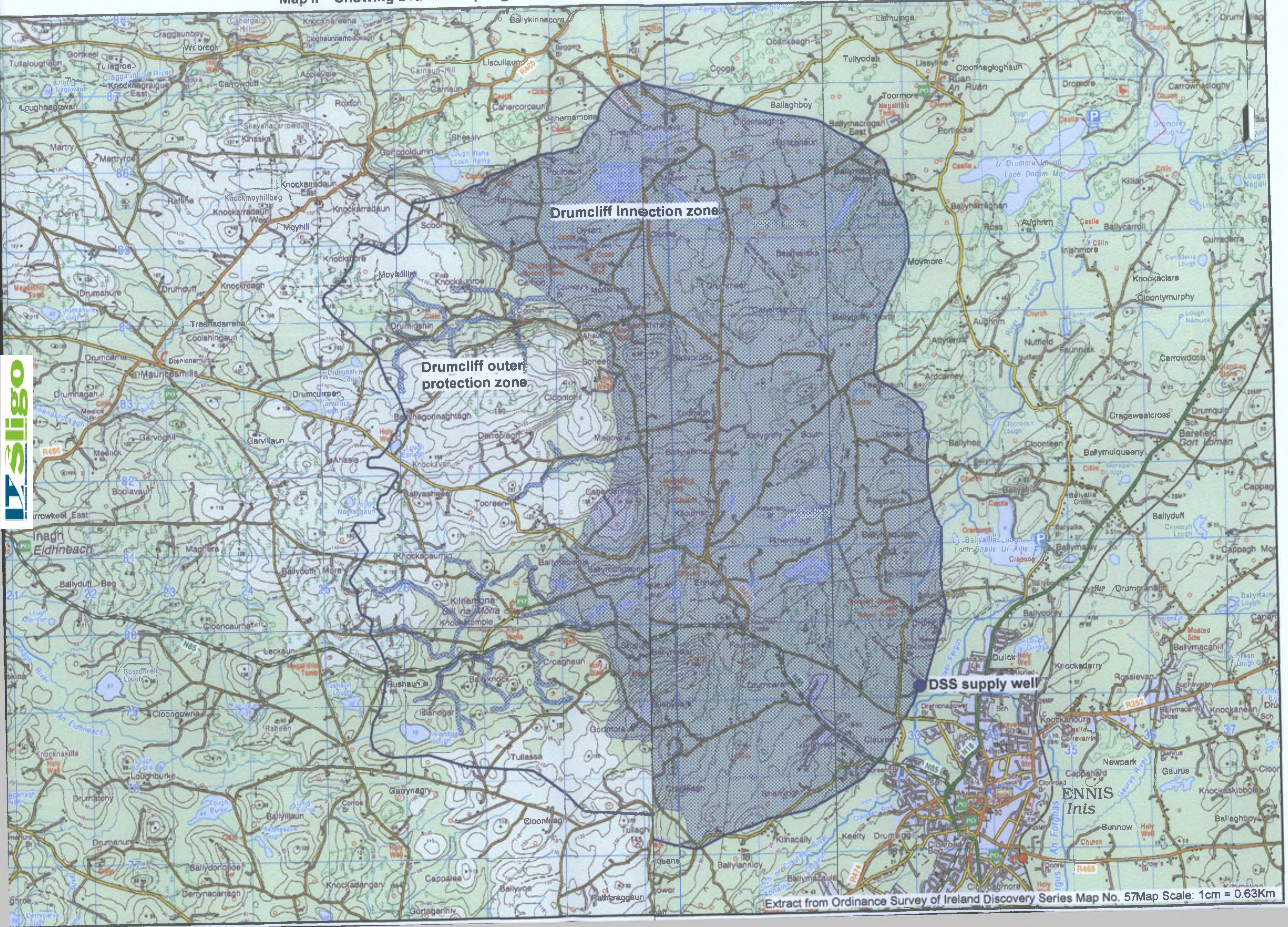
2.6. Recommendations

Deakin (1999), recommended continued monitoring of water quality within the catchment and the development of hazard mapping of potential activities, which would impact on water quality.

2.7. Farm Surveys

A farm survey carried out in 2003 by Clare County Council took the form of three sub-catchments, 1) Shallee River; 2) Ballycullinan Lough; 3) Drumcliff Springs; The primary focus of the farm survey was to assess farmyard pollution control that is in place on the farm. A total of one hundred and sixty farms were surveyed.

Map ii Showing Drumcliff Springs Catchment Area, \ner and Outer Protection Zones highlighted



3 LITERATURE REVIEW

A literature review was conducted on studies carried out on similar catchments to the Drumcliff Springs, on Geological Survey of Ireland (GSI) reports on water quality, on various studies on the impacts from nutrients, on reports regarding the impact of septic tank effluents on groundwaters and on guidance documents/manuals and legislation on the protection of groundwaters.

3.1. Geology

Pouladower spring, situated adjacent to the Drumcliff Springs Catchment, is a large karst spring and is considered a combined groundwater and surface water source, Deakin (2000). It responds rapidly to recharge. *"The water quality at the spring is of good quality due to the lack of hazards, adequate dilution and sedimentation in lakes within the catchment. Groundwater also contributes to the source from smaller fissures outside the main conduits of flow,"* (Deakin, 2000).

The lack of soil cover over the Burren Plateau means that there is limited storage of precipitation as soil moisture, thus rainfall becomes recharge (Drew and Daly 1993). This is the case in a large proportion of the Drumcliff springs catchment where the soil cover is minimal (Cullen, 1991 and Deakin 2000).

3.2. Water Flows

"*Surface run-off from soils is principally a winter phenomenon whereas drainage from paved and hard surface takes place all year round.*" (Mulqueen, 2001). Rainfall falling on an impermeable surface will give rise to overland flow to groundwater and to streams and rivers. "*Some infiltration into the soil occurs, depending on the slope and the water table level, where rainfall falls on permeable soils.*" (ibid).

In considering groundwater flow, Drew and Daly (1993) state "*for pollutants to reach the water table and enter groundwater, dilution is much greater in rocks with intergranular permeability and thus the resultant pollutant concentrations are much less. The worst situation is in karst limestone areas where flow rates are very high due* *to the widening of fissures by solution. There is little scope for attenuation other than by dilution".* The authors also state that "*permeability is a measure of the capacity of the rock to transmit water. Consequently the degree and type of permeability affects not only the groundwater and surface water flow in an area but also the degree of vulnerability to pollution".* This is significant when considering the Drumcliff springs catchment, since it is defined as a karst limestone aquifer.

Daly (2002c) considers preferential flow paths in soils and subsoils and states *"where present, bypass flow can greatly decrease the time taken for solutes and micro-organisms to migrate through the soil and subsoil".* He states "*research in this area indicates that bypass flow is likely to occur especially, in areas of very shallow bedrock after heavy rainfall, thus bypassing the protection provided by the topsoil and upper part of the subsoil".*

Catchments with fractured rock or karst weathered limestone aquifer below a thin soil or subsoil cover and pasture are particularly vulnerable to contamination by cryptosporidium and other microbial pathogens, e.g. E.coli 0157, (Ball, 1997). The author states "*during summer months, when the soil is dry, and following short intense rainfall showers, preferential flow paths, where present, provide conduits for rapid recharge to the water table for slurry/manures (containing microbial pathogens) that are spread on land*" This has serious health implications for private well supplies that do not have any form of treatment.

Flynn and Sinreich (2004) consider that there are numerous factors that influence vulnerability, however they claim there is a general consensus that geological and hydrogeological factors, including texture, geochemistry and water content of the various units encountered by a contaminant along a flow path play an important role. The spatial variation in these properties can be critical in determining whether contaminant break-through to a water supply will occur. Their research indicates that water can travel rapidly through the unsaturated zone, particularly in fractured limestone.

Traditionally soil scientists believed that Phosphorus (P) added to soil was readily immobilised and could not be leached. However it is now accepted that diffuse leakage of P from soils can occur and may be contributing to water quality deterioration. Where gley soils have been drained, there is a preferential flow path for the P loss to groundwater or subsurface flow (EPA, 2001a).

3.3. Water Quality

McGarrigle et al (2003) reports that groundwater quality is a function of natural processes as well as anthropogenic activities. In light of this there is a need to take account of any baseline quality criteria in interpreting the results of groundwater monitoring programmes.

Daly, (1994) states that groundwater chemistry is dependent on the nature of subsoils and rocks that it passes through. In Ireland, limestone rock is common, and consequently the groundwater is generally hard. These findings are confirmed by (Cronin and Deakin, 2000).

In assessing groundwater quality data in a similar catchments to Drumcliff Springs, in Mid-Galway, South Mayo and North Clare, Drew and Daly (1993) state "*iron levels, can be due to either natural conditions, contamination by organic wastes or occasionally by corrosion of steel liners.*" They indicate that "*effluent from organic wastes can cause deoxygenation in the ground resulting in dissolution of iron from the soil, subsoil and bedrock. Nitrates are more likely to originate from point sources rather than diffuse sources and bacterial contamination is a common contaminant. In karst areas, due to the minimal attenuation, treatment of a potable supply is required. They conclude that the groundwater pollution originated from four main sources: a) septic tanks systems, in particular where soakpits are used, b) farmyards, c) landspreading of organic wastes and d) sewage in sinking streams.*" Other significant local contamination can arise from leakages, spillages and dumps/landfill sites. To protect the groundwater, they advocate that landuse planning is required to provide a balance between protection of the environment and the need for development. Daly (1994) agrees with the above stating that "*the main source of chemical pollutants is from farmyards and septic tanks, however overall, pollution of groundwater is microbial rather than chemical. The significant parameters arising from human activities are nitrate, ammonia, potassium, chloride, iron and manganese. These* *parameters along with E. coli are categorised as indicator parameters of groundwater contamination."*

Cronin, and Deakin (2000) conclude that the main quality issues arising in water supplies in Co. Clare are iron and manganese, especially in groundwater's derived from sandstone and shale formations, bacteriological pollution, high turbidity and high lead levels (in one supply in East Clare, which has since been replaced by a new supply). They state that the iron and manganese problem is caused by natural conditions as a result of the dissolution of iron and manganese from the sandstone and shale under reducing conditions. The same conditions apply for lead.

In some springs and boreholes in karst areas, high turbidity occurs after heavy rainfall. (Cronin and Deakin, 2000). They conclude that *"the high turbidity is caused where (a) sediment that has collected in fissures and cavities is washed out at the start of recharge events, and (b) where there is a direct link between the source and a swallow hole into which surface water containing sediment is flowing."* EPA (2001b) describes that *"turbidity in water arises from the presence of very finely divided solids, which are not filterable by routine methods,"* whereas colour in water, *"reflects the presence of complex organic molecules derived from vegetable matter such as peat, leaves, branches, etc."* The degree of colour in water will vary to a large extent, due primarily to the origins of the vegetable matter. As with turbidity, "*the highest colour levels in rivers occurs in floods, especially the first flood after a dry season when accumulated deposits of decaying leaves and debris are swept up into the heavy flow releasing highly colouring matter" (ibid).*

"Bacteriological pollution is present in a relatively high proportion of groundwater supplies in Clare and arises mainly from extremely vulnerable areas providing little or no protection, rapid groundwater flow, poor design in septic tanks and farmyard systems, landspreading of organic wastes and poor location and protection of wells" (Cronin and Deakin, 2000). The authors found that Nitrate levels are generally low and with the exception of one supply, all were below the European Community (EC) Maximum Allowable Concentration (MAC) of 50mg/l NO_3 (EC Regulations, 2001). Elevated Nitrate levels were recorded in the Bridgetown Public Water Scheme i.e.

33.5mg/l NO_3 and 38.55mg/l NO_3 on October 1997 and March 1998 respectively, where the guide level of 25mg/l NO_3 was exceeded (Clare County Council data).

Interim guideline values for a range of substances, which can be used to assist in the characterisation of Groundwater are set out by the (EPA, 2003). The methodology for assessment of groundwater chemical status and assigning either good or poor groundwater status is defined. The methodology is consistent in approach and takes account of the natural variation in quality due to geology. A characterisation "core group" – refer to Table 3.1 listing the parameters, which should be analysed for in all cases with an additional guide list of "site specific" parameters that may be added to the core group.

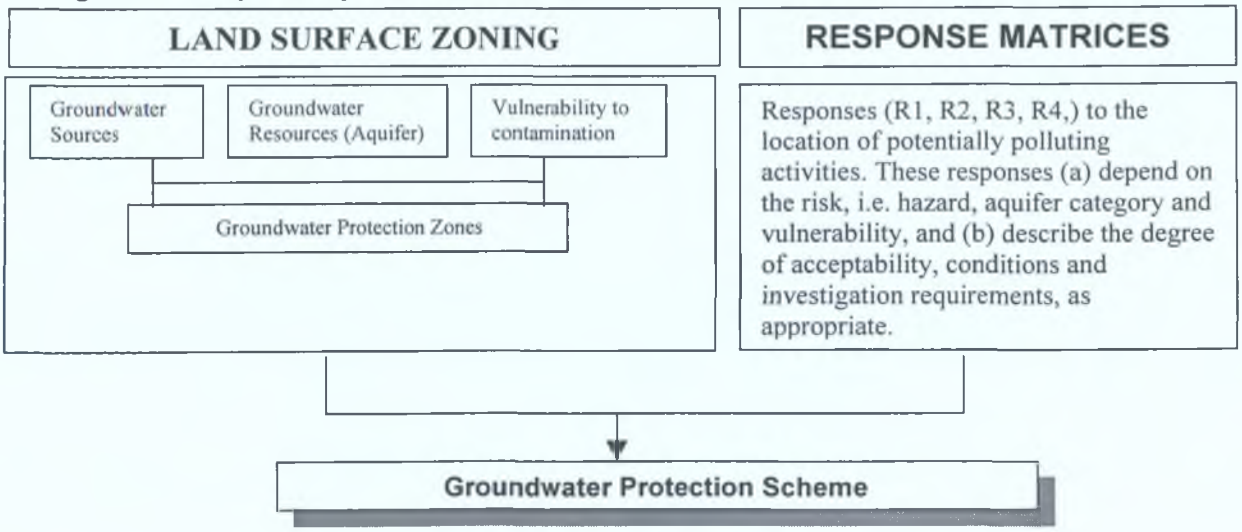
3.4. Groundwater Protection Plans

DOELG, EPA and GSI (1999) set out the methodology for the preparation of Groundwater Protection Schemes and provides guidelines for planning and licensing authorities to assist in decision making on the location and control of developments and activities to protect groundwater. There are two main components to the scheme:

1). Land surface zoning

2). Groundwater protection responses

Fig. 3.1 Summary of Components of Groundwater Protection Scheme



Reproduced from Groundwater Protection Schemes, DOELG, EPA, GSI, (1999) The scheme is based on the concept of groundwater contamination risk and risk management to maintain the quality and quantity of groundwater. The probability of contaminated groundwater is dependent on the hazard or potential source of contaminant within the catchment and the vulnerability risk of the hazard reaching the groundwater. The groundwater protection responses for different zones indicate the acceptability of certain activities with respect to the hazard, the aquifer category, source protection and groundwater vulnerability. Responses have been developed for potential hazards such as landfills, on-site wastewater systems and landspreading of organic wastes.

As for Drumcliff Springs, a groundwater source protection plan for Pouladower spring was developed by Deakin (2000), which defines the catchment area, the main inflows and identifies the geology, soils, depth to bedrock and vulnerability risk to groundwater in the catchment area.

3.5. Impact on Groundwaters from Septic Tanks

The EPA (2000a) provides guidance on design, operation and maintenance of on-site wastewater treatment for single houses. The objective is to prevent direct discharge of untreated wastewater to groundwater. The methodology is outlined for site characterisation and assessment and includes the groundwater protection response matrix, which takes account of site assessment, geology, subsoil, aquifer, etc.

Septic tanks systems are the most important means of sewage disposal in Ireland with over 300,000 septic tanks serving in excess of one million people (Daly, Thorn and Henry 1993). The effluent from septic tanks is highly pollutant containing faecal bacteria, which is the most common form of pollutant, high levels of nitrogen, phosphorus and other constituents. This research is confirmed by Keegan (2001) and Daly (2001). In a paper by Daly, D., (2004) he further states that "*septic tank systems are reported as one of the main sources of bacteriological pollution of private wells due to inadequate construction and location of the system rather than the system itself. Thus effluents from on-site systems pose a threat both to human health and to the environment.*"

Treatment of the effluent takes place in the ground and consequently the degree of contamination is dependant on the composition and thickness of subsoil on site. The role of the ground or geological materials is critical in its safe disposal (Daly, Thorn and Henry 1993). Septic tank effluent can cause pollution where soakage is either inadequate or excessive. There is a need for additional treatment in unsuitable sites and the distance between the wastewater treatment system and a well or borehole located on the one site is critical. Daly (2001) states "*if installed properly in accordance with the EPA manual and certified by a "competent" person, septic tanks provide adequate and cost effective treatment of the effluent in a sustainable manner*." However advanced systems are required in areas, which are unsuitable for conventional systems. The use of the EPA manual, which requires site characterisation and evaluation, is essential before a decision can be made on the most suitable system. Keegan (2001) concurs with this and with regard to the development of the response matrix. Keegan considers that for extremely vulnerable inner source protection areas, conventional septic tanks are not acceptable and a minimum of 1.8m of unsaturated soil/subsoil beneath the invert of the polishing filter is required. The depth of subsoil over the bedrock is critical in keeping the groundwater safe and clean and needs to be taken into account in the assessment of potentially polluting activities from a hydrogeological perspective (Daly, 2002b). This form of control has major implications for development of on-site systems within the Drumcliff catchment area, as the catchment borders the Ennis urban area with the associated increase in development pressures.

Other research by Gray (2004) found that the appropriate selection and installation of septic tanks, as well as percolation areas, is critical if the wastewater treatment system is to be effective in preventing surface and groundwater pollution. Gray further states that *"no two sites are identical hence the tank design and installation must be optimised for each household and location, together with the variable geological factors particular to the site."* He stipulates that account must be taken of the fact that all used water is routed to the tank rather than only foul waste in the design criteria. In the past this has resulted in loss of solids from the tank reducing the efficiency of the percolation area.

Effluent treatment is most effective in dry soils i.e. where there are aerobic conditions, however even with good subsoil conditions, some contaminants will enter the groundwater, mainly nitrates and chlorides and to a lesser degree, sulphates. A minimum safe distance of 60m is recommended where the groundwater protection is relatively poor, thus site suitability is critical (Daly, 2002d).

Management of the threat posed from on-site wastewater treatment is a crucial issue in land-use planning. Even with the installation of advanced systems, the quantity of effluent produced does not decrease. When account is taken of the quality and quantity of the effluent, there is a significant risk to groundwater. Microbial contamination of wells from septic tank effluent is very high, (it is estimated to be between 30 - 50%). Faecal bacteria are an indicator of microbial pathogens such as viruses and cryptosporidium, adding to the threat to human health. Daly, D. (2004) reiterates the fact that the location of a well and an on-site wastewater treatment in one site is inherently risky unless ground conditions are suitable. With respect to future developments in unsewered areas, as a result of the spread of urban areas, the impact on groundwater needs to be managed in terms of density of developments, use of adequately trained staff in assessment of sites, use of advanced systems to reduce the pollutant loading and the need for enforcement by local authorities of the systems in place (Daly, 2001b).

In order to achieve sustainable development, there is a need to preserve the quality of water resources. The most controversial issue emerging is that of wastewater treatment for domestic waste, both rural and urban. This highlights the need for better implementation of existing and future standards, stronger enforcement and monitoring and greater responsibility in minimising the risk to groundwater. (Daly, G. 2004)

3.6. Impact on Groundwaters from nutrients

The origin of nutrients lost to waterbodies is from both point and diffuse sources (Mulqueen, 2001). The nutrient enrichment of waterbodies is determined by the interaction between rainfall and the ground surface, subsurface soil and rock layers and drainage from farmyards, dairy buildings, domestic and business premises, industrial sites and public utilities.

It is generally accepted that there is a positive relationship between the soil Phosphorus test (STP) and loss to water (Tunney, Daly and Kurz, 2001) who indicate the EPA's estimate that over 50% of phosphorus (P) loss to waters is from agricultural sources. From an agricultural perspective, P loss to waters is considered to be from diffuse sources, in particular after heavy rainfall events, following landspreading, where P has accumulated in the top layer of soil and from fields that are intensively grazed. The amount of P loss is dependant on hydrological and management characteristics of the site.

Contribution of diffuse agricultural sources to the overall P load increases with the percentage of agricultural land in a catchment. Most of the P loss is attributed to excessive accumulation of P in soils because of long-term inputs of inorganic fertilizer and manures (NDP and EPA 2000). P loss is affected by the catchment topography, geology, soil type and land use. It can be by overland flow or by subsurface preferential flow. The highest loss is from arable lands, the lowest from forested areas. Rainfall is a significant factor in P loss, the highest loss is after the first storm event following a dry period. Groundwater P concentrations is influenced mainly by geology and overlying soils and it has been shown that the groundwater flow increases during high flow events, especially in karstic areas (Drew and Daly 1993). Groundwater can also be a source of P to lakes and rivers.

Average STP (soil test P) in Ireland has increased tenfold from less than one in 1950 to over eight by the year 2000 (Tunney, Daly and Kurz, 2001). In their research, they show that the higher the soil P tests the higher the risk of potential P loss to water. The average water-soluble P concentration in waters, from a high P site, is about ten times higher than for a low P site. Soils with a higher iron and aluminium content have a higher capacity to bind P than peat soils (ibid). Where manure/slurry/fertilizer is applied yearly to grassland, the P accumulates in the top layer of the soil, which becomes easily saturated with P and, after heavy rainfall events, the water infiltrates the top layer and can carry significant amounts of P to surface waters (ibid). Where the water table is shallow phosphorus spread on riparian zones are highly susceptible to being lost to streams.

EPA (2000b), research indicates that there is still a surplus in the balance in P inputs and outputs, which is contributing to the increase in soluble P in waters. This research also indicates that for sustainable grass production and water quality, the STP should be in the lower range for optimum or near optimum agronomic production (Tunney, Daly and Kurz, 2001).

Ryan (2001) found that leaching of nitrate occurs when, concurrent with downward soil water movement, and the supply of nitrate in the soil solution exceeds plant and denitrification demands. Hence nitrate loss to water occurs mainly in winter when soil moisture is at field capacity, precipitation levels are highest, thus there is greater movement of water downwards. Ryan further states that ploughing of grass leads to increased mineralisation of soil organic N and increases the risk of nitrate leaching to waters. Factors, which predispose nutrient leaching, include excessive application rates in late autumn when there is no uptake of nutrient by crops. Data on recharge from free draining soils indicate minimal recharge to groundwater between May and August, however the recharge becomes significant from October onwards. Nitrate leaching is dependant on hydraulic conductivity of the soil (Mulqueen, 2001).

Teagasc (2001) provides advice on the nutrient requirements to achieve optimum yields, which takes account of the nutrient content of the soil and the type of crop. Advice is also given on soil testing and of the index system for both mineral and peat soils for Phosphorus, Nitrogen and Potassium. In reference to a study by Mounsey, Sheehy, Carton and O'Toole (1998), Carton (2003) alludes to the nutrient use on twelve dairy farms with standard nutrient advice. While the nutrient value of farmyard wastes and effluents is accepted, the results indicate that there was an overuse of nutrient but with a significant variation from farm to farm. Carton (2001) also states that manure application in winter should be avoided on agronomic principles.

The EPA (2004) set out the methodology for assessment of lands/areas where there is significant risk of causing water pollution. The methodology is designed for use in conjunction with the Groundwater Protection Schemes - Response Matrix for Landspreading. They consider that the groundwater vulnerability is the most important factor in determining the control measures on an area where landspreading is proposed. Animal wastes contain large numbers of microbial pathogens, (faecal bacteria, cryptosporidium and viruses), that pose a significant risk to human health. The depth of soil over bedrock is important as it acts as a filter of the microbes thus providing protection. Microbe movement ranges from negligible distances in compact clay soils to kilometres per day in karstic areas.

3.7. Storm Contaminants

Kelly and Fitzsimons (2000) examined the potential pollutants contained in stormwater run-off. Their research indicates that significant levels of contaminants are present, including sediments, metals, hydrocarbons, salts and nutrients and microbes, and many of these contaminants are "List 1" substances under the European Communities Groundwater Directive. They also state that it is quite common for the stormwater to be discharged to a soakway. As the Drumcliff Springs catchment borders onto the Ennis urban area, this method of disposal of stormwaters within the confines of the catchment boundary raises a significant pollution risk to the groundwater source.

3.8. Legislation

The Water Framework Directive (WFD) introduces new approaches to considering groundwater, which will be allocated to groundwater bodies by 2005 (Daly, 2002a). The concept of "status" of the groundwater body is introduced and it will require greater integration of qualitative and quantitative aspects of both surface water and groundwater within the hydrological cycle (CEC, 2000).

Table 3.1: *Extract from EPA, Towards Setting Guidelines Values for the protection of Groundwater in Ireland – Interim Report List of Parameters.*

- Core Parameters or Natural Substances, which should be analysed for in all cases where background concentrations are being established in groundwater bodies.

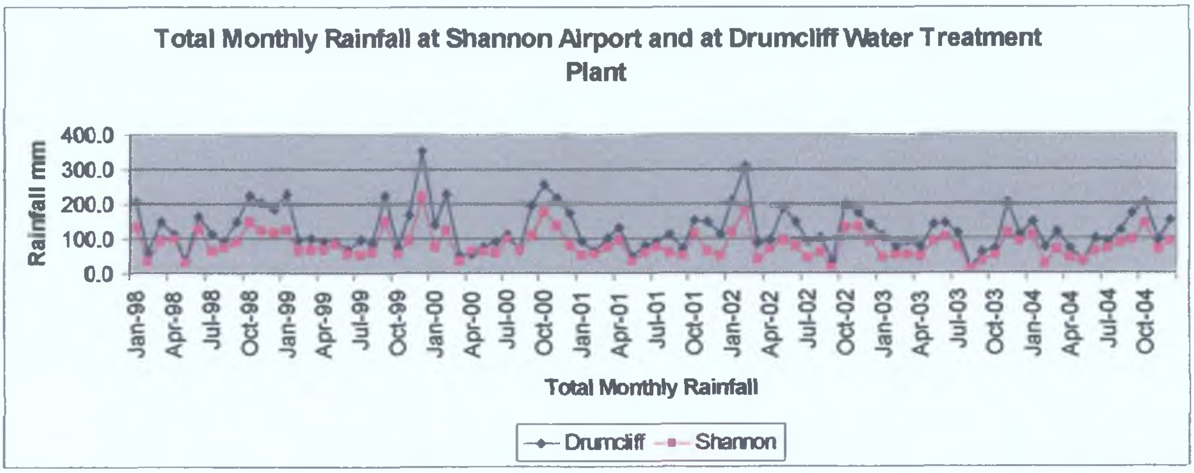
Physicochemical-Microbiological	***Inorganic***	***Metals***	***Organics***
Coliforms (faecal)	Alkalinity	Aluminium	TON
Coliforms (total)	Ammonia (as ammonium)	Arsenic and its Compounds	Total Hydrocarbons
Electrical Conductivity	Bicarbonate	Boron	
Temperature	Calcium	Cadmium and its compounds	
TOC	Carbonate	Chrominium and its compounds	
Colour	Chloride	Copper and its compounds	
PH (pH units)	Dissolved Oxygen	Mercury and its compounds	
	Hardness (as $CaCO_3$)	Nickel and its compounds	
	Iron	Zinc and its compounds	
	Manganese		
	Magnesium		
	Nitrate (as NO_3)		
	Nitrite (as NO_2)		
	Orthophosphate		
	Potassium		
	Sodium		
	Sulphate mg/l		

5 RESULTS

5.1. METEOROLOGY

The total monthly rainfall collected by Met Eireann at Shannon Airport and by Ennis Town Council staff at the Water Treatment Plant at Drumcliff was compared. Data is available for every day of the monitoring period at Shannon Airport, whereas there are data gaps for some periods of the monitoring period at Drumcliff. Higher rainfall levels were recorded at Drumcliff through out the period under comparison. Fig. 5.1 shows good correlation in the rainfall data between both monitoring stations. The average monthly rainfall at Drumcliff Water Treatment Plant is 127mm over the monitoring period 1998 – 2004 inclusive, and ranges between 11mm to 353mm. Overall rainfall levels have fallen since February 2002, the maximum rainfall level reached was 204mm. The average monthly rainfall during for the years 2002, 2003 and 2004 is 122mm.

Fig. 5.1 Chart indicating the total monthly rainfall at Shannon Airport and at Drumcliff WTP.

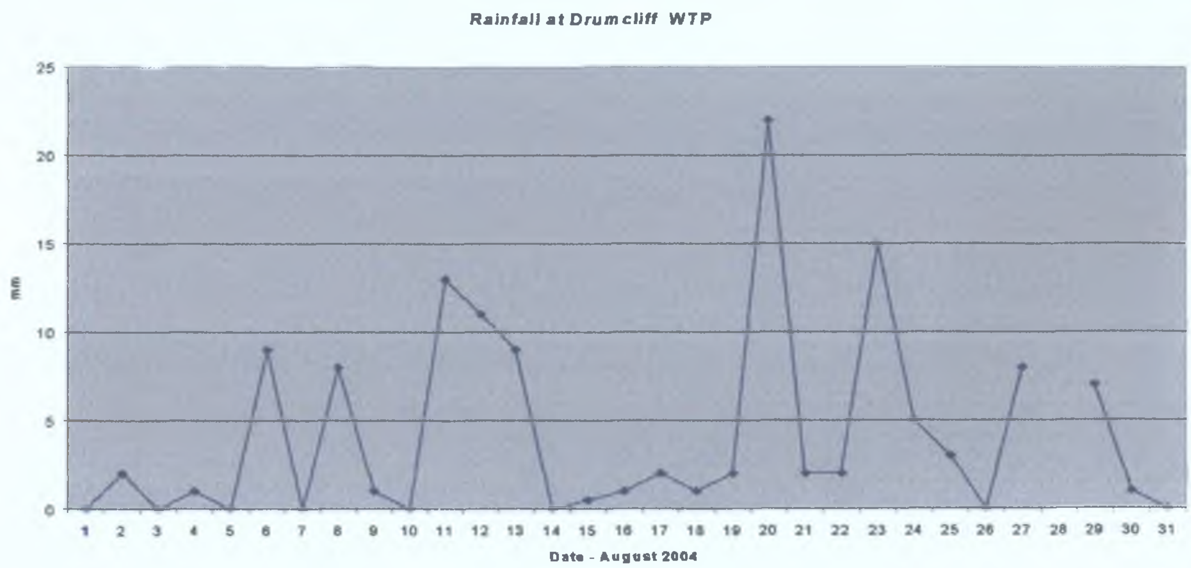


5.2. WATER QUALITY

5.2.1. Raw Water Quality at the Water Treatment Plant at Drumcliff

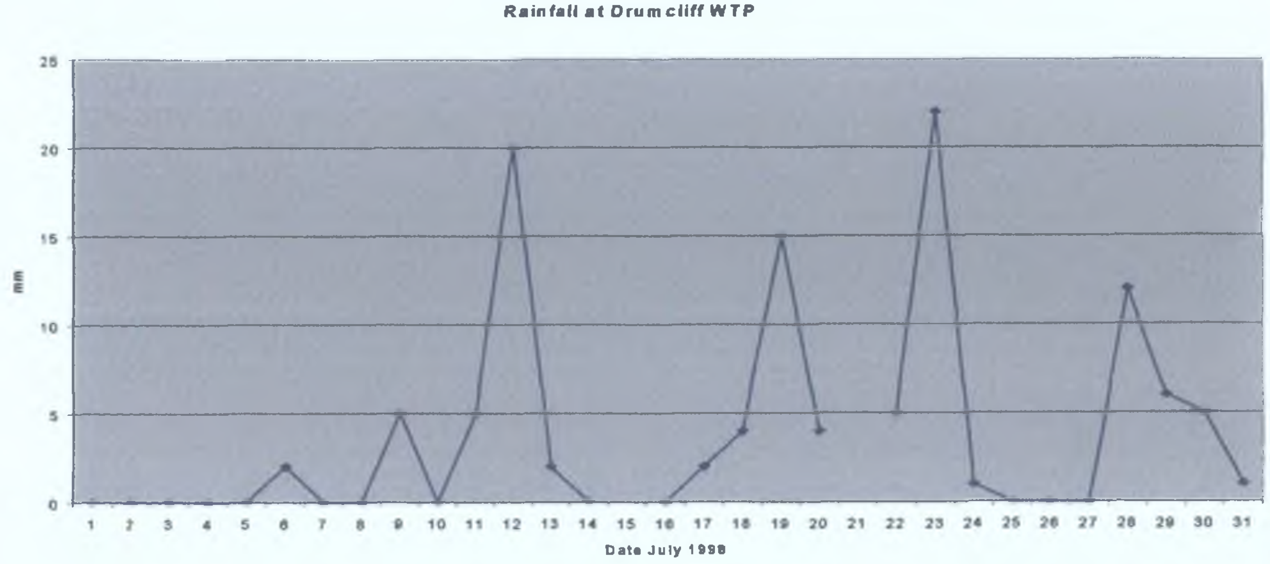
Daily data is available of analysis of the raw water intake at the Drumcliff Water Treatment Plant. The average colour level over the monitoring period 1998 to 2004 is 32 hazen units. However the maximum colour level in the raw water recorded at the Water Treatment Plant on 30th August 2004 is 250 hazen units. The mean of the annual maximum colour level over the monitoring period 1998 to 2004 is 151 hazen units. The high colour level recorded in 2004, occurred seven days following two high rainfall episodes i.e. 22mm rainfall on August 20th and 15mm rainfall on August 23rd as seen in Fig. 5.2.

Fig. 5.2 Chart indicating the daily rainfall recorded at Drumcliff WTP during August 2004.



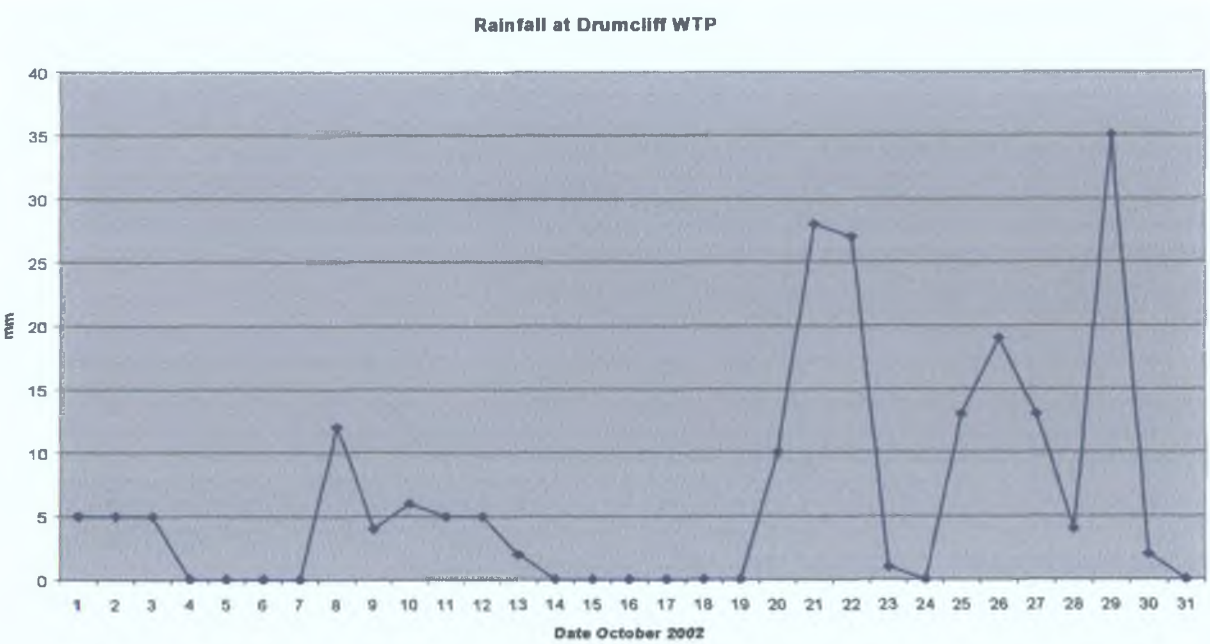
Similarly on 24th July 1998, the maximum colour level recorded in the raw water at the Water Treatment Plant of 175 hazen units, followed a series of high rainfall episodes in July i.e. 20mm on July 12th, 15mm rainfall on July 19th and 22mm rainfall on July 23rd as seen in Fig. 5.3.

Fig. 5.3 Chart indicating the daily rainfall recorded at Drumcliff WTP during July 1998.



The mean turbidity level recorded in the raw water at the Water Treatment Plant at Drumcliff is 2 nephelometric turbidity units (N.T.U.), which is within normal limits. However there is a wide range in the maximum turbidity levels recorded over the monitoring period ranging from 9 to 50 N.T.U. The maximum level recorded of 50 N.T.U. occurred on the same day as the maximum colour level was recorded on 30th August 2004 following a period of heavy rainfall c.f. Fig. 5.2. Similarly the next highest turbidity level, recorded on 31st October 2002, occurred following a series of heavy rainfall episodes with 28mm rainfall on the 21st October, 27mm rainfall on the 22nd, 13mm rainfall on 25th, 19mm rainfall on 26th, 13mm rainfall on 27th and 35mm rainfall on 29th October as seen in Fig. 5.4.

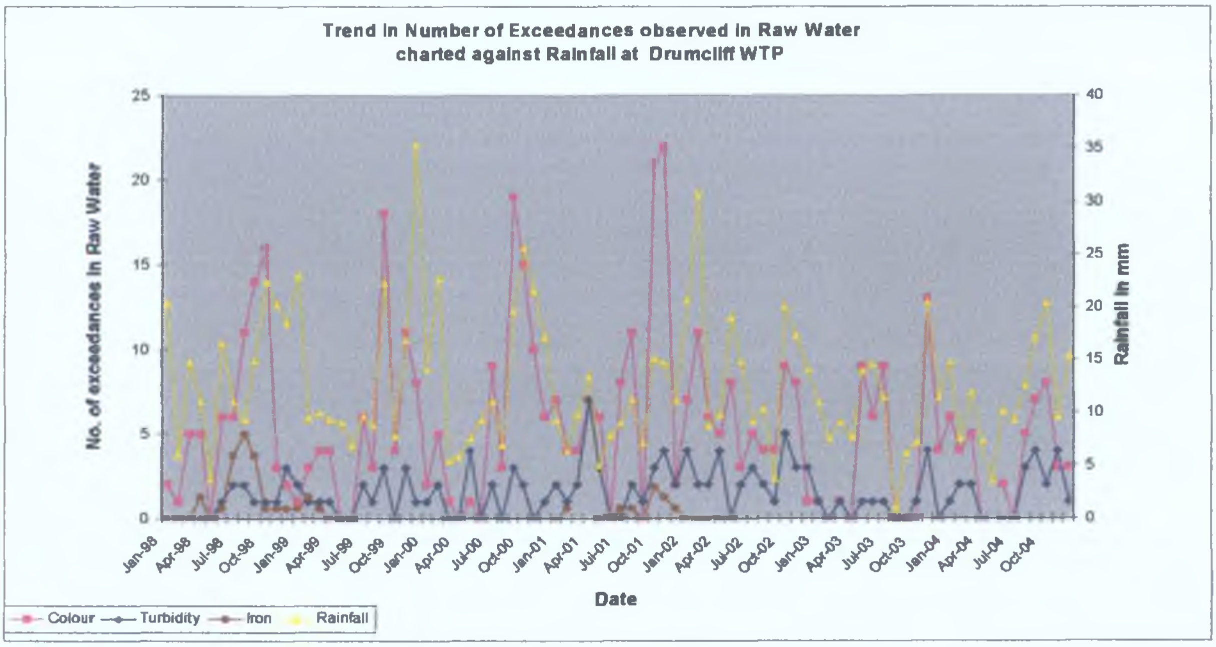
Fig. 5.4 Chart indicating the daily rainfall recorded at Drumcliff WTP during October 2002.



There are no iron measurements recorded for the year 2000. Since 2003, analysis is not carried out for iron on the raw water at the Water Treatment Plant at Drumcliff. Of the data available the average iron levels recorded are within the standards set out in the European Communities (Drinking Water) Regulations, 2000. S.I. 439 of 2000, i.e. 200mg/l Fe. The maximum iron level recorded during the monitoring period is 410 mg/l Fe on 10th September 1998, followed by 367 mg/l Fe recorded on 23rd October 2001. On the 9th September 1998, 32mm rainfall was recorded at Drumcliff. Rainfall levels recorded in the days preceding the elevated iron reading of 367mg/l Fe in October 2001, are only slightly above the average daily rainfall amount of 7.9mm for the month of October 2001. The rainfall levels recorded ranged between 6mm and 10mm during the period 15th to 23rd October 2001.

A reasonable correlation in the number of exceedances noted for the parameters colour, turbidity and iron, i.e. where the data recorded is above normal levels or exceeds standards as set out in the European Communities (Drinking Water) Regulations, 2000. S.I. 439 of 2000, is observed when compared with rainfall data recorded at the Drumcliff Water Treatment Plant as seen in Fig. 5.5.

Fig. 5.5 Chart indicating the number of exceedances in the raw water quality for the parameters colour, turbidity and iron at Drumcliff Springs against rainfall.



Since 2001, bacterial analysis has been carried out on the raw water at the Water Treatment Plant at Drumcliff on a weekly basis. Bacterial levels recorded range from 0/100mls to 4721/100mls for the parameter total coliforms. Likewise for the parameter Faecal coliforms, levels ranged from 0/100mls to 1553/100mls. In some instances, due to inadequate dilution of the sample, the bacterial numbers observed were too numerous to count thus the exact bacterial count is unknown. The highest bacterial counts were recorded on the 15th September 2004. Elevated rainfall measurements of 36mm rainfall on the 13th and 20mm rainfall on the 14th September are noted.

5.2.2. Water Quality at Drumcliff Springs, Poulacorey and Drumcaranmore Swallow Holes

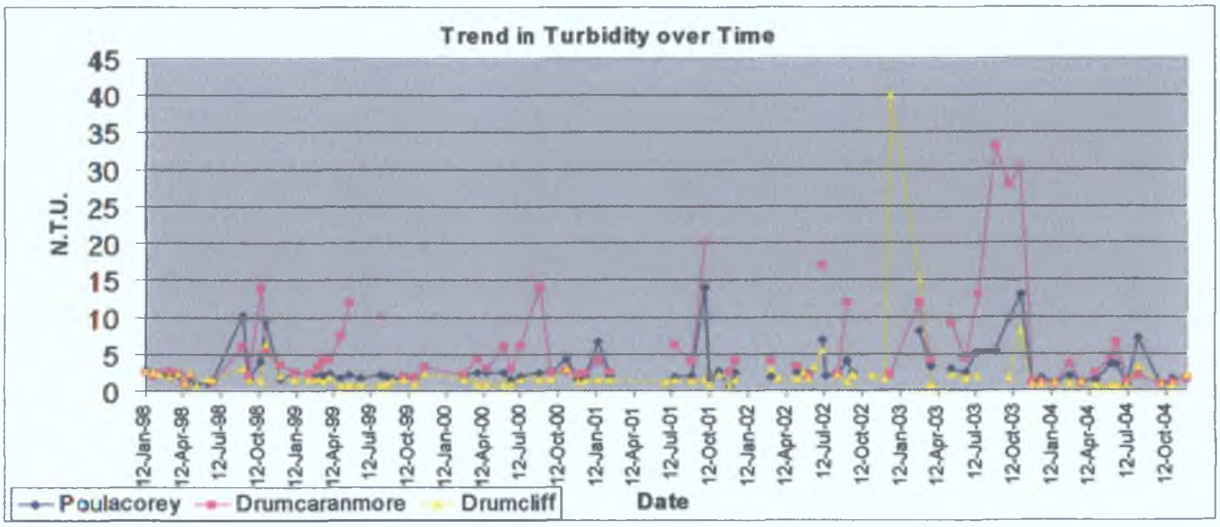
For the parameter colour, the mean annual colour level recorded at Drumcliff Springs is 26 hazen units, whereas at Poulacorey the annual average colour is 37 hazen units and at Drumcaranmore it is 57 hazen units. The colour levels at all three sites fluctuate over time with reasonable correlation of peak colour levels between the three sites. The maximum or peak colour levels recorded differ significantly, in that the highest colour level recorded of 250 hazen units is at Drumcaranmore swallow hole, whereas the maximum colour level recorded at Poulacorey swallow hole is 150 hazen units and at Drumcliff Springs, it is 60 hazen units. While Table 5.1 below indicates that there is a relationship between colour and rainfall at the swallow holes and at Drumcliff springs, no definite trend emerges when the colour data is compared with rainfall measurements taken at Drumcliff WTP.

Table 5.1 Detailing the correlation between elevated rainfall measurements and elevated colour levels recorded at Drumcliff Springs, Drumcaranmore and Poulacorey Swallow Holes.

Date	*Colour Hazen units Poulacorey Swallow Hole*	*Colour Hazen units Drumcaranmore Swallow Hole*	*Colour Hazen units Drumcliff Springs*	*Comment*
01/09/1998	150	125	50	13mm Rainfall previous day and 23mm rainfall on 01/09/1998
14/10/1998	70	150	50	Dry previous day, 15mm rainfall on 14/10/1998
19/07/2001	70	100	60	Rainfall earlier in month, 5mm rainfall previous day.
28/09/2001	70	125	10	8mm rainfall on 27/09/2001 and 6mm rainfall on 28/09/2001.
08/07/2002	70	250	30	Dry day before, 9mm rainfall on 08/07/2002
03/09/2002	20	100	5	No rainfall –Dry. Rainfall episode (11mm) occurred 30/08/2002
27/08/2003	40	150	0	No rainfall –Dry
01/10/2003	40	150	15	No rainfall –Dry

Average annual Turbidity levels for the monitoring period 1998 – 2004 at the Drumcliff Springs is 2.4 N.T.U., whereas at Poulacorey swallow hole it is 3.0 N.T.U. and at Drumcaranmore swallow hole the average annual turbidity levels is 5.6 N.T.U. Turbidity levels recorded at Drumcliff Springs are generally lower than those recorded at Poulacorey and Drumcaranmore swallow holes, with the exception of one date in December 2002 when the turbidity level recorded was 40 N.T.U. Elevated turbidity levels were observed at all three sites throughout 2003, with the average annual Turbidity level for the year 2003, rising to 5.3 N.T.U. at Poulacorey swallow hole, 13.6 N.T.U. at Drumcaranmore swallow hole and 3.7 N.T.U. at Drumcliff Springs. c.f. Fig. 5.6. The turbidity levels recorded for the year 2004 reverted back to levels comparable to the averages obtained over the entire monitoring period 1998 – 2004. As stated in 5.1 above, total rainfall amounts recorded at the Drumcliff Water Plant decreased in 2003.

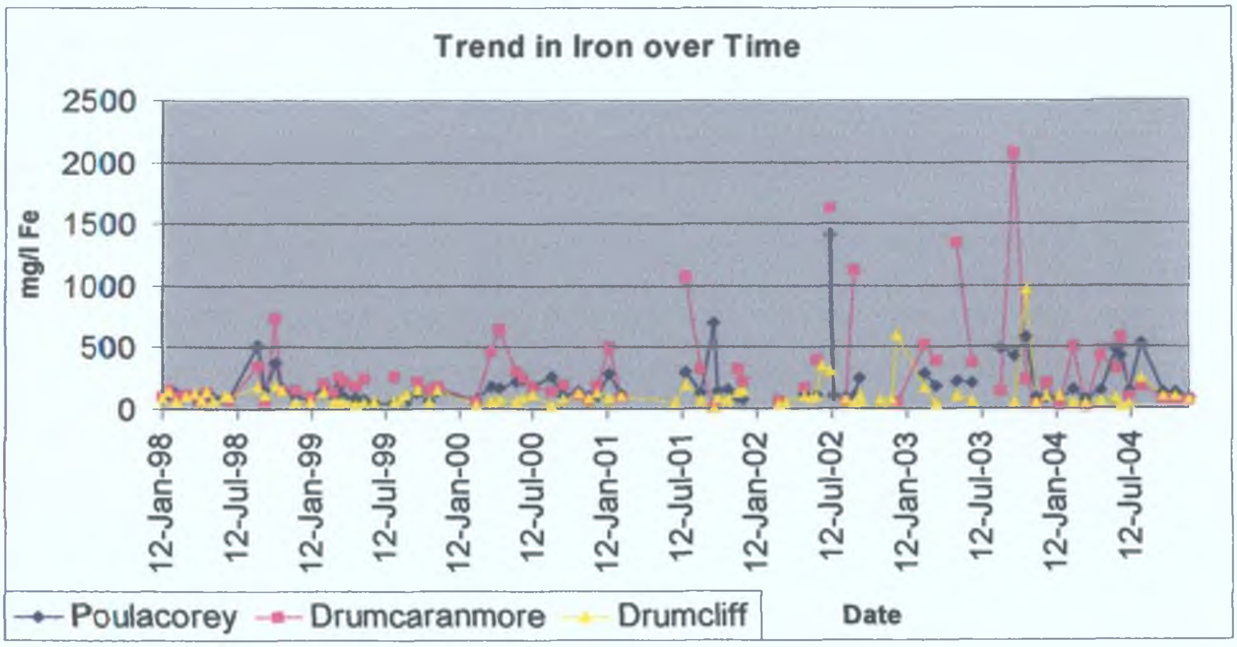
Fig. 5.6 Turbidity data charted against time recorded at Drumcliff Springs and at Poulacorey and Drumcaranmore Swallow Holes.



When the rainfall data was compared with the occurrence of elevated turbidity levels, very little correlation was found. In the majority of instances when high turbidity levels were recorded, low rainfall or dry weather conditions prevailed. Only three of the dates where elevated turbidity readings occurred coincided with high colour levels in the water, i.e. on 1st September 1998, 28th September 2001 and on 3rd September 2003. In two of the instances, rainfall occurred on the previous day, and in the third case, a rainfall episode occurred four days prior to the elevated reading. In all three cases a dry weather period had preceded.

Average annual iron levels recorded at Drumcliff Springs is 114 mg/l Fe compared to 191 mg/l Fe at Poulacorey swallow hole and 302 mg/l at Drumcaranmore swallow hole. There is a gap in the analytical data available for the parameter iron for the year 2002. Where fourteen samples were taken at Drumcliff Springs, only seven samples were taken at Drumcaranmore swallow hole and eight at Poulacorey swallow hole. No explanation is available for the discrepancy in the data available. On occasion, water samples cannot be taken at Drumcaranmore swallow hole due to low water levels. There is a significant range observed in the data, with the maximum iron level recorded at Drumcliff Springs of 971mg/l Fe compared to 1418mg/l Fe at Poulacorey swallow hole and 2070mg/l Fe at Drumcaranmore swallow hole. Minimum values ranged from 1mg/l at Drumcaranmore swallow hole to 50mg/l at Poulacorey Swallow hole. Overall iron levels recorded at Drumcaranmore are highest, Fig. 5.7. Further peaks in the iron levels were observed during the period July 2001 to December 2003, which is similar to the elevated turbidity levels recorded.

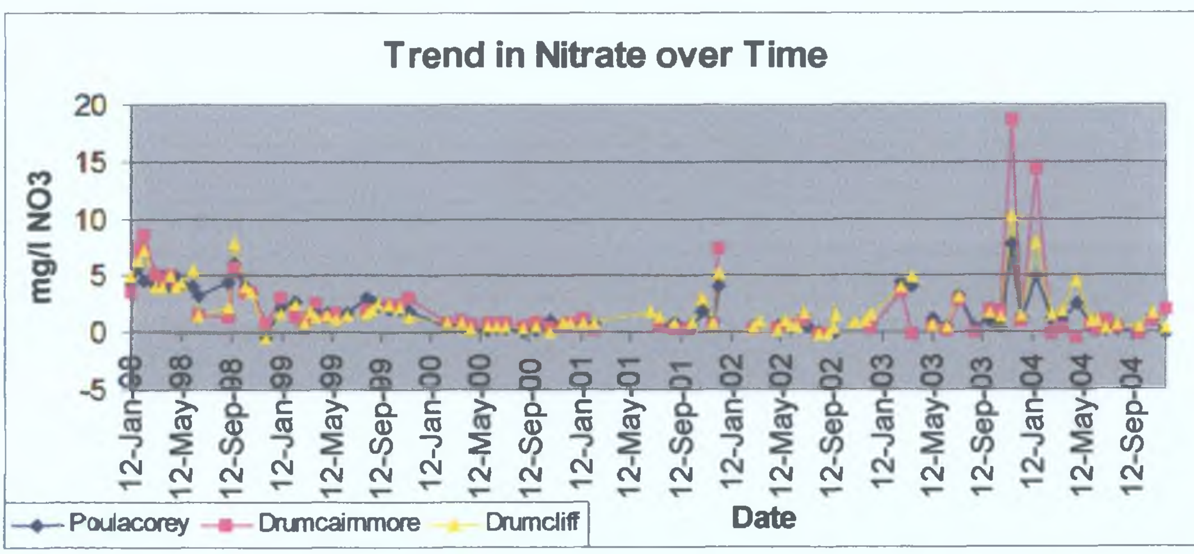
Fig. 5.7 Chart detailing iron levels recorded over the monitoring period 1998 – 2004 at Drumcliff Springs, Poulacorey and Drumcaranmore swallow holes.



When the data is compared with rainfall measurements over the same period, there is no definite pattern emerging with regard to correlation between rainfall and the occurrence of elevated iron levels. In some instances, where elevated iron levels are recorded, the weather was dry while in other cases, rainfall was noted in the days preceding the sample date. In general where a prolonged period of rainfall was observed, the iron levels recorded were more elevated. A trend was observed in comparing the iron levels at Drumcliff Springs with levels observed in the swallow holes. During dry weather, where high iron levels were observed at Drumcaranmore, but not at Poulacorey swallow hole, iron levels at Drumcliff springs were generally lower. However if the iron levels observed at Poulacorey swallow hole are high, then the iron level observed at Drumcliff Springs tend to be higher.

Nitrate levels recorded at Drumcliff Springs, Poulacorey and Drumcaranmore swallow holes follow a similar trend, with levels recorded at Drumcaranmore being generally higher than those recorded at the other two sites. However overall the nitrate levels recorded are low. The average annual nitrate level over the monitoring period 1998 – 2004, for Drumcliff Springs is 2.0mg/l NO_3. At Drumcaranmore swallow hole the average nitrate level is 2.1mg/l NO_3 and at Poulacorey swallow hole the level is 1.8 mg/l NO_3. Elevated levels were observed in November 2003 and in January 2004, at all three sites, but the nitrates levels appear to have reverted back to normal levels since then. Fig. 5.8.

Fig. 5.8 Chart detailing nitrate levels recorded at Drumcliff Springs, Poulacorey and Drumcaranmore swallow holes over the monitoring period 1998 – 2004.

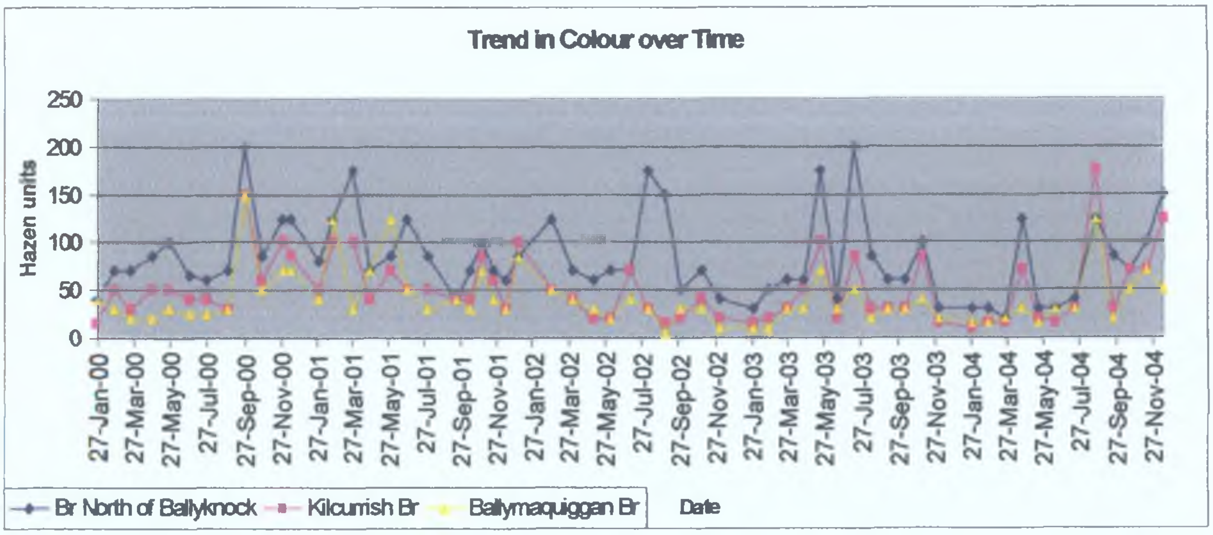


In correlating the rainfall data with the high nitrate levels, a period of low rainfall amounts occurred prior to the sample date in November 2003, with one rainfall episode (12mm rain) occurring five days earlier. Similarly in January 2004, the four days prior to the sample date were dry, but the previous week was wet.

5.2.3. Water Quality in the Shallee River

Colour levels in the Shallee River vary over time with no definite trend emerging. Reasonable correlation between the three monitoring points is noted in the pattern of colour levels recorded. Maximum colour levels are observed at the Bridge North of Ballyknock, which is located in the upper reaches of the river system. The average colour levels at the Bridge North of Ballyknock is 82 hazen units compared to 51 hazen units at Kilcurrish Bridge and 42 hazen units at Ballymaquiggan Bridge. c.f. Fig. 5.9.

Fig. 5.9 Chart showing colour levels for the Shallee River over the monitoring period 2000 –2004.



There is some correlation between elevated rainfall measurements and the occurrence of peaks in colour levels recorded, but it is not always consistent as can be seen in Table 5.2.

Table 5.2 Detailing the correlation between elevated rainfall measurements and elevated colour levels recorded in Shallee River.

Date	*Colour Hazen units*	*Comment*
25/05/2000	100	Rainfall previous ten days
28/09/2000	200	Very heavy rainfall on that date
29/11/2000	125	No correlation with rainfall
14/12/2000	125	Rain 2-3 days previously
28/03/2001	175	No correlation, Elevated rainfall for previous month, but low rainfall for previous 10 days before date of recording.
07/08/2002	175	Rainfall elevated on date of recording.
04/09/2002	150	No correlation with rainfall
22/05/2003	175	Elevated rainfall in previous days
17/07/2003	200	Rainfall peaked on that date
21/04/2004	125	Elevated rainfall for previous week
24/08/2004	125	Elevated rainfall for previous 5 days
17/11/2004	100	Elevated rainfall on that date
15/12/2004	150	No correlation with rainfall

Conductivity levels at the three monitoring stations over the monitoring period, 2000 – 2004, show that the levels recorded at the Bridge North of Ballyknock are generally lower than those recorded at the other two monitoring stations. The average conductivity level at the Bridge North of Ballyknock is 316 µS/cm compared to 468 µS/cm at Kilcurrish Bridge and 481 µS/cm at Ballymaquiggan Bridge. There is a large range in the data recorded refer to Table 5.3. In comparing the rainfall data with the conductivity levels recorded, there is elevated rainfall (10mm) on the day previous to the maximum conductivity level of 912 µS/cm recorded at the Bridge North of Ballyknock on 2^{nd} January 2001. Similarily the maximum conductivity level recorded at Ballymaquiggan Bridge on 25^{th} January 2001, coincides with a period of four days elevated rainfall, on 21^{st} – 10mm, 22^{nd} – 4mm, 23^{rd} – 7mm and on 24^{th} January – 13mm rainfall. However for the maximum conductivity level at Kilcurrish Bridge recorded in September 2001, there was no rainfall in the preceding days.

Table 5.3 Showing the average, minimum and maximum Conductivity levels recorded over the monitoring period 2000 – 2004 at the three monitoring stations on the Shallee River.

	Br.North of Ballyknock	***Kilcurrish Br.***	***Ballymaquiggan Br.***
Average	316	468	481
Minimum	172	307	100
Maximum	912	630	747
Median	297	472	493

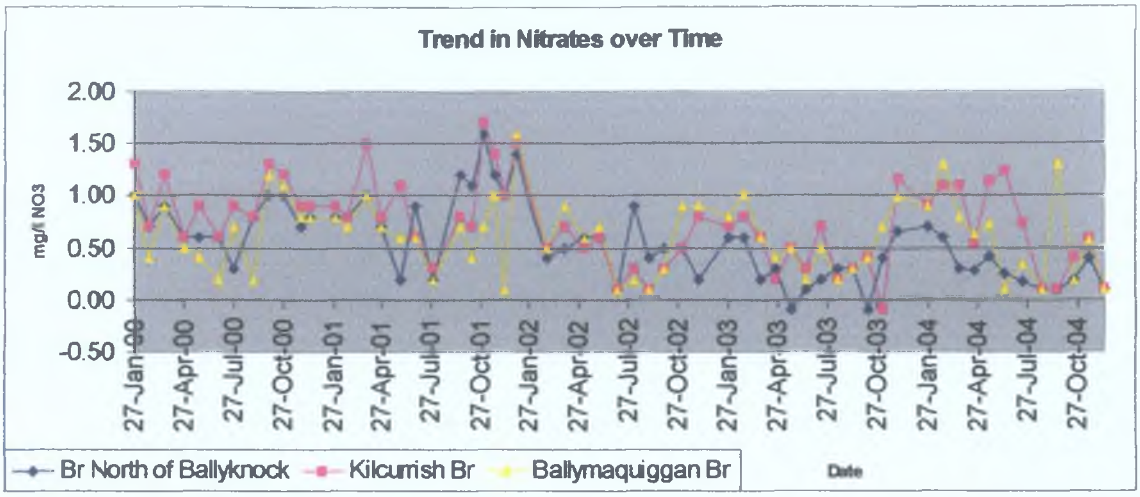
Nitrate levels recorded in the Shallee River ranged between <0.10 mg/l NO_3 and 1.7mg/l NO_3, c.f. Table 5.4. While a similar pattern in the nitrate levels emerges between the three monitoring stations, levels at the Bridge North of Ballyknock are generally lower than those recorded at the two bridges downstream, c.f. Fig 5.10.

Table 5.4 Showing the average, minimum and maximum Nitrate levels recorded over the monitoring period 2000 – 2004 at the three monitoring stations on the Shallee River.

	Br.North of Ballyknock	***Kilcurrish Br.***	***Ballymaquiggan Br.***
Average	0.56	0.72	0.61
Minimum	<0.10	<0.10	<0.10
Maximum	1.60	1.70	1.60
Median	0.56	0.70	0.60

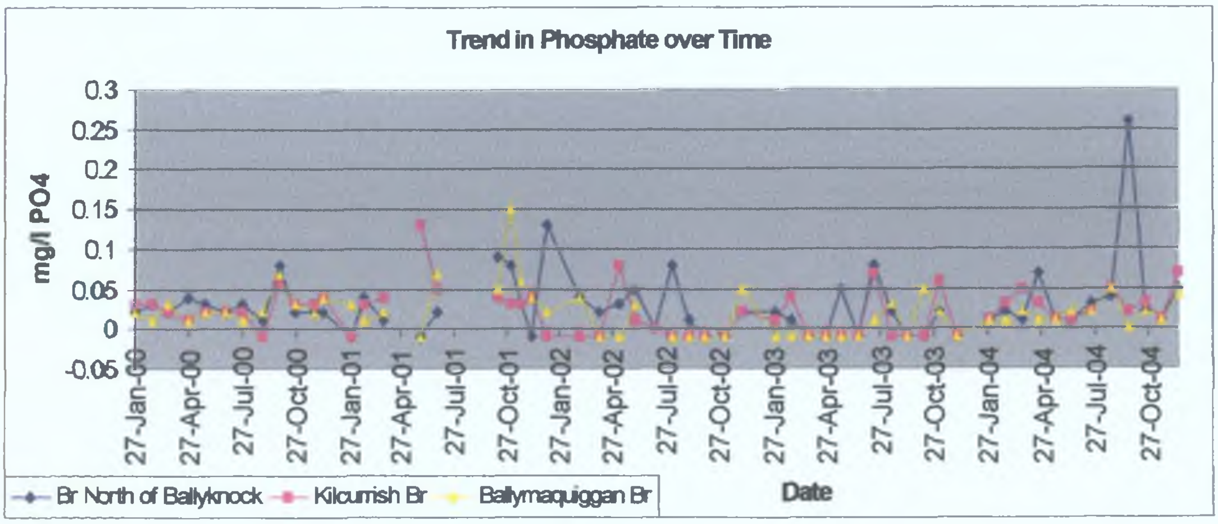
There is no trend emerging when rainfall measurements are compared with the nitrate data. On two occasions, when elevated nitrate levels were noted at all three stations, i.e. on 22nd November 2001 and on 3rd January 2002, the rainfall data for these two dates indicate that low rainfall amounts were recorded for the period preceding the elevated readings in November 2001, whereas rainfall of 12mm and 13mm were recorded on the two days prior to the January 2002 peak level.

Fig. 5.10 Chart showing nitrate levels in the Shallee River over the monitoring period 2000 – 2004.



Phosphate levels in the Shallee River over the monitoring period 2000 – 2004, ranged from a low of <0.01mg/l PO_4 to a maximum of 0.26mg/l PO_4 c.f. Fig. 5.11. The highest phosphate level (0.26mg/l PO_4) recorded was at the Bridge North of Ballyknock on 22nd September 2004, in the upper stretches of the river, with an average level of 0.03mg/l PO_4 recorded over the monitoring period. Elevated phosphate levels, while not as high as that recorded in September 2004, were also observed during the period July 2001 to July 2002. The average phosphate level at the two other sites, at Kilcurrish Bridge and Ballymaquiggan Bridge, was 0.02mg/l PO_4. Phosphate levels recorded follow a similar pattern at all three monitoring sites with the exception of the maximum phosphate level recorded at the Bridge North of Ballyknock, which is atypical of the norm.

Fig. 5.11 Chart showing phosphate levels in the Shallee River over the monitoring period 2000 – 2004.



In comparing rainfall measurements with the phosphate concentrations recorded, there is no definitive trend emerging in the results as elevated phosphate levels are observed under both dry and wet weather conditions Table 5.5. In cases following a significant rainfall episode, then elevated phosphate levels are observed at the two uppermost sites and at the Ballymaquiggan Bridge when there was rain on the previous day(s).

Table 5.5 Detailing the correlation between elevated rainfall measurements and elevated phosphate levels recorded as mg/l PO_4 in the Shallee River.

Date	*Br.North of Ballyknock*	*Kilcurrish Br.*	*Ballymaquiggan Br.*	*Comment*
28/09/2000	0.08	0.06	0.07	28mm Rainfall on sample date plus rain on previous days
12/10/2001	0.09	0.04	0.05	Dry, low rainfall on previous day
31/05/2001	-0.01	0.04	-0.01	Low rainfall (2mm)
01/11/2001	0.08	0.03	0.15	8mm rainfall on sample date
22/11/2001	0.03	0.03	0.06	Low rainfall (1mm)
03/01/2002	0.13	-0.01	0.02	4mm rainfall on sample date
08/05/2002	0.03	0.08	0.01	Dry weather
17/07/2002	0.08	0.07	0.01	24mm rainfall on sample date
06/11/2003	0.02	0.06	0.02	7mm rainfall on sample date
25/03/2004	0.01	0.05	0.02	Dry weather – wet the week before
24/08/2004	0.04	0.05	0.05	Low rainfall (5mm)
22/09/2004	0.26	0.02	0.01	6mm rainfall on sample date, 25mm rain on previous day
15/01/2004	0.05	0.07	0.04	11mm rain on sample date

5.3. AGRICULTURE

Data from a farm survey of the Drumcliff Springs catchment undertook by Clare County Council during the winter period 2003, show that of the one hundred and sixty farms surveyed, one hundred and twenty-five farms (78%) were classed as low pollution risk, i.e. where pollution control on the farm is satisfactory. Twenty-eight farms (17.5%) were classified as medium pollution risk and seven farms (4.5%) were found to have a high pollution risk. Farms are classed as high pollution risk where a direct discharge from the farmyard to a watercourse is observed, or where a significant risk of pollution to waters including groundwaters, is arising, e.g. where it was felt that there was inadequate slurry storage capacity.

A map (Map iii) showing the location and the pollution risk of the farmyards within the catchment area shows that four farms classified as highest pollution risk are situated to the north-east of the catchment, two farms are located centrally and one farm is located along the western boundary. All of the high pollution risk farms, with the exception of one farm, located along the western boundary, are located within the Inner Source Protection Zone for the Drumcliff Springs. Similarly dry stock animals are kept on all but two of the high-risk farms, one farm keeping a dairy herd only and the other farm keeps a mixed herd of both dairy and dry stock animals. Soil type in the immediate vicinity of the high risk farms is detailed in Table 5.6.

Table 5.6 Detailing the soil type in the vicinity of farms classified as high pollution risk during the farm survey of the Drumcliff Springs catchment conducted in 2003.

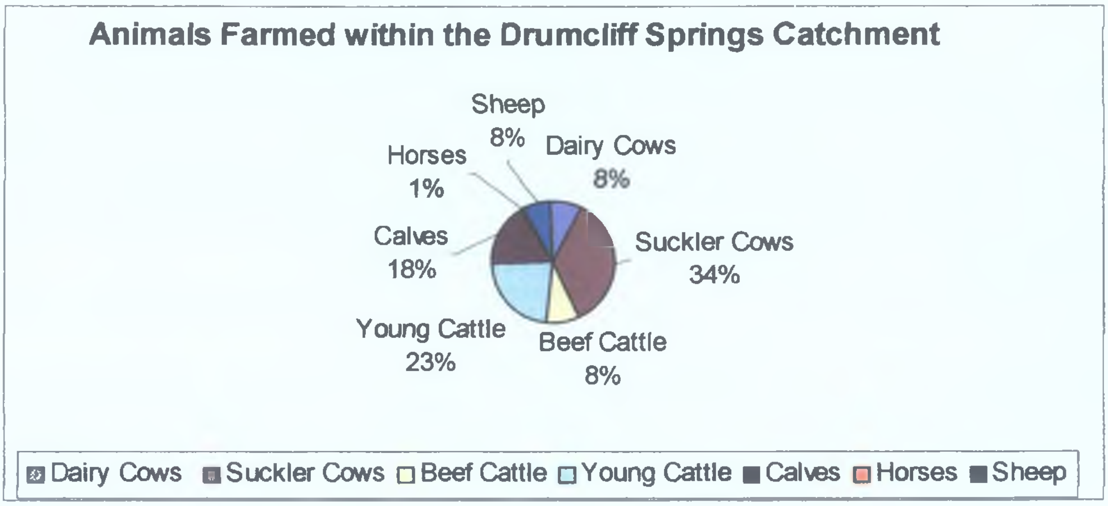
No. of farms	*Soil Type*	*Series*	*Location within the Catchment*
3	Rendzina	Kilcolgan Bouldery Phase	North-east – 2; Central (Eastern side) - 1
2	Brown-Earths	Kinvarra	North-East
1	Grey-Brown Podzolics	Patrickswell Lithic Phase	Central (Western side)
1	Gley	Kilrush	Western Boundary

The main issues identified in the farm survey were:-

- Poor management of effluent collection facilities that were in place on the farm.
- Inadequate storage facilities for slurry and silage effluents arising on the farm.
- Poor outwintering practices, whereby effluent was allowed to build-up at the feeding points and where excessive poaching of the land by animals was permitted.
- Inadequate guttering on some farmyard sheds and buildings and where clean storm water was allowed to mix with soiled yard areas.

The survey indicates that agricultural activities within the catchment is not intensive. Dry stock is generally farmed within the catchment, the highest percentage being suckler cows - 34% and young cattle - 23%. Only 8% of the overall total number of animals farmed are dairy animals. Figure 5.12 shows a breakdown of the animal types farmed within the Drumcliff Springs catchment. While the majority of animals are housed over the winter period, 22% are outwintered on the craggy Burren lands. Silage, both pit and baled, along with hay is used as fodder for the animals. Supplementary fodder in the form of hay, baled silage and meal is given to outwintered animals.

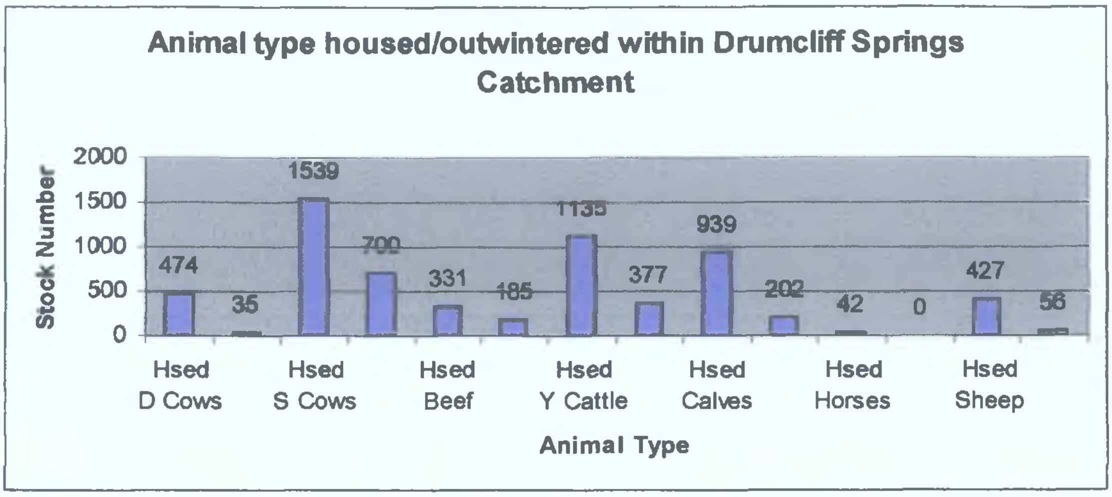
Figure 5.12 Indicating the % of animal type farmed within the Drumcliff Springs Catchment.



The volume of slurry/Farmyard Manure (FYM) arising from the number of animals indicated in the survey, over a twenty-week housing winter period, is estimated at 20,566m^3 compared with the total tank capacity within the catchment of 39,373m^3. The volume arising as a result of direct deposition from the animals outwintered over the same time period within the catchment is estimated to be 6476m^3 (NDP and DOAFRD, 2000).

The farm survey was concerned primarily with farmyard pollution control and the stock numbers given are typically the number of animals that are kept over the winter period as given by the farmer. During the summer period, with increased level of summer grazing, the stock numbers held within the catchment will rise, but this precise number is unknown.

Figure 5.13 Shows the numbers of animal housed/outwintered within the Drumcliff Springs Catchment.



Basing the calculation on these animals numbers, the amount of nitrogen generated from the animals within the catchment is estimated as 344 tonne and the amount of phosphorus generated is estimated as 51 tonne.

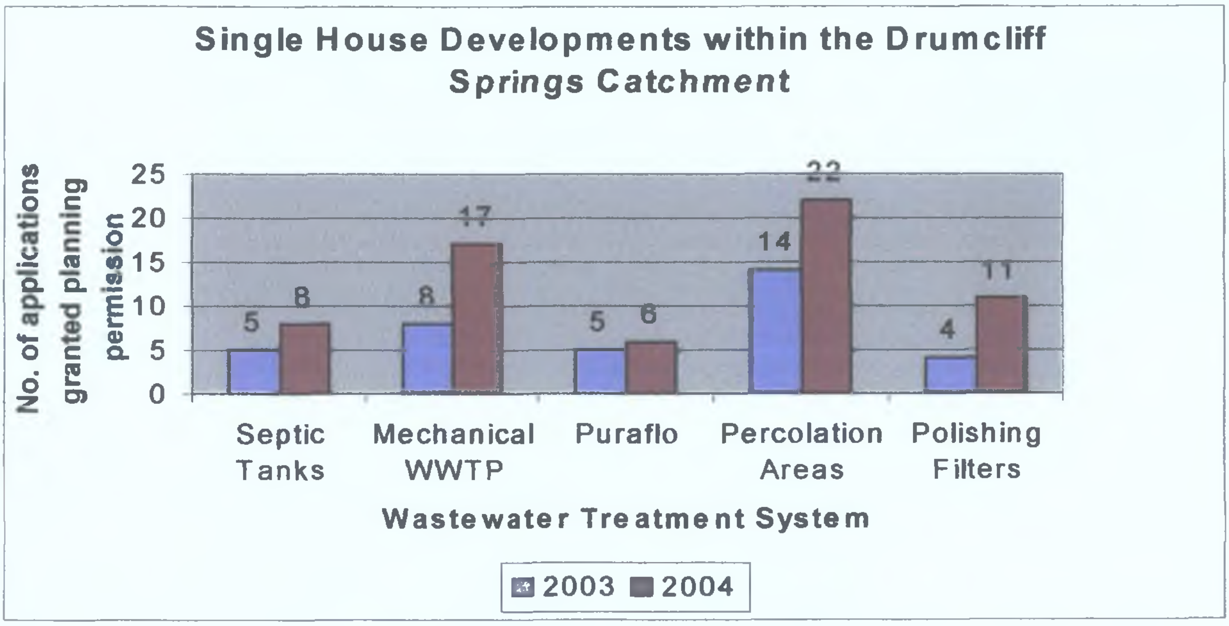
5.4. SINGLE HOUSING DEVELOPMENT

The planning authority at Clare County Council has digitally mapped all planning applications, inclusive of single house developments, agricultural and commercial developments, submitted for the years 2003 and 2004. Some applications for the period 1995 through to 2002 inclusive have also been mapped digitally, but the dataset is incomplete. A map (Map iv) showing the location of all planning applications submitted within the catchment area indicates that the pattern of developments is concentrated within the inner protection zone for Drumcliff Springs.

Results from examination of the planning applications within the catchment area, submitted for single housing developments to both local authorities, for the years 2003 and 2004 show an increase, in the use of advanced wastewater treatment systems over the conventional septic tank and percolation area. (Figure 5.13). In accordance with the Clare County Development Plan (1999), and with reference to Chapter 3.5, (Daly, 2002b) information was sought on site characterisation with each application and advanced wastewater treatment systems were required for the disposal of foul waste on site.

Applications, typically 34% of the total number of applications received, which were withdrawn, invalidated or refused, were not taken into account in this assessment.

Figure 5.14 Chart indicating the type of Wastewater Treatment for Single Housing Developments, which were granted planning permission within the Drumcliff Springs Catchment for the period 2003/2004.



In 2003, five developments were granted planning permission for septic tanks in comparison to thirteen advanced wastewater treatment systems. In cases where outline planning permission was granted prior to 2003, for a development with a septic tank, permission consequent to outline permission required that a septic tank was acceptable unless the applicant proposed an alternative advanced wastewater treatment system. In 2003, planning permission was granted for thirteen advanced wastewater treatment systems, (inclusive of both mechanical and Puraflo systems) whereas in 2004, the number increased to twenty-three advanced wastewater treatment systems. Likewise even though the number of proposed percolation areas exceeds the number of polishing filters, the percentage increase over the two years of proposed polishing filters is higher than that of percolations areas.

5.5. INDUSTRIAL/COMMERCIAL DEVELOPMENT

Industrial/Commercial activity occurring within the catchment is limited and consists of two quarries, two petrol stations (one large station and one small), a small hotel, which has a licence to discharge effluent to waters, pursuant to Section 4 of the Local Government (Water Pollution) Act, 1977 as amended by the 1990 Act and a wastewater treatment plant, which serves a small housing development. A map of the commercial activities located within the Drumcliff Springs catchment area is shown in Map v.

5.5.1. Quarries

Both quarry facilities are located within the Inner Source Protection Zone of the catchment. The facility at Fountain Cross is located adjacent to rising springs that drain into the Lough Clegan system, which is considered one of the five main inflows to the Drumcliff springs (Deakin, 1999). The quarry is located in a band of limestone, which constitutes a regionally important acquifer. The quarry is in operation since the early sixties and limestone rock is extracted from 28.3 hectares at a rate of 370,000m^3 per annum. The current operation involves extraction of stone, crushing and screening for the production of aggregates, production of readymix concrete, precast concrete, tarmacadam and asphalt mixes and agricultural lime (Clare County Council, 2005). An application to the planning authority for extension and retention of the quarry site is currently under consideration by the planning authority.

The second quarry at Toonagh quarries an area of 64.3 hectares and has been in operation since the late sixties, although quarrying took place on a smaller scale since the forties. Limestone rock is extracted, crushed and screened for the production of aggregates. Concrete blocks are also produced on site. The rate of extraction is not available for commercial reasons (Clare County Council, 2005).

5.5.2. Petrol Stations

Of the two petrol stations located within the catchment, one, the larger of the two is located adjacent to Drumcaranmore swallow hole. The petrol tanks serving this petrol station have approximately 50,000 litres capacity and the diesel tanks have approximately 10,000 litres capacity. A garage is also attached to this facility, waste oils are kept within a bunded area and other waste material is stored in covered containers. Planning permission for the development was granted prior to the discovery by Ennis Town Council of a direct link between Drumcaranmore and Drumcliff Springs. A planning application for a proposed new development including the replacement of the existing tanks with new double lined tanks at the petrol station was granted by Ennis Town Council in December 2004. The conditions of the grant of permission were appealed to An Bord Pleánala, who has upheld the decision made by Ennis Town Council. The second and smaller petrol station is located outside the Inner Source Protection Zone and the petrol tanks have approximately 20,000 litres capacity sand the diesel tanks have approximately 10,000 litres capacity. The forecourts of both stations are draining to oil interceptors

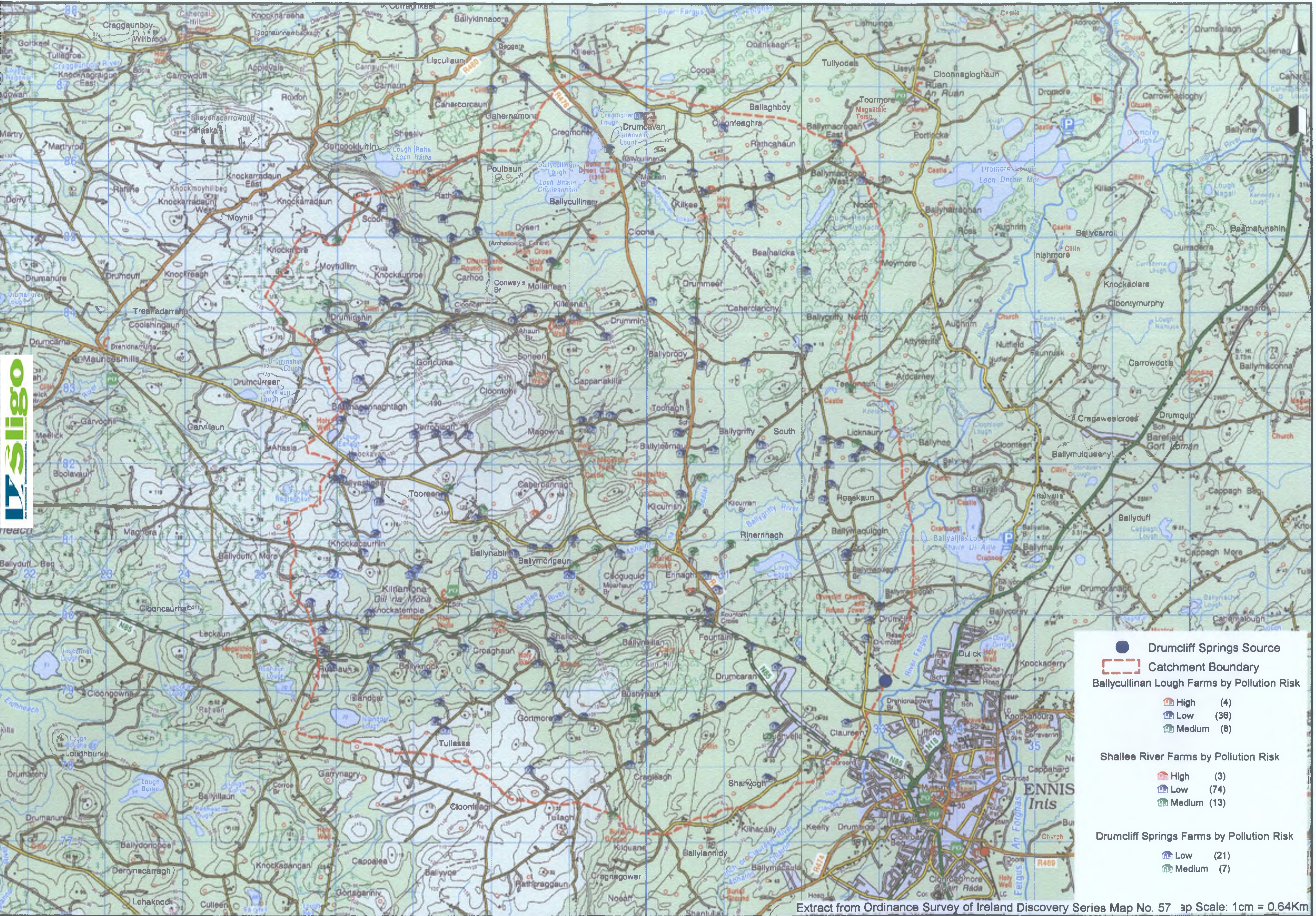
5.5.3. Wastewater Treatment Plants

There are three wastewater treatment plants located within the Inner Source Protection Zone of the catchment. One facility is licenced to discharge trade effluent to waters, pursuant to Section 4 of the Local Government (Water Pollution) Act, 1977 as amended by the 1990 Act. This facility is located near to Fountain Cross, which is one of the five main inflows to Drumcliff Springs identified (Deakin 1999). The wastewater treatment system in place is a "Puraflo" filter system. Dry weather flow is estimated at 9.6m^3 per day and the population equivalent for the plant is sixty persons. Results of analysis of the discharge indicate full compliance with the standards as set by the local authority in the licence issued pursuant to Section 4 of the above named Act, (Clare County Council, 2000).

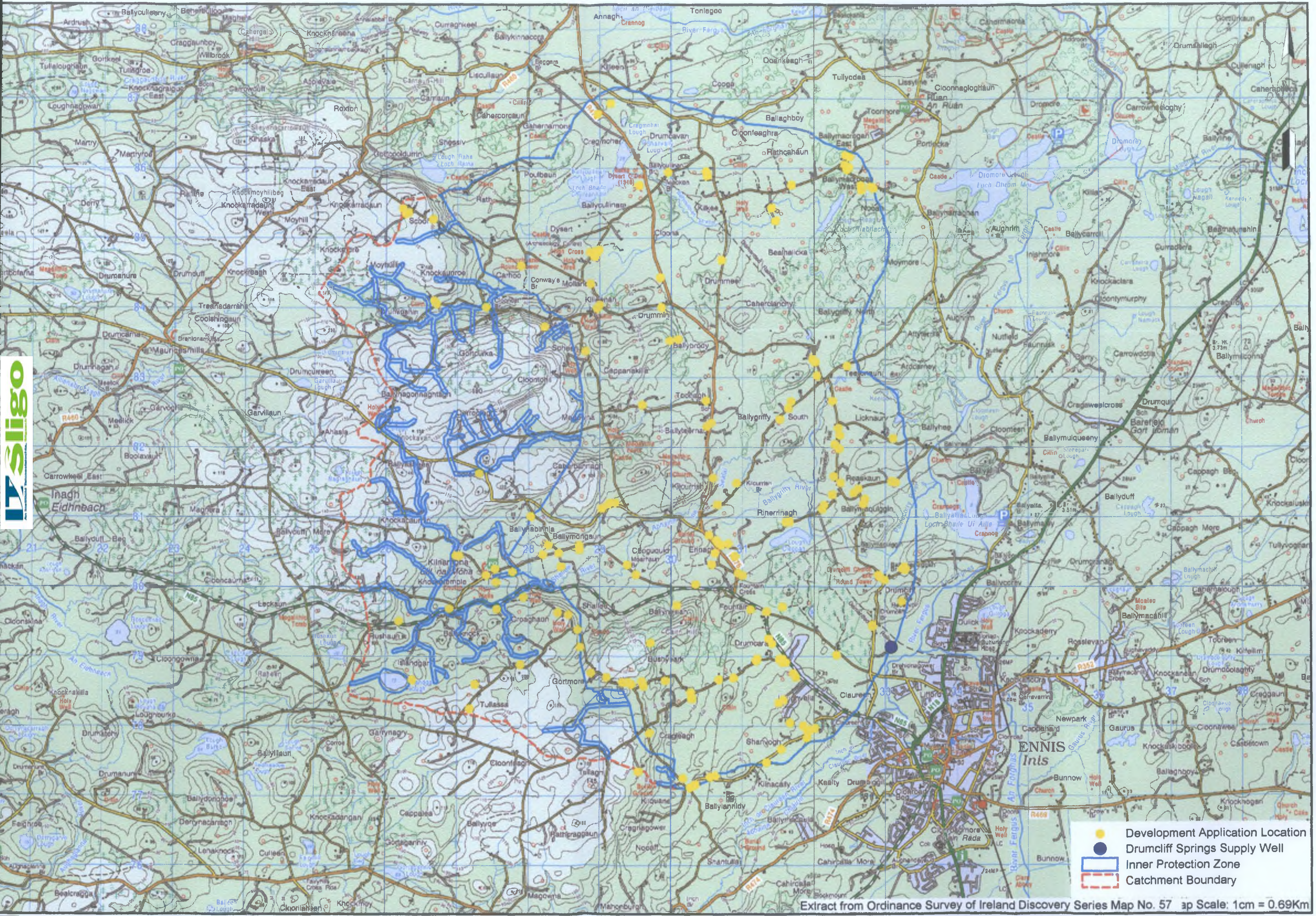
A second wastewater treatment plant operated by Clare County Council, which serves a group of private dwelling houses, is located in Toonagh (Clare County Council 2004a). The wastewater treatment system in place is a biological disc. However there is no data available regarding the population equivalent for the plant or the typical discharge volume from the plant. Results of analysis from this wastewater treatment plant show poor compliance with the standards set out in the Urban Waste Water Regulations, 2001, S.I. No. 254 of 2001.

A third wastewater treatment system, a septic tank, serves a small housing development on the Lees Road, which is located south-east of Lough Cleggan and is within a short distance of the Drumcliff Springs. The septic tank is maintained by Clare County Council however there is no data available regarding the size of the septic tank nor the population equivalent for the plant.

Map iii **Showing location of farmyards within the Drumcliff Springs Catchment**



Map iv Showing location of Development Applications within the Drumcliff Springs Catchment for 2003 and 2004



Map v Showing location of Industrial/Commercial Developments within the Drumcliff Springs Catchment Area

6 DISCUSSION

6.1. GEOLOGY

The geology of the catchment is a critical contributory factor to the water quality of Drumcliff Springs. As detailed in Chapter 2 – Previous Studies, the catchment is a karst aquifer, the bedrock is predominantly Carboniferous limestones and is characterised by features such as disappearing rivers, swallow holes and springs (Cullen 1989). With reference to Drew and Daly (1993) whose research indicates that flow rates are very high in karst limestone areas as a result of the widening of fissures in the rock by solution thereby allowing little scope for attenuation other than by dilution. Similarly Flynn and Sinreich (2004) indicate that the geology and hydrogeological factors play an important role in determining the vulnerability of a water supply. The water flows within the catchment area are known to be fast with travel times of less than 24 hours between both Poulacorey and Drumcarronmore swallow holes and Drumcliff Springs (Cullen, 1990). This is significant in that if a contaminant enters the groundwater system, then because of the karst nature of the catchment, there is minimal purification or attenuation of the contaminate, which can be either of natural origin or as a result of human influence. A very high risk exists that the groundwater will become polluted in a very short time, making the Drumcliff Springs supply source extremely vulnerable.

The concept of preferential flow paths is an important consideration, in that it has been demonstrated in the past that in areas of very shallow bedrock following heavy rainfall that bypass flow is likely to occur (Daly, 2002c). The Drumcliff Springs catchment is predominantly an area with fractured rock and thin overlying soils, thus the likelihood of contaminants entering the groundwater system is high with consequential potentially serious health implications to the supply, especially when considering that there is minimal treatment of the supply at present and the population number that the supply serves.

Along the western boundary of the catchment the soils, consisting of surface water gleys and glacial tills, which overly the Younger Upper Carboniferous Sandstones and Shales are impermeable and contain a high percentage of iron (Cullen, 1989 and Finch, 1971).

Research shows that rainfall falling in this area gives rise to a high percentage of run-off to surface waters (Deakin 1999), and may contain iron from the bedrock and humic acids/organic matter, which are washed into solution following heavy rainfall episodes after a dry period.

The groundwater system is very vulnerable to contamination as contaminants entering either the surface water along the western boundary of the catchment or entering into the groundwater system within the catchment could potentially be observed at Drumcliff Springs as a result of the very fast flow through times observed.

6.2. WATER QUALITY

The concept of quality status is a new concept introduced by the Water Framework Directive (CEC, 2000) that can be allocated to groundwater bodies and, which will require greater integration of qualitative and quantitative aspects of both surface and groundwater within the hydrological cycle (Daly, 2002a). Since the monitoring programme was set up for the raw water at Drumcliff Springs, a list of core parameters have been developed by the EPA (2003), together with interim guideline values to be used in assistance with the characterisation and assessment of groundwater quality status in accordance with the Water Framework Directive (CEC, 2000). The parameters selected by Ennis Town Council and Clare County Council in the monitoring of the groundwater supply do not encompass all parameters included in the list of core parameters as detailed in Table 3.1, albeit the significant parameters are included for analysis on a regular basis. Consideration should be given to the analysis of all core parameters listed on an annual basis, so as to obtain a clear assessment of the groundwater quality status on an ongoing basis.

There is considerable water quality data available in which to assess what the contributory factors affecting the water quality at Drumcliff Springs are. In reviewing the water quality data, the results indicate a variability over time for all the parameters, which has no particular pattern. There appears to be some correlation between rainfall and the incidence of elevated levels recorded but it is not always consistent nor is it considered predictable. This confirms the view taken by Cullen (1990) that the relationship between rainfall and the occurrence of the contaminant variables is not close enough to allow for prediction.

A difficulty, which arose in assessing the data, was the inconsistency in the parameters analysed for the different waters, thus comparisons of the contaminant variables could not be made between the levels observed at Drumcliff Springs and the two swallow holes and levels in the Shallee River.

While McGarrigle et al (2003) reports that groundwater quality is a function of natural processes as well as anthropogenic activities, the evaluation of the results indicate that overall, there has been no deterioration in water quality within the catchment, which suggests that the anthropogenic activities in place at present within the catchment are not impacting to any significant extent on the water quality. It also suggests that measures that have been put in place to minimise the risk of pollution of the groundwater are effective to some degree.

Cullen (1990) suggests that elevated colour and turbidity levels are related somewhat to rainfall as a result of the wash out of organic matter from the soils into sinking streams. The results from the Shallee River appear to mirror this view in that elevated colour levels were observed at the uppermost monitoring station, where the impermeable gley soils predominate hence there is a higher likelihood of surface run-off. However further downstream the colour levels decrease, most likely as a result of dilution in the river system and settling out of solids and the organic matter. Cullen, (1991) concludes that the source of contamination is from a) the Shale bedrock, and b) the degree of purification due to conduit flow and the lack of thick overburden within the catchment. Consequently, Cullen (1991) concludes that the catchment is highly vulnerable to contamination from septic tanks and agricultural effluents if a protection plan is not in place. This would suggest that while it may be very easy to contaminate the water, it is also highly probable that the contaminate may be flushed out of the system very quickly.

High colour and turbidity levels in the public water supply is aesthetically not acceptable and its presence could be interpreted in such a manner that the supply is not suitable for human consumption. This obviously will impact on the number of complaints that are received by the local authority regarding the quality of the water supply, but it will also impact on the percentage compliance of the supply to the European Communities (Drinking Water) Regulations, 2000. Cronin and Deakin (2000) suggest that the elevated turbidity levels may be as a result of natural geological factors. The EPA (2001b) take a similar view as to the origin of turbidity levels in water, however the local authority must also take account of the compliance rate and negative impression of the water supply in addressing this problem and in provision of a potable water supply, which complies with EC (European Communities) Legislation and which the public will perceive as a good water supply. Drew and Daly (1993) suggest that in karst areas due to minimal attenuation, that treatment of potable supplies is required. There are plans to upgrade the water treatment plant at Drumcliff, but the timeframe for completion of the works is uncertain. In any event, even taking account of the Fast Forward Planning process, the upgrading of the plant will require considerable investment and will take some time before it is commissioned.

Sandstones and shales predominate along the western boundary of the catchment and contain high levels of iron, typically 4% (Finch, 1971). Cullen (1991) reports that the most likely source of the elevated iron levels at Drumcliff Springs is from the western catchment where the sandstones and shales predominate. There is no iron data available for the Shallee River, so a comparison of iron levels along the river system and with the levels observed at the swallow holes and at Drumcliff Springs could not be made. In comparing the iron data available, the highest levels recorded were noted at Drumcarronmore swallow hole, which is originating from natural iron sources in the bedrock (Deakin, 1999). No definite trend emerged, which might link the iron levels with rainfall, this would indicate that the iron source is of natural origins rather than from human influences.

As stated in Chapter 5.2.2, the water quality at Drumcarronmore was consistently poorer than that observed at Poulacorey swallow hole or at Drumcliff Springs. Considering that the travel time between Drumcarronmore and Drumcliff Springs is less than twenty-four hours, one would expect that the poor water quality would be reflected at Drumcliff Springs also. This is not the case, the poor water quality is observed at Drumcliff Springs only after very heavy rainfall episodes and when the water levels are high, i.e. during the winter period normally. Again this confirms conclusions from the earlier study, (Deakin, 1999), that Drumcarronmore contributes during wet weather only. If account is taken of the five main inflows to Drumcliff Springs, which were identified by Deakin, (1999) and the fact that four of the five inflows drain to the Ballygriffey River, which sinks at Poulacorey swallow hole, then it is logical that the majority of the flow to the Drumcliff Springs will be from Poulacorey swallow hole, so the impact of the poor water quality from Drumcarronmore swallow hole will be diluted unless the volume of water from Drumcarronmore has increased or the water quality at Poulacorey swallow hole is also very poor. The percentage water sinking at Poulacorey varies with differing water levels in the river hence the ratio of contribution from each of the swallow holes cannot be calculated. In addition as a result of the large volume of water in the Ballygriffey River many of the contaminants in the river system are diluted before they reach Poulacorey swallow hole and in a previous study, Deakin, (1999) states that a proportion of the river will not sink at Poulacorey swallow hole but rather will bypass the swallow hole and drain to Ballyalla Lough, which is part of the Fergus River system.

In considering the nutrient levels in both the Shallee River and at Drumcliff Springs and the two swallow holes, the overall levels observed for both nitrates and phosphates are low. Similar patterns emerged at all stations with respect to the variability in the results over the monitoring period, with the highest phosphate levels being observed in the upper stretches of the Shallee River and at Drumcarronmore swallow hole. The high phosphate level (0.26mg/l PO_4) recorded at the Bridge North of Ballyknock on 22nd September 2004, in the upper stretches of the Shallee River, could be interpreted to be as a result of overland flow due to the impermeable gley soils present and the top soil layer being saturated with phosphorus, but it could also be as a result of landspreading of organic waste in the vicinity of the monitoring station that had occurred within a short timeframe of the sampling date. There is no way of verifying this link of landspreading organic waste with the elevated results, but taking that agriculture is the primary activity within the catchment, it cannot be ruled out.

For the parameter nitrate the reverse is observed in that the higher nitrate levels occur in the lower stretches of the Shallee River. One interpretation of this could be that nitrate from septic tanks within the inner protection zone is contributing to the higher nitrate levels observed, especially when one considers that the pattern of development is concentrated within the inner protection zone. While this cannot be ruled out, it is considered that since the nitrate levels recorded are low, and that if there is a contribution from septic tanks, that it is negligible and is not measurable. The nitrate levels in the lower stretches of the river could also be arising from agricultural activities in the vicinity, in particular if organic waste was disposed off in an inappropriate manner, e.g. spreading slurries during the winter months or outside of optimal growing season and because of the karstic nature of the area, bypass flow is likely to occur via preferential flowpaths (Daly, 2002b).

Microbial contamination is a major area of concern and can arise anywhere in the catchment. Daly (1994), reports that overall pollution of groundwater is microbial rather than chemical. The bacterial analytes used, are indicators of faecal contamination and if present, they represent the potential presence of viruses, e.g. cryptosporidium, which is resistant to disinfection and has serious public health implications. Ball (1997), states that during summer months, when the soil is dry, and following short intense rainfall showers, that preferential flow paths provide conduits of rapid recharge to groundwater for slurries and manures that are spread on land. The Drumcliff Springs catchment contains all the above criteria, i.e. karst environment, thin overlying soils, predominant agricultural activity, so there is a real danger of microbial pathogens entering into the groundwater, with implications to both private, group and public water supplies, especially where there is minimal treatment of the water supply. Another potential source of contamination is from septic tanks, which Keegan, (2001), Daly (2001) and Daly D., (2004) all conclude that one of the main sources of bacteriological pollution is from septic tank systems – in particular if the septic tank and the supply source are located both on the same site. With reference to Chapter 5.2.1, the results show that there is a link between rainfall and the presence of bacteria in both surface and groundwaters monitored, in that the highest bacterial levels recorded in the raw water at Druncliff Springs occurred after heavy rainfall, confirming that bacterial contamination is very responsive in this karst environment and poses a very significant risk to public health.

6.3. AGRICULTURE

Agricultural activity can also present a risk to the groundwater quality in the catchment if good practice is not adopted. Nutrients can be lost from both diffuse and point sources. The EPA (2001a) reports that there is strong evidence to suggest that nutrient loss from agriculture, inclusive of from farmyards, is now the single biggest source of pollution in Ireland. Because the Drumcliff Springs catchment is characterised by sinking rivers and streams, enrichment of the surface water is very likely to impact on the groundwater quality also.

The nutrient enrichment of waterbodies is determined by the interaction between rainfall and the ground surface, subsurface soil and rock layers and drainage from different facilities, e.g. farmyards (Mulqueen, 2001). The risk to groundwater from agricultural development presents in one of the following ways.

- As a result of direct discharges to waters from farmyards where there is inadequate effluent storage or there is mismanagement of the facilities that are in place.
- As a result of landspreading of organic waste during inappropriate times or at an application rate, which exceeds the capacity of the land to assimilate the waste being applied.
- As a result of inappropriate practices when outwintering stock, i.e. the location of feeding points; allowing effluent build up at a feeding point; excessive poaching of the land;

As referred to in Chapter 5.3, agricultural activity within the catchment is not intensive. Map III shows that the farmyards are located throughout the entire catchment thus the impact on the groundwater quality can arise from anywhere in the catchment. The results of the farm surveys carried out by Clare County Council in 2003 show that the overall impact on the groundwater as a result of poor pollution control on farms is minimal with one hundred and twenty-five farms (78%) of the total surveyed classified as low pollution risk (Cremin, 2003, Duffy, 2003, and Imbusch, 2003). This correlates with the nutrient levels observed in the Shallee River in that the nutrient levels are generally low. However seven farms (4.5%) were classified as having a high pollution risk and discharges from these farms could give rise to contamination of the water supply at Drumcliff Springs if recommendations as issued by Clare County Council, in the form of both Section 12 notices pursuant to the Local Government (Water Pollution) Act, 1977 as amended by the 1990 Act, and advisory letters are not implemented. While reinspection of the farms giving rise to a pollution risk will show if remedial measures have been put in place to address the pollution problems identified, it is much more difficult to assess if there has been progress where management of facilities or agricultural practices are the issue.

In considering the location of the high-risk farms in the catchment, only one farm is located in the outer protection zone. Four of the remaining six farms are located in the north-eastern section of the catchment and the other two remaining farms are located centrally. Within the inner protection zone, as detailed in Chapter 2.1 (Cullen, 1989), the overlying soils are thin with the soil types identified as rendzina, brown-earths and grey-brown podozolics c.f Table 5.6. When account is taken of these soil types and the depth of soil over the bedrock, there is minimal assimilation capacity provided for any discharges of effluents from the farms. In addition because of the karst nature of the area, there is an increased likelihood of preferential flow paths being present whereby pollutants, both from point and diffuse sources, can gain access to the groundwater system.

There is no pattern or trend emerging with respect to the type of herd kept on the farm or to the problems identified on the high-risk farms. The percentage of dairy herds at 8% reflects the low agricultural intensity within the catchment, as dairy farming requires a higher nutrient input, in fodder, which in turn requires that the land is farmed in a more intensive way.

Landspreading of organic waste is another significant hazard, which must be taken into account as a contributory factor, and which can impact on the groundwater quality in the catchment as a result of nutrient and bacterial contamination. While spreading organic waste is seen as a method whereby the nutrients taken from the land in the form of fodder are returned to the land, if this activity is not carried out in an environmentally friendly manner, then the risk of nutrient loss to waters plus the risk of bacterial contamination of waters increases significantly. In assessing the groundwater vulnerability with regard to the landspreading of organic wastes, the EPA (2004) consider that soil type and depth of soil over bedrock are critical factors in defining whether the land is suitable for the spreading of organic waste. The soil acts as a filter and if of sufficient depth, it will be capable of providing protection to the groundwater from the large numbers of microbes present in the waste stream.

Rainfall plays has a major role in defining whether the landspreading of farm effluents is giving rise to a pollution threat to groundwater. The EPA (2000b) indicates that phosphorus (P) loss to waters occurs in particular, after heavy rainfall events following landspreading or where there is excessive accumulation of P in soils. In addition research by Tunney, Daly and Kurz (2001) reports that it is generally accepted that there is a positive relationship between the soil Phosphorus test (STP) and loss to water. If one considers that there has been a tenfold increase in the average STP in Ireland since 1950, then the STP level will have a significant influence on whether there is effective uptake of P by the soil following landspreading or whether it is lost to surface water or groundwaters. P loss can also occur as a result of overland flow to surface waters when excessive amounts of slurry are spread in wet conditions, or where a sufficient buffer strip is not in place or via preferential flow paths to the groundwater (NDP and EPA, 2000).

Similarly nitrate leaching occurs when concurrent with downward soil water movement or the supply of nitrate in the soil exceeds plant and denitrification demands. (Ryan, 2001). This suggests that nutrient management planning (NMP) is very important in minimising the impact of nutrients on groundwater. Indeed Carton, (2001) states that NMP is the foundation for the design of manure management programme involving land application in Ireland. Farmers participating in the Rural Environmental Protection Scheme (REPS) implement NMPs on their farms and in doing so take account of the most recent Teagasc advice (2001) regarding the correct nutrient content of the soil required for optimum growth – this equates to 25% of the farms surveyed in 2003 (Cremin, 2003, Duffy, 2003 and Imbusch, 2003). Farmers not participating in REPS i.e 75% of the farms surveyed in 2003, and who do not carry out a NMP for their farm are not obliged to adopt Teagasc advice. If account is taken of research carried out by Mounsey et al (1998) as detailed in Carton (2003), then the assumption can be made that overuse of nutrient is likely and that there will be variation in nutrient use from farm to farm where NMPs have not been implemented.

Regulation with respect to the spreading of organic waste is difficult to implement and to police. While no exact figures are available, farmers often use contractors to spread organic waste on their farms and this can give rise to problems in that they loose control with respect to when to spread and whether it is during the appropriate weather conditions. Carton (2003) advises that manure application in winter should be avoided on agronomic principles. However where contractors are used to spread organic waste, unless the farmer states specifically where and at what application rate the slurry is to be spread, then there is the additional risk that the landspreading is carried out in an inappropriate manner resulting in excess nutrient gaining access to surface waters or to the groundwater. At the time of writing a voluntary code of good practice regarding this activity exists DOELG and DOAFF, (1996), new regulations are due to be issued in the near future on the matter, and they will most likely incorporate the principles of the voluntary code of good practice. In any event public awareness within the farming community would be beneficial in order to advise on the groundwater vulnerability of the catchment and on best practice, which should be adopted.

Forty farmers (25%) within the catchment area, participate in the Rural Environmental Protection Scheme (REPS), in which they undertake nutrient management planning for their farms and to implement the voluntary code of good practice. This should ensure that their farming practice is environmentally sustainable, but it is not always the case, as some farmers who participate in REPS, have been classified as medium or high pollution risk in farm surveys conducted by Clare County Council.

In accordance with the Ground Water Protection Plan for the catchment, which was adopted in June 2003 by Clare County Council, the response matrix for landspreading within the inner protection zone is R4 i.e. landspreading is not acceptable. This response is in line with the national standard guidelines as developed by the DOELG, EPA and GSI (1999). This raises a major problem in that landspreading is recognised as a disposal method for organic waste by the Department of Agriculture and Food, but if the response matrix for landspreading is followed, then a farmer may not be allowed to spread the waste on his/her land if it is located within the inner protection zone. While the issue of where to landspread can be addressed somewhat in conditions attached to the grant of planning permission, not all farmers will need to apply for planning permission, nor will all farmers have alternative lands available outside of the inner protection zone, where they could spread the waste. Additionally there is no alternative disposal route available to farmers in the vicinity of the catchement in the event that other spreadlands are not available. With reference to 6.2 above, the water quality within the catchment has not deteriorated since the initial studies were carried out in the late eighties and early nineties. Consequently if the Council can achieve a situation whereby a) they make farmers aware of the vulnerability of the groundwater as a result of spreading of organic waste on lands, b) that they ensure that the code of good agricultural practice is adhered to strictly, and c) that they strive in as far as is possible to promote the spreading of organic waste outside of the catchment, then a restricted low slurry application rate, i.e. no greater than $25m^3$/hectare could be tolerated without a significant impact arising to the groundwater. However the impact on water quality would need to be monitored on an ongoing basis to ensure that there is no deterioration in the overall water quality and the risk to the water supply is sustainable. Even so, with reference to Chapter 3.6 the risk of microbial pathogens entering into the groundwater as a result of landspreading organic waste will remain EPA (2004), and this practice will need to be considered seriously by the Council in delivery of a potable water supply.

An alternative option to the above would be to strictly adhere with the response matrix for landspreading within the inner protection zone and not to permit the landspreading of organic waste. This would require the making of bye-laws pursuant to Section 21 of the Local Government (Water Pollution) Act, 1990. It is anticipated that there would be considerable opposition to the making of bye-laws from the farming community and also from local representatives. The making of bye-laws is a reserved function of the local authority, hence it is highly likely that given the expected opposition to them, it may result in being a lengthy process. To implement the bye-laws would require enforcement necessitating increased resources. Another consideration in the making of the bye-laws is that for farmers located within the inner protection zone, who have no other lands available where slurry could be spread, then alternative arrangements would need to be in place for the safe disposal of slurry.

With reference to Chapter 5.3, outwintering is practiced by a number of farmers in the catchment, with 22% of the animals held over the winter period being outwintered on the craggy Burren lands. This is a significant number of animals and the manner in which the livestock is managed is critical. The results of the farm survey in 2003 indicates that one of the issues identified as giving rise to a pollution risk was poor outwintering practices, whereby effluent was allowed to build-up at the feeding points and where excessive poaching of the land by animals was permitted (Cremin, 2003, Duffy, 2003 and Imbusch, 2003). When these conditions occur, there is an increased risk of downward movement of surface run-off containing nutrients and microbial pathogens to waters. As with landspreading of organic waste, education of the farming community is necessary, in order that the vulnerability of the groundwater from such practices is fully understood. Supplementary fodder in the form of hay, baled silage and meal is given to outwintered animals, which implies a higher stocking density than employed years ago and the consequential higher impact on the outwinterage.

6.4. SINGLE HOUSING DEVELOPMENT

Single housing development like agricultural developments pose a threat to the water quality within the catchment if the wastewater treatment on site is not managed properly. The treatment of the effluent discharged from septic tanks takes place in the ground, hence, and dependant on the type of soil and thickness of the overburden, a risk of pollution exists if soakage on site is either inadequate or excessive (Daly, Thorn and Henry, 1993). Both the agricultural and the single housing developments are dispersed throughout the entire catchment so the impact on water quality may arise anywhere in the catchment area. Map IV shows how single houses are present predominantly within the inner protection zone, where the depth of soil overlying the bedrock is minimal, consequently the assimilation capacity of the soil is reduced thereby creating additional pressures to the groundwater quality and making the groundwater very vulnerable to contamination.

From a geological perspective, the catchment bounds onto and includes the outer perimeter of the Ennis urban area. In recent years there has been an increase in developments within the catchment, as a result of an expanding urban area with developments occurring both along the outer town boundary and also within short commuting distances from the town. The entire catchment is served by on-site wastewater treatment. Up until recently this consisted of septic tanks and their associated soakways or percolation areas. In June 2003, a Ground Water Protection Scheme for the catchment was adopted by Clare County Council, which required the installation of advanced on-site wastewater treatment for all single housing developments, (Clare County Council, 1999 and Daly and Deakin, 2000). This form of control is necessary because the groundwater is so vulnerable to pollution, but it has major implications for planning and development of one-off houses within the catchment area, in particular, taking account of the increasing number of people seeking to live in the area.

A land-serviced initiative has been completed recently within the Ennis Town Council area, which extended the public sewer line to service a large housing development site located inside the catchment boundary. The sewer line does not extend to the town boundary at Loughville, located adjacent to Drumcarranmore swallow hole. It is probable that for future housing developments to proceed within the town boundary, but in unsewered areas, that a condition will be attached to the grant of planning, that will require the public sewer line to be extended to service the site. In the meantime there is a considerable number of single houses, within both the town boundary and the Drumcliff Springs catchment, where wastewaters from the houses are treated in septic tanks. Even taking that access to the public sewer is made available to all existing householders located within the town boundary, it is unlikely that every household would make the connection to the public sewer unless a legal notice requiring them to make the connection was implemented - most likely pursuant to the Local Government (Water Pollution) Act, 1977 as amended by the 1990 Act. Another consideration, with respect to the availability of a public sewer is the risk of a break/seepage in the sewer line or at the pumping station as a result of a malfunction of pumps etc. The consequences to groundwater quality in this type of situation is very serious in particular, if the pumping station is located adjacent to Drumcarronmore swallow hole as any spillage or leak in the sewer line could travel quickly to the Drumcliff Springs and contaminate the water supply source with the consequent serious implications to the potable water supply serving a large population.

Research has shown that septic tank effluent is highly pollutant containing microbial pathogens, high levels of nutrients and other constituents (Daly, Thorn and Henry, 1993), hence the potential to contaminate the groundwater is very high, even more so in a karst environment, where there is minimal attenuation due to the thin overburden. Daly (2002d) recommends that a minimum safe distance of 60m should be implemented between septic tank systems and the water supply source where the groundwater protection is relatively poor. Once the contaminant enters the groundwater, fast flow through times are provided through widened fissures to a potential water supply source. The implications from septic tank contamination is very significant when one considers that in general, single house developments occur in rural areas, that may not be serviced by either public or group water schemes, indeed very often the water supply for the one-off development is located within the same site as the septic tank. While the exact figures cannot be confirmed it is estimated that within the Drumcliff Springs catchment approximately 50% of the catchment area has access to either a group or public water supply. In situations where the water supply and the wastewater treatment system are both located on the one site, the manner in which the effluent from the septic tank is treated is critical in that the soil through which it passes acts as a filter. If there is an insufficient depth of soil available, then a serious risk of contamination of the groundwater exists together with a risk to public health from microbial pathogens present, if the water is used as a potable supply (Ball, 1997, and Daly, D., 2004). The appropriate treatment of the wastewaters on site, that is accordance with the EPA manual (EPA, 2000a), is necessary to minimise the impact on water quality and to provide a safe and clean groundwater, but it will not eliminate the risk. This will impose additional financial implications on the developer, requiring that a site characterisation assessment be carried out and the need to install an advanced wastewater treatment system.

Both Clare County Council and Ennis Town Council in assessing planning applications require a site assessment of the development site, and since November 2004, a person from an approved panel must carry out the site assessment (Clare County Council, 2004c). Gray (2004) reports that no two sites are identical, so it is critical that the treatment system and installation is optimised for each location and takes account of the variable geological factors particular to the site. Within the Drumcliff Springs catchment advanced wastewater treatment is mandatory in accordance with the Groundwater Protection Scheme thus the implementation of the guidelines issued in the EPA manual (EPA, 2000a), regarding the design, operation and maintenance of wastewater treatment for single houses is crucial if sustainable development is to be achieved (Daly, 2002b and Daly, G., 2004). In addition consideration should to be given to the concentration of one-off houses with the inner protection zone in the provision of sustainable planning for the area, taking account of the risk to water quality. Supervision and enforcement of proposals that are granted permission by the planning authority for wastewater treatment, if implemented, would help to minimise the risk of mismanagement of the systems installed. However this would require additional resources, both human and financial to implement.

The review of the planning applications for single housing development, which were granted permission over the period 2003 - 2004, indicate an increase in the use of mechanical and "Puraflo" wastewater systems. Likewise there has been an increase in the number of percolation and polishing filters observed in the years 2003 and 2004. This can be viewed as a step in the right direction, which will help to minimise the risk to groundwater quality within the catchment, but taking an overall perspective, the number of developments in the catchment that are serviced by older septic tanks far outweigh the number of advanced wastewater treatment systems present, so the hazard from septic tank contamination remains a significant threat.

6.5. INDUSTRIAL/COMMERCIAL DEVELOPMENT

Industrial and commercial development within the catchment area is limited but its impact on groundwater is not necessarily so. The impact on water quality will vary depending on the nature of the activity and its polluting potential.

6.5.1. Quarries

There are two quarry facilities located within the inner protection zone of the catchement, one located at Toonagh and the second located adjacent to Fountain Cross. Deakin, (1999) identified Fountain Springs as one of the five main inflows to the Drumcliff Springs. The area quarried is extensive and production levels at both facilities are significant as is the potential risk to groundwater. The threat to groundwater from the quarrying of stone can arise in a number of ways primarily from:-

- Large volumes of suspended solid material that are generated during the quarrying operational process. If they are not controlled, discharges containing high levels of suspended solids will drain off-site to surface waters or via fractures in the rock as preferential flow, to the groundwater.
- Seepages to the ground of fuel oils and other hazardous materials used on site. As outlined above, if hazardous substances are not contained adequately they will disperse very quickly in water and contaminate either or both surface waters or groundwaters.

- Groundwater levels may be affected as a result of the operational processes at the quarry. The water table level may be altered to some degree as a result of the quarrying process, and when account is taken of the proximity of the quarry to Fountain Springs, there is a potential risk to the abstraction rate of water at the supply source at Drumcliff Springs.

In considering the above, a potential risk to the groundwater quality exists if a discharge from the quarry at Fountain is proposed and it is not managed appropriately. The discharge would most likely be to the adjacent surface water that is fed by the rising springs at Fountain Cross. As stated in Chapter 2.2, the rising at Fountain Cross drains into Lough Cleggan and from here to the Ballygriffey River system, which sinks at Poulacorey swallow hole, hence if the discharge contained significant amounts of suspended solid material or hazardous substances, the discharge could potentially reach Drumcliff Springs in a short space of time. If a discharge were to occur from the quarry at Toonagh, the potential flowpath that might impact on the Drumcliff Springs would be via conduit groundwater flow as there is no direct surface water link to the Drumcliff Springs.

Similarly due to the karst nature of the catchment there is the potential for very fast conduit flow of hydrocarbon contaminants to a groundwater supply source from both quarries, with consequent implications to public health if adequate control are not put in place on site.

The impact on groundwater levels is another potential risk, albeit it is dependant on the level at which the rock is being quarried. With particular reference to the quarry located at Fountain Cross, and to the proximity of the quarry to one of the main inflows to the Drumcliff Springs identified by Deakin, (1999), there is a risk that the groundwater flow may be altered to some extent, which would have implications to the abstraction rate at Drumcliff.

6.5.2. Petrol Stations

Petrol stations by their nature contain hazardous material and pose a very significant risk to groundwater if they are not managed appropriately. The larger of the two petrol stations located at Loughville poses the greater risk as it is located adjacent to the Drumcarronmore swallow hole, which has a proven travel through time to Drumcliff Springs of less than twenty-four hours Cullen, (1990). This is very significant when one considers that there is minimal treatment at Drumcliff Water Treatment Plant at present, only chlorination and fluoridation and the fact that even the smallest quantity of oil contaminant could give rise to a significant public health risk. The contaminant would reach the water supply source before any remedial action could be taken to minimise its impact at the abstraction point. Drumcliff Springs is a major water supply serving a large population in the region of 22,000 people thus the significance of a contamination episode has enormous implications regarding the provision of a potable water supply to the public.

When the petrol station at Loughville was built initially, Ennis Town Council was unaware of the link between Drumcarronmore and Drumcliff Springs. It is highly probable that permission for the development would be refused if an application were submitted on a greenfield site today. While it would appear that good practice is being adopted at the facility in that overground tanks are bunded and an oil interceptor is in place, the underground storage tanks are not double lined, so the management and maintenance regarding the integrity of the tanks and indeed the entire facility is crucial. The proposed new development includes the replacement of existing tanks with new double lined tanks and as stated in Chapter 5.5.2, the conditions attached to the grant of permission for the development were appealed to An Bord Pleánala, who has upheld the decision made by Ennis Town Council.

The second smaller petrol station at Ballyknock, is located in the outer protection zone and while the risk to groundwater exists, the likelihood of contamination of the Drumcliff Springs water supply from this facility is less than that for the larger facility at Loughville. In any event it is necessary that any petrol station/garage facility located within the catchment area is managed in an appropriate manner and that the integrity of all tanks is maintained.

6.5.3. Wastewater Treatment Plants

Of the three-wastewater treatment systems in place within the catchment, two of the wastewater treatment plants (WWTP) use advanced wastewater treatment that is in line with EPA guidelines (EPA, 2000a). There is a major difference in the efficiency of the two advanced wastewater treatment plants, in that the WWTP at Fountain (Clare County Council, 2000) is in compliance with standards set out in a licence pursuant to Section 4 of the Local Government (Water Pollution) Act, 1977 as amended by the 1990 Act to discharge trade effluent to waters, whereas the second WWTP at Toonagh (Clare County Council, 2004a), is not in compliance with the standards set out in the Urban Waste Water Regulations, 2001, S.I. No. 254 of 2001.

The third wastewater treatment system located at Lees Road, is a large septic tank. When one considers the proximity of the septic tank to the Drumcliff Springs and to Lough Cleggan, the thickness of the overlying soils, where the treatment of the effluent takes place (Daly, Thorn and Henry 1993), there is a significant risk of contamination of the groundwater from this system. The date of installation of the septic tank at this location is unknown, but in any event new guidelines and standards have been introduced in the interim (EPA, 2000a). It is highly likely that a soakpit is in place to treat effluent from the septic tank, thus in order to minimise the risk of contamination of the groundwater, it is critical that the system be upgraded, with at the very least a new polishing filter, or alternatively an advanced wastewater treatment system be installed that is in line with the requirements of the Groundwater Protection Plan adopted by Clare County Council (Clare County Council, 1999).

A similar view as that taken in 6.4 above with regard to the threat to groundwater quality from the WWTP can be adopted, however the volume of discharge will be greater. In considering the impact from the WWTP's, one could say that where an effluent discharge from a treatment plant is not compliant with standards set, then a situation arises whereby a highly pollutant effluent is discharging to a percolation area or to surface water that is located in a vulnerable karst environment. The potential to contaminate the groundwater is greatly increased in this instance due to the increased volume of effluent that is discharged. Considering the implications from such a discharge, it is critical that remedial action is taken in order to bring the effluent discharge, from the WWTP at Toonagh and the septic tank at Lees Road, up to standard.

6.6. Surface Run-off from paved areas

Research by Kelly and Fitzsimons, (2000) indicated that significant levels of contaminants, many of which are "List 1" substances under the Protection of Groundwater Regulations, 1999, are present in stormwater run-off and that the most common form of disposal for surface run-off is to a soakway. Part of the Ennis town boundary is included within the Drumcliff Springs catchment, so paved areas from this section of the town must be considered as a potential risk to groundwater quality. The potential risk is even greater when one considers that this area is closest to Drumcarronmore swallow hole, where the poorest water quality is observed. The scope of this study does not include a quantification of the impact from paved areas within the catchment area on the groundwater system. But, certainly the Town Council in planning for future upgrades or changes in the manner that storm waters from the area is managed should consider the implications to groundwater quality in their assessment.

6.7. Fuel Tanks

Home heating fuel tanks are another hazard that could potentially impact on water quality in the catchment, albeit there is no evidence that this is the case. Because of the hazardous nature of fuel oil, its presence poses a risk. The number of fuel tanks has not been quantified nor is it within the scope of this study. A typical home heating oil tank contains on average approximately 500 litres of oil. If a spill or leak of this order occurred, this would equate to 25 parts per million, taking account that the discharge rate at Drumcliff Springs as 20,000m^3 (Deakin, 2000). Data is not available regarding the number of home heating fuel tanks that are in place within the catchment or of the number of fuel tanks on farms, or indeed if the tanks are double lined, but it is an area worthy of consideration and further study as it constitutes a significant hazard that could have major implications on the water quality at Drumcliff Springs if a leak were to occur.

6.8. Major Emergency Response

The risks posed from a major emergency event occurring within the catchment are very similar to the risks arising as a result of a hydrocarbon leak from fuel tanks, or from surface run-off from paved areas in that they contain the potential to release hazardous substances to the environment and they pose a major threat to the water supply source should the hazardous material enter the groundwater system. The N85 national route and the R476 regional route dissect the catchment and traffic volumes on both routes are significant in that they serve as access routes to the coast and to the Burren, with their obvious associated tourism potential. A major emergency plan is in place in the event of a situation giving rise to death, serious injury, serious disruption of essential services or damage to property, beyond the normal capabilities of the Gardái, local authorities and health services (Clare County Council, 2004b). However if such an event were to occur, there are serious implications to the groundwater and ultimately to the water supply given the nature of the catchment, if cognisance is not taken of the groundwater vulnerability in the response implemented by the emergency services. In the event of an oil spill on one of the public roads, the fire service use an absorbent material (Elephantsorb) to soak up the spill. A biodegradable material, (Road Bio) which is detergent based, is then applied to the road, rubbed in and then washed off. Similarly if an acid or alkaline spill occurrs, the response is to dilute with water. Both responses give rise to large volumes of water that are not contained and will discharge to the ground. While the likelihood of such an event occurring may be low and the response mechanisms employed by the fire service are in line with best practice, the potential risk of pollution of the groundwater system still remains. The environment section of Clare County Council are currently in discussions with the fire service to address the risks posed within the catchment and to develop a protocol to be used in response to emergency situations.

There are many factors that contribute to the vulnerability of the Drumcliff Springs catchment. Of primary importance is the geology, in which Carboniferous limestones predominate, and where the karst aquifer is characterised by features such as disappearing rivers, swallow holes and springs. The karst nature of the catchment creates a natural fast conduit of flow to the Drumcliff Springs for the contaminants, which can be both natural and anthropogenic in origin, and together with the thin overlying soils, which provides little attenuation, makes the supply source extremely vulnerable to contamination.

There is an onus on Ennis Town Council to protect the good water status at Drumcliff Springs in provision of a water supply suitable for human consumption, which is in accordance with the European Communities (Drinking Water) Regulations, 2000. By their very nature the natural contaminants affecting the water supply can only be mitigated through further treatment of the supply. The upgrading of the water treatment plant at Drumcliff is presently at the planning stage, and even taking account that the fast forward process is implemented for the development, is it will be a minimum of two years before improved treatment of the supply is in place. The hazards however, posed to the quality of the groundwater as a result of human activity can be addressed through sustainable planning and the adoption of good practice in all disciplines, i.e. in single house developments, agricultural practices, commercial activity, etc. Unless these hazards are managed in a manner, which will minimise their impact on water quality, then the implications from the contamination of a large water supply are considerable and the objectives of the Water Framework Directive 2000/60/EEC, that is to achieve "good status" for all waters, including groundwaters, by 2015, resulting from the impact of human activity will not be achieved.

7 CONCLUSIONS

This study reviewed factors, both natural and anthropogenic that are contributing to the water quality at Drumcliff Springs. The karst nature of the aquifer together with the thin overburden provides little attenuation to the natural contaminants within the catchment. Unless further treatment of the water supply is put in place, it will be difficult to control the occurrence of natural contamination in the supply. Anthropogenic activities within the catchment must be controlled and managed in an environmentally friendly manner in order to provide a potable water supply that is in accordance with the European Communities (Drinking Water) Regulations, 2000.

In evaluating the new analytical water quality data available for the catchment over the period 1998 – 2004, many of the findings from previous studies regarding the source of the contaminants have been confirmed and they demonstrate clearly the impact arising from the geological influences on the catchment. The results indicate that there has been no deterioration in water quality within the catchment, thus the impact from human influences on the water quality is not observed to any significant extent and the Groundwater Protections Plan that was put in place to minimise the risk of pollution to groundwater is effective to some degree.

The significant points concluded from the evaluation of the analytical data are as follows:-

- There is some correlation between the occurrence of high colour and turbidity levels in the water and rainfall, but the correlation is neither consistent nor predictable.
- A similar pattern to that observed for colour and turbidity, is noted for the parameter iron, and demonstrates the relationship between the geology of the catchment, rainfall and water quality observed.
- Elevated colour and turbidity levels were observed in the upper reaches of the Shallee River, where impermeable gley soils predominate, whereas the levels for colour and turbidity decrease further downstream in the karstified areas.
- The largest flow to the springs is from Poulacorey swallow hole (Deakin, 1999), consequently the water quality in the Ballygriffey River has a greater influence on water quality at the Springs.

- The poorest water quality was identified at the Drumcarronmore swallow hole, but because this swallow hole contributes to the Drumcliff Springs during wet weather only, poor water quality is not always observed at Drumcliff Springs as a result.
- The nutrient levels observed are generally low and demonstrate that there is little impact on the water quality from anthropogenic activities. Phosphate levels observed are higher in the upper reaches of the Shallee River, whereas the nitrate levels are highest in the lower reaches of the river channel.
- A significant danger of pathogenic contamination of the water supply exists as a link between high microbial levels and rainfall was demonstrated. Microbial contamination can arise from both agricultural and septic tank wastes.

The anthropogenic hazards highlighted in the study all have the potential to cause significant impact on groundwater quality unless they are controlled in an environmentally friendly manner.

The main conclusions arising from anthropogenic activities are as follows

- New single housing developments are concentrated within the inner protection zone of the catchment, and if planning of these developments is not managed in an environmentally sustainable manner, then a serious risk of contamination of the groundwater exists. While an increase in the use of advanced wastewater treatment from single housing developments is observed, the threat of microbial contamination remains from older septic systems located within the catchment.
- Similarly municipal wastewater treatment plants located within the catchment pose a significant risk of contamination of the groundwater. Upgrading of the treatment plants together with appropriate management of the wastewater systems is required in order to minimise the threat posed.
- Agricultural activity is not intensive with 78% o the farms surveyed, classified as low pollution risk. Six of the seven farms classified as high risk are located within the inner protection zone for the Drumcliff Springs supply source and will require remedial works to be carried out to minimise the pollution risk.
- Landspreading poses a significant threat of contamination of the groundwater as a result of both microbial contamination and elevated nutrient levels. The response matrix as detailed in the groundwater protection plan, requires that organic wastes are not spread within the inner protection zone. Public awareness of the public health implications

associated with this practice must be promoted, together with the adoption of the code of Good Practice and the promotion of low application rates. Consideration should be given to the introduction of bye-laws restricting the spreading of organic waste within the catchment having regard to the ongoing monitoring data available.

- The use of hazardous substances in commercial/industrial operational processes, including the use of hydrocarbons is another significant potential source of contamination of the water supply at Drumcliff. A similar risk from the storage of home heating fuel in the event of a leak, also exists and can occur anywhere in the catchment.

As stated above, the risk of pathogenic contamination to the water supply is a serious concern and has major public health implications. The potential to contaminate the supply by hydrocarbons poses another serious danger unless the activities giving rise to this risk are managed appropriately.

The geology of the catchment and karst nature of the aquifer contributes to a large extent to the risks arising from the hazards posed by human activities, due to the minimum attenuation as a result of the thin overburden, preferential flowpaths and fast groundwater flow within the aquifer system. Consequently the implementation of the groundwater protection plan and public awareness of the groundwater vulnerability within the catchment is critical in protecting the water supply.

8 RECOMMENDATIONS

1. To address the difficulty, which arose in the evaluation of the water quality data whereby there was inconsistency in the parameters analysed for the different waters, thus making it difficult to carry out comparisons of the contaminant variables in the different water bodies, monitoring should be carried out of the significant parameters, i.e. for colour, turbidity, iron, nitrate, phosphate, total coliforms and faecal coliforms at all stations identified as monitoring locations for water quality in the catchment. An additional monitoring station should be included in the northern section of the catchment area at the bridge on the Ballycullinan stream near Kilkee, so as the impact on water quality at the Drumcliff Springs form this area can be measured. The data collected should be reviewed on a regular basis so that appropriate action can be taken and good water status can be maintained.

2. In order to protect good water quality, vigilance must be maintained in the control of housing developments within the catchment. It is important to continue to implement the recommendations and response matrix included in the groundwater protection plan for the catchment and to take account of available monitoring data. Particular emphasis should be given to the location and to the wastewater treatment systems proposed for one-off single housing developments especially where there are clusters of houses present and the water supply for the development is abstracted from the same site. Consideration should be given to the inclusion of conditions for grant of permission regarding:-
   i. The implementation of a quality assurance system for new proposed wastewater treatment systems, to include certification by an approved person and the requirement of ongoing maintenance. The implementation of this system will also require follow-up and enforcement by the local authority.
   ii. The attaching of a condition regarding the requirement for double lined fuel tanks.

3. The public sewer should be extended to the town boundary at Loughville, with the requirement for all householders located within both the town boundary and the catchment boundary area, to connect to the public sewer so as to minimise the risk of contamination of the supply.

4. Increased maintenance should be adopted in the management of the wastewater treatment plant at Toonagh in order that the discharge effluent becomes compliant with the standards set out in the Urban Waste Water Regulations, 2001, S.I. No. 254 of 2001. Similarly the septic tank located at the Lees road housing development should be managed is such a manner that the risk to groundwater is minimised. Consideration should be given to the upgrading of both wastewater treatment systems.

5. Agricultural activities and practices need to managed in such a manner that they take account of the groundwater protection plan for the catchment and minimise the risk of contamination of the groundwater. A multi faceted approach is required to achieve for this and will include:
   i. Promotion of public awareness of the farming community regarding the vulnerability of the groundwater within the catchment as a result of agricultural practices i.e. from spreading of organic waste on land, uncontained discharges, inappropriate outwintering practice and from the storage of hydrocarbon fuels on farms.
   ii. Promotion of the code of good agricultural practice and, where a pollution risk is observed, strict adherence to the code should be enforced by the local authority.
   iii. In as far as is possible the response matrix attached to the groundwater plan, regarding the spreading of organic waste on land, should be adopted. Where this is not possible, a maximum application rate of $25m^3$ per hectare per annum should be applied. However should a deterioration in the water quality be observed, in particular with respect to the bacterial contaminants, then serious consideration must be given to the introduction of bye-laws restricting the spreading of organic waste in specified areas within the catchment.

6. A policy statement, which details the response to be taken in major emergencies within the catchment should be developed. Implementation of the policy statement should include liaison between all parties involved in response to major emergencies so that all parties are aware of the risk to groundwater and of the consequent implications to the water supply source should it become contaminated as a result of a major accident or spill.

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Appendix A

ANALYTICAL DATA FOR RAW WATER AT DRUMCLIFF SPRINGS 1998 - 2004

Analytical Data of Raw Water at Drumcliff WTP - 1998

Date	Temp (°C)	pH (pH units)	Colour (hazen)	Turbidity (N.T.U)	Conductivity (uS/cm)	Iron (ug/L Fe)
05/01/1998	9.6	7.4	40	2.3	516	110
06/01/1998	9.5	7.4	50	2.1	503	120
09/01/1998	7.9	7.4	40	1.6	486	120
12/01/1998	7.8	7.5	40	1.8	480	100
14/01/1998	9.0	7.5	40	2.1	509	140
16/01/1998	8.9	7.5	40	1.8	486	130
19/01/1998	8.5	7.6	50	2.9	495	160
21/01/1998	8.3	7.5	40	2.6	398	130
23/01/1998	8.0	7.6	40	3.4	490	170
28/01/1998	9.5	7.6	30	1.9	486	150
29/01/1998	10	7.6	30	2	495	160
02/02/1998	8.0	7.6	20	1.5	409	150
04/02/1998	8.3	7.6	30	1.8	458	120
06/02/1998	8.5	7.6	25	2.0	403	100
09/02/1998	9.3	7.6	40	2.1	439	140
11/02/1998	9.3	7.6	40	2.5	495	NM
13/02/1998	8.5	7.6	40	2.5	459	100
16/02/1998	9.5	7.6	30	1.8	486	130
18/02/1998	9.4	7.6	30	1.6	486	130
23/02/1998	9.3	7.6	50	2.0	495	140
25/02/1998	9.0	7.7	40	2.3	490	120
27/02/1998	8.5	7.6	30	1.6	490	130
02/03/1998	9.1	7.6	50	1.3	558	150
03/03/1998	8.5	7.6	70	2.6	500	160
06/03/1998	9.0	7.7	60	1.9	503	160
09/03/1998	9.0	7.6	50	2.1	405	150
11/03/1998	9.4	7.6	40	2.0	498	120
13/03/1998	10.0	7.7	40	1.3	NM	100
16/03/1998	10.0	7.6	30	1.0	NM	100
19/03/1998	9.1	7.5	20	1.6	NM	100
23/03/1998	10.3	7.6	20	1.5	NM	100
25/03/1998	10.1	7.6	30	1.6	NM	100
27/03/1998	10.3	7.6	70	2.5	NM	130
30/03/1998	10.3	7.7	50	2.3	NM	130
01/04/1998	10	7.6	40	1.6	NM	90
06/04/1998	10.3	7.6	50	1.3	467	110
08/04/1998	11.3	7.63	40	1.9	473	100
09/04/1998	12.3	7.38	40	1.8	446	140
14/04/1998	10.1	7.3	30	1.3	501	100
16/04/1998	10.9	7.49	30	1	500	100
20/04/1998	11.9	7.53	30	1	498	120
22/04/1998	11.9	7.5	30	0.9	465	80
24/04/1998	15.1	7.44	50	1.9	450	200
27/04/1998	16.1	7.53	80	2.6	424	210
29/04/1998	16.9	7.44	60	2.1	458	130
30/04/1998	17	7.45	50	1.6	450	120
05/05/1998	18	7.5	40	1.3	503	120
06/05/1998	18	7.52	40	1.4	505	130

NM: Not Measured

Analytical Data of Raw Water at Drumcliff WTP - 1998

Date	Temp (°C)	pH (pH units)	Colour (hazen)	Turbidity (N.T.U)	Conductivity (uS/cm)	Iron (ug/L Fe)
07/05/1998	18	7.53	40	1.5	508	130
08/05/1998	18.1	7.5	40	1.2	500	90
11/05/1998	18.3	7.52	30	1.1	510	120
12/05/1998	18.1	7.51	30	1	500	100
14/05/1998	18.6	7.52	30	1.6	497	80
15/05/1998	18.2	7.54	30	1.3	491	80
19/05/1998	20.1	7.43	30	1	500	80
20/05/1998	*21.1*	*7.4*	*30*	*0.8*	*500*	*80*
21/05/1998	21.1	7.4	30	0.8	502	90
22/05/1998	20.9	7.42	30	0.9	500	100
02/06/1998	15.1	7.48	25	1.3	500	110
05/06/1998	15.3	7.49	25	1	487	NM
08/06/1998	15.4	7.52	30	1.3	499	90
10/06/1998	15.7	7.58	30	1.6	489	110
11/06/1998	15.8	7.53	40	1.6	478	120
15/06/1998	16.4	7.4	60	1.8	433	150
17/06/1998	*16.7*	*7.42*	*40*	*1.3*	*456*	*160*
18/06/1998	16	7.49	50	1.9	440	180
19/06/1998	16.7	7.19	100	8	311	300
22/06/1998	18.1	7.42	60	2.5	460	180
24/06/1998	20.3	7.43	40	1.7	473	150
26/06/1998	20.4	7.49	40	1.6	470	110
29/06/1998	20.3	7.58	80	2	460	130
30/06/1998	20.1	7.48	70	2.5	465	120
01/07/1998	20	7.42	60	2	431	100
03/07/1998	*22.5*	*7.42*	*30*	*1.8*	*475*	*110*
06/07/1998	22.9	7.49	30	1.2	435	100
08/07/1998	22.6	7.41	30	1.6	440	90
13/07/1998	20.2	7.49	30	1.9	491	NM
14/07/1998	17.5	7.1	30	3.1	471	220
15/07/1998	18	6.9	30	2.4	477	210
16/07/1998	18	7.1	30	2	483	100
17/07/1998	18	7.9	30	2	494	260
20/07/1998	19	6.95	20	2	639	250
21/07/1998	*21*	*7.1*	*60*	*2.6*	*452*	*190*
22/07/1998	20	7.1	60	2.1	467	180
23/07/1998	19	7.1	50	2.2	466	300
24/07/1998	30	6.9	175	9.8	320	NM
27/07/1998	19	7.1	40	2.2	470	140
29/07/1998	21	7	30	2	521	190
31/07/1998	18	7	50	2.4	505	290
04/08/1998	21	6.9	100	5	393	330
05/08/1998	22	6.9	85	3	581	210
06/08/1998	22	*7*	*60*	2.5	*491*	330
10/08/1998	27	6.9	50	2.8	580	200
11/08/1998	22	6.9	40	2	594	140
12/08/1998	30	6.9	50	2.5	572	120
13/08/1998	27	6.9	40	2	562	130

NM: Not Measured

Analytical Data of Raw Water at Drumcliff WTP - 1998

Date	Temp (°C)	pH (pH units)	Colour (hazen)	Turbidity (N.T.U)	Conductivity (uS/cm)	Iron (ug/L Fe)
14/08/1998	28	6.9	40	1.17	562	390
17/08/1998	22	7	40	2	563	30
18/08/1998	22	7	40	1.8	550	NM
19/08/1998	23	7.1	30	1.5	509	NM
20/08/1998	19	7.2	50	3	602	280
21/08/1998	20	6.97	30	1.3	505	90
24/08/1998	21.5	6.75	70	4.5	427	300
25/08/1998	23.5	6.8	100	4	387	280
26/08/1998	22.5	7.2	60	1.5	453	190
27/08/1998	25	7.14	50	1.2	464	160
28/08/1998	25	7.22	40	1.5	463	140
31/08/1998	15	7.17	50	1.5	489	120
01/09/1998	18	7.01	40	1.5	482	140
02/09/1998	16.4	7.09	100	3.5	398	270
03/09/1998	15	7.04	50	1.5	453	190
04/09/1998	20	7.06	40	1.2	475	160
07/09/1998	17.5	6.98	40	1.5	469	150
08/09/1998	18	7.12	60	1.5	453	210
09/09/1998	18	6.85	100	3.5	397	380
10/09/1998	18	6.9	125	8.5	354	410
11/09/1998	18	7.01	70	2.6	437	190
14/09/1998	20	7.06	50	1.3	489	190
15/09/1998	21	7.05	50	1	496	90
16/09/1998	18	7.1	40	1	491	90
17/09/1998	18	7.2	50	1.5	466	130
18/09/1998	18	6.99	50	1.5	484	120
21/09/1998	16	7.03	40	1	506	110
22/09/1998	16.5	7	50	1.2	508	140
23/09/1998	16	7.06	40	1.3	510	110
24/09/1998	16	7.01	40	1.2	515	120
25/09/1998	15	7.02	40	1.2	505	120
28/09/1998	17	7	70	2.3	466	250
29/09/1998	16	7.03	60	2	477	200
30/09/1998	16	6.98	50	1.7	495	170
01/10/1998	16.5	6.98	40	1.5	498	180
02/10/1998	16	7.23	40	1.3	500	150
05/10/1998	16	7.23	50	1.5	499	150
06/10/1998	16	7.05	50	1.3	499	150
07/10/1998	16	7	40	1.2	508	150
08/10/1998	14.4	7.1	50	1.8	509	NM
09/10/1998	14.5	7.02	30	1	512	NM
12/10/1998	15.1	7.08	50	1.3	492	160
13/10/1998	14.2	7.1	50	1.3	499	160
14/10/1998	14.5	7.42	50	1.4	497	190
15/10/1998	14.2	6.74	150	1	342	NM
16/10/1998	13.8	6.97	70	2.8	457	NM
19/10/1998	13.6	7	50	1.8	490	140
20/10/1998	13.9	7	40	1.2	497	120

NM: Not Measured

Analytical Data of Raw Water at Drumcliff WTP - 1998

Date	Temp (°C)	pH (pH units)	Colour (hazen)	Turbidity (N.T.U)	Conductivity (uS/cm)	Iron (ug/L Fe)
21/10/1998	14.6	6.86	50	2	495	150
22/10/1998	14.7	6.8	125	10	349	NM
23/10/1998	17.2	6.92	70	3.5	449	NM
27/10/1998	14.4	6.97	50	2.3	496	110
28/10/1998	15.5	6.97	70	9	422	220
29/10/1998	13.4	7.08	50	3.8	484	130
30/10/1998	12.6	7.07	50	3.2	480	NM
02/11/1998	13.8	6.89	40	2.2	474	100
03/11/1998	12.8	6.95	60	4	449	120
05/11/1998	14.6	7.1	50	5.5	498	NM
06/11/1998	13.5	7.05	40	2	507	NM
09/11/1998	15.6	7.03	50	2.6	547	NM
10/11/1998	16.1	7	40	NM	483	NM
11/11/1998	12.5	7.04	30	NM	495	NM
12/11/1998	15	7.2	30	NM	517	NM
13/11/1998	12.3	7.11	40	NM	452	NM
16/11/1998	12	6.88	20	NM	508	NM
18/11/1998	13.3	7.44	30	NM	480	110
19/11/1998	14.3	7.05	20	NM	501	80
23/11/1998	13.9	6.84	40	4	465	210
24/11/1998	14.3	6.91	20	1.5	500	100
25/11/1998	14.5	6.85	40	2.5	469	NM
27/11/1998	14.9	7.28	20	1.25	510	110
30/11/1998	15.4	6.97	30	1.3	513	110
02/12/1998	16	7.19	15	1	539	90
03/12/1998	16.4	7.09	30	1	529	80
04/12/1998	16.4	6.96	30	0.9	527	90
07/12/1998	17	7.06	15	1	538	NM
08/12/1998	14.3	6.98	20	1	539	90
09/12/1998	15.3	7.1	15	1.3	524	110
10/12/1998	16.3	NM	15	1.2	534	NM
14/12/1998	13.1	7.15	100	16	358	NM
15/12/1998	13.8	7.13	60	5.5	427	230
17/12/1998	11.8	7.28	15	3.1	525	130
18/12/1998	11.9	7.1	20	2.7	501	140
22/12/1998	10.2	7.23	20	2.5	518	100
23/12/1998	10.2	7.1	15	2.4	511	130
30/12/1998	11.1	6.96	20	3.1	517	100
31/12/1998	10.6	6.94	40	6.8	458	160

NM: Not Measured

Analytical Data of Raw Water at Drumcliff WTP - 1999

Date	Temp (°C)	pH (pH units)	Colour (hazen)	Turbidity (N.T.U)	Conductivity (uS/cm)	Iron (ug/L Fe)
04/01/1999	11.8	7.2	30	4.5	456	100
06/01/1999	12.4	NM	15	2	493	70
07/01/1999	8.1	7.1	15	1.5	499	NM
08/01/1999	11.1	7.4	15	1.7	512	NM
11/01/1999	NM	NM	5	NM	NM	NM
19/01/1999	11.8	7.4	20	2.7	457	NM
25/01/1999	10.8	7.5	20	2	488	NM
26/01/1999	12.2	7.5	20	2	467	230
27/01/1999	13.1	7.3	60	8	439	180
28/01/1999	14.3	7.5	20	2	474	160
29/01/1999	12.8	7.5	15	1.3	501	110
01/02/1999	NM	NM	10	1.4	NM	NM
04/02/1999	12.9	7.5	10	1.3	511	NM
05/02/1999	20	7.5	10	1.3	517	NM
09/02/1999	11.5	7.5	60	4.2	431	270
11/02/1999	10.1	NM	15	1.3	518	NM
12/02/1999	12	7.5	15	1	516	250
15/02/1999	10.8	7.4	25	1.5	507	NM
22/02/1999	12.8	7.5	50	2.4	464	180
23/02/1999	12.7	7.5	40	1.8	486	150
24/02/1999	11	7.3	30	2.3	468	190
01/03/1999	14.1	7.2	60	4	436	NM
02/03/1999	NM	NM	70	NM	NM	NM
03/03/1999	11.9	7.4	65	5.2	420	180
05/03/1999	14.7	7.4	30	1.6	487	NM
08/03/1999	NM	NM	25	1.2	NM	NM
10/03/1999	11.6	7.6	20	1.2	500	NM
11/03/1999	12.4	7.6	20	1	505	NM
16/03/1999	12.8	7.6	20	1.8	516	150
18/03/1999	14.6	7.6	30	1.3	584	110
22/03/1999	15.4	7.7	15	1.3	536	110
25/03/1999	13.8	7.7	20	1.3	537	100
29/03/1999	10.9	7.6	55	2.8	459	220
01/04/1999	16.2	7.6	35	1.5	501	NM
06/04/1999	19.7	7.6	35	1.4	492	150
07/04/1999	20	7.6	55	1.6	470	NM
09/04/1999	21	7.7	35	1.3	485	NM
12/04/1999	20.4	7.6	20	1.1	496	NM
13/04/1999	13.3	7.6	70	4.3	434	NM
15/04/1999	15	7.7	35	1.7	476	130
20/04/1999	18.4	7.7	20	1	510	100
22/04/1999	19.6	7.6	50	2.4	445	140
23/04/1999	19.9	7.6	25	1.3	483	100
26/04/1999	21.8	7.6	45	1.5	479	120
28/04/1999	16.6	7.6	20	1.4	499	110
04/05/1999	24.2	7.6	20	1	529	70
05/05/1999	15.3	7.6	20	1	523	90

NM: Not Measured

Analytical Data of Raw Water at Drumcliff WTP - 1999

Date	Temp (°C)	pH (pH units)	Colour (hazen)	Turbidity (N.T.U)	Conductivity (uS/cm)	Iron (ug/L Fe)
06/05/1999	17.3	7.7	15	1	528	80
10/05/1999	20	7.7	20	1	547	150
12/05/1999	16.7	7.8	25	1.7	518	100
14/05/1999	15.6	7.8	25	1.1	500	100
17/05/1999	17.2	7.6	30	1.3	510	120
19/05/1999	14.1	7.7	25	1.25	527	NM
21/05/1999	14	7.7	20	1	525	NM
24/05/1999	14.8	7.8	20	1	498	NM
26/05/1999	14.9	7.7	20	1.2	485	NM
30/05/1999	14.8	7.6	30	1.2	498	NM
31/05/1999	14.5	7.6	30	1.3	494	NM
01/06/1999	15.8	7.7	25	1.3	491	NM
02/06/1999	15.5	7.6	25	1.4	496	NM
07/06/1999	15.9	7.6	15	1	485	NM
08/06/1999	14.7	7.7	25	1	473	NM
09/06/1999	14.9	7.7	20	0.8	484	NM
10/06/1999	14.9	7.6	20	1	496	NM
11/06/1999	15.5	7.6	20	1	491	NM
14/06/1999	15.1	7.6	20	1	492	NM
16/06/1999	15.4	7.5	20	0.8	490	NM
18/06/1999	14	7.5	20	0.8	474	NM
22/06/1999	14.5	7.5	20	0.9	441	NM
23/06/1999	15.7	7.5	20	1	491	NM
25/06/1999	16	7.5	20	1	492	NM
28/06/1999	NM	7.6	20	1.5	521	NM
29/06/1999	17.1	7.5	20	2.1	479	NM
30/06/1999	16.7	7.6	20	1.1	520	NM
01/07/1999	15.8	7.5	25	1.1	480	NM
02/07/1999	15.9	7.5	55	3	444	NM
05/07/1999	16.7	7.5	50	1.6	467	NM
06/07/1999	16.5	7.5	35	1.4	472	NM
07/07/1999	16.9	7.5	35	1.4	475	NM
08/07/1999	16.9	7.5	30	1	476	NM
09/07/1999	17.2	7.6	30	1	473	NM
12/07/1999	17.3	7.5	20	1.1	478	NM
13/07/1999	17.2	7.5	20	0.9	477	NM
14/07/1999	17.4	7.5	20	1	483	NM
15/07/1999	17.2	7.5	25	0.8	483	NM
16/07/1999	16.9	7.5	20	0.9	484	NM
19/07/1999	16.9	7.3	85	9.1	342	NM
20/07/1999	16.5	7.4	70	4.7	398	NM
22/07/1999	16.8	7.5	50	1.7	460	NM
23/07/1999	16.8	7.6	40	1.3	472	NM
26/07/1999	16.7	7.6	30	1.2	501	NM
27/07/1999	16.6	7.6	30	1.6	501	NM
28/07/1999	16.7	7.6	25	1.1	504	NM
29/07/1999	17.3	7.6	25	0.9	512	NM

NM: Not Measured

Analytical Data of Raw Water at Drumcliff WTP - 1999

Date	Temp (^oC)	pH (pH units)	Colour (hazen)	Turbidity (N.T.U)	Conductivity (uS/cm)
30/07/1999	16.9	7.6	20	0.8	513
03/08/1999	17.6	7.5	30	2.3	520
04/08/1999	17.7	7.5	20	1	510
05/08/1999	17.2	7.5	20	1.1	512
06/08/1999	17.2	7.5	20	0.9	514
09/08/1999	16.9	7.5	20	1.2	510
10/08/1999	16.8	7.5	20	0.8	513
11/08/1999	16.9	7.5	20	0.8	521
12/08/1999	16.7	7.5	20	0.8	519
17/08/1999	18.3	7.5	20	1.1	510
18/08/1999	15.9	7.5	20	0.9	515
19/08/1999	15.8	7.5	20	0.7	519
20/08/1999	16.8	7.5	20	0.7	512
24/08/1999	16.8	7.5	20	0.9	527
25/08/1999	16.7	7.5	20	0.8	518
26/08/1999	16.2	7.4	100	15	409
27/08/1999	16.2	7.4	60	3.5	445
30/08/1999	16.2	7.5	40	1.1	482
31/08/1999	16.2	7.5	30	1	487
01/09/1999	16.4	7.5	40	0.9	483
02/09/1999	16.2	7.5	30	1	487
03/09/1999	16.4	7.4	25	1	504
06/09/1999	16.3	7.4	20	0.7	500
07/09/1999	16.2	7.4	20	0.9	497
08/09/1999	16.3	7.5	70	3.5	436
09/09/1999	16	7.4	125	16	375
10/09/1999	15.9	7.5	100	6.6	386
13/09/1999	15.5	7.4	70	1.8	459
14/09/1999	15.2	7.5	70	3.4	433
15/09/1999	15.2	7.5	65	1.6	470
16/09/1999	15.1	7.5	55	1.4	485
17/09/1999	15.2	7.5	50	1.1	493
20/09/1999	15.1	7.5	50	1.7	490
21/09/1999	14.9	7.5	50	1.3	512
22/09/1999	15	7.3	100	4.3	458
23/09/1999	14.9	7.5	65	2	475
24/09/1999	14.8	7.4	50	1.5	503
27/09/1999	15	7.5	40	2.8	499
28/09/1999	14.7	7.5	80	3.2	430
29/09/1999	14.6	7.4	60	1.8	478
30/09/1999	14.5	7.5	65	2.2	456
01/10/1999	14.3	7.5	50	2	472
04/10/1999	13.5	7.5	60	3	475
05/10/1999	13.7	7.4	40	1.9	486
06/10/1999	13.7	7.5	30	1.8	497
07/10/1999	13.6	7.5	30	1.3	505
08/10/1999	13.4	7.5	30	1.1	503
12/10/1999	13.8	7.5	35	1.2	507
13/10/1999	13.2	7.5	40	1	535

Analytical Data of Raw Water at Drumcliff WTP - 1999

Date	Temp (°C)	pH (pH units)	Colour (hazen)	Turbidity (N.T.U)	Conductivity (uS/cm)
14/10/1999	13.1	7.5	35	1.3	525
15/10/1999	13.1	7.5	30	1.6	518
18/10/1999	13.2	7.5	30	1.4	523
19/10/1999	12.9	7.5	30	1	525
20/10/1999	12.9	7.5	30	1.1	524
21/10/1999	13	7.5	20	1	521
22/10/1999	13.1	7.5	20	1	527
26/10/1999	13	7.5	30	1.2	527
27/10/1999	12.4	7.6	30	1.1	533
28/10/1999	12.6	7.6	30	1.2	531
01/11/1999	12.7	7.6	40	1.8	498
02/11/1999	12.2	7.5	60	2.8	460
03/11/1999	12.1	7.5	55	2	482
04/11/1999	12.3	7.6	50	2.2	500
05/11/1999	11.9	7.5	35	1.4	524
08/11/1999	12.2	7.5	45	2	521
09/11/1999	12.1	7.5	35	1.3	524
11/11/1999	12	7.5	40	2	525
12/11/1999	11.9	7.5	35	1.1	528
15/11/1999	11.7	7.5	35	1	539
16/11/1999	11.2	7.5	30	1	537
17/11/1999	11.1	7.5	30	1.1	535
18/11/1999	11	7.5	35	1	533
19/11/1999	10.9	7.5	50	2.3	478
22/11/1999	9.8	7.5	35	1.2	528
23/11/1999	10.7	7.5	30	1.1	532
24/11/1999	10.6	7.5	30	1	531
25/11/1999	10.9	7.4	100	11	393
26/11/1999	10.9	7.5	60	3	495
29/11/1999	10.6	7.4	115	16	314
30/11/1999	10.6	7.4	70	5.5	441
01/12/1999	10.6	7.5	40	2.4	493
02/12/1999	10.8	7.5	40	2.8	494
03/12/1999	10.5	7.6	40	2.8	493
06/12/1999	10.5	7.6	40	1.8	502
07/12/1999	10.4	7.6	60	3.3	420
08/12/1999	10.2	7.6	40	2.5	457
09/12/1999	9.6	7.6	60	4.5	442
10/12/1999	9.5	7.6	40	2.6	463

Analytical Data of Raw Water at Drumcliff WTP - 2000

Date	Temp (°C)	pH (pH units)	Colour (hazen)	Turbidity (N.T.U)	Conductivity (uS/cm)	Total Coliforms (No./100mls)	Faecal Coliforms (No./100mls)
04/01/2000	10.2	7.4	30	2.0	460	NM	NM
07/01/2000	9.5	NM	30	2.4	463	NM	NM
10/01/2000	9.9	7.7	20	2.3	460	NM	NM
11/01/2000	9.9	7.7	20	2.0	460	NM	NM
13/01/2000	11.7	7.5	40	5.2	680	NM	NM
14/01/2000	15.7	7.6	30	2.0	NM	NM	NM
17/01/2000	10.1	7.7	20	1.3	NM	NM	NM
18/01/2000	10.7	7.7	20	1.5	NM	NM	NM
19/01/2000	13.1	7.6	20	1.0	485	NM	NM
20/01/2000	8.5	7.6	15	1.3	480	NM	NM
21/01/2000	10.2	7.7	20	1.4	NM	NM	NM
24/01/2000	12.1	7.7	15	1.6	503	NM	NM
25/01/2000	12	7.6	20	1.3	504	NM	NM
26/01/2000	12.1	7.7	20	1.4	510	NM	NM
27/01/2000	12.6	7.6	20	1.4	511	NM	NM
28/01/2000	12.6	7.9	15	1.2	512	NM	NM
31/01/2000	17	7.5	50	3.7	408	NM	NM
01/02/2000	17.5	7.5	30	2.3	448	48	8
02/02/2000	NM	7.6	30	2.5	402	NM	NM
03/02/2000	NM	7.6	20	2.0	452	NM	NM
04/02/2000	NM	7.6	20	2.4	458	NM	NM
07/02/2000	11.2	7.7	40	4.0	449	NM	NM
08/02/2000	11	7.6	40	4.0	419	107	0
09/02/2000	10.6	7.7	25	2.8	451	NM	NM
10/02/2000	10.7	7.7	20	2.0	467	NM	NM
11/02/2000	11.2	7.6	35	3.7	434	NM	NM
14/02/2000	7.9	7.7	20	1.7	479	62	0
15/02/2000	7.8	7.6	20	3.7	415	NM	NM
16/02/2000	7.9	7.5	40	5.5	420	NM	NM
17/02/2000	NM	7.5	30	3.8	417	NM	NM
18/02/2000	7.7	7.6	30	2.5	457	NM	NM
21/02/2000	8	7.7	20	1.6	476	37	0
22/02/2000	8.9	7.7	15	1.7	461	NM	NM
23/02/2000	8.3	7.7	20	1.6	455	NM	NM
24/02/2000	8.5	7.7	20	1.7	456	NM	NM
25/02/2000	8.2	7.7	20	1.5	462	NM	NM
28/02/2000	8.3	7.6	70	15.0	331	>100	>100
29/02/2000	8.1	7.6	50	3.4	438	NM	NM
01/03/2000	8.5	7.6	40	3.4	420	NM	NM
02/03/2000	8.9	7.8	30	2.0	455	NM	NM
03/03/2000	8.6	7.7	25	3.0	453	NM	NM
06/03/2000	8.4	7.8	20	1.5	454	8	0
07/03/2000	9.1	7.8	15	1.5	457	NM	NM
08/03/2000	9.4	7.8	15	1.5	453	NM	NM
09/03/2000	10.1	7.8	20	1.7	452	NM	NM
10/03/2000	NM	7.8	20	1.5	455	NM	NM
13/03/2000	9.9	7.7	20	1.4	473	8	0

NM: Not Measured

Analytical Data of Raw Water at Drumcliff WTP - 2000

Date	Temp (°C)	pH (pH units)	Colour (hazen)	Turbidity (N.T.U)	Conductivity (uS/cm)	Total Coliforms (No./100mls)	Faecal Coliforms (No./100mls)
14/03/2000	9.9	7.9	15	1.4	482	NM	NM
15/03/2000	9.8	7.8	20	1.5	483	NM	NM
16/03/2000	9.6	7.6	20	1.4	486	NM	NM
20/03/2000	9.9	7.8	15	1.0	500	5	1
21/03/2000	9.6	7.8	10	1.0	503	NM	NM
22/03/2000	9.8	7.9	10	1.0	504	NM	NM
23/03/2000	9.7	7.7	20	1.0	507	NM	NM
24/03/2000	9.7	7.8	12	1.1	506	NM	NM
27/03/2000	9.5	7.8	15	1.2	496	47	12
28/03/2000	9.9	8	15	1.1	493	NM	NM
29/03/2000	9.7	7.9	20	1.0	495	NM	NM
30/03/2000	9.7	7.9	20	1.8	495	NM	NM
31/03/2000	9.6	8	15	1.1	498	NM	NM
03/04/2000	9.3	7.7	25	2.0	455	210	70
04/04/2000	9	8	20	1.5	482	NM	NM
05/04/2000	9	7.8	20	1.4	487	NM	NM
06/04/2000	9.2	7.9	15	1.1	490	NM	NM
07/04/2000	9.2	7.9	20	1.1	493	NM	NM
10/04/2000	10	7.8	10	1.0	498	0	0
11/04/2000	10.1	NM	NM	NM	NM	NM	NM
12/04/2000	10.3	7.7	10	1.5	528	NM	NM
13/04/2000	12	7.9	12	1.2	498	NM	NM
14/04/2000	10.5	8.1	10	1.2	500	NM	NM
17/04/2000	9.7	7.9	15	1.1	501	1	0
18/04/2000	10.9	7.8	15	1.0	497	NM	NM
19/04/2000	10.1	7.8	10	1.0	492	NM	NM
20/04/2000	10.2	7.9	15	1.0	494	NM	NM
25/04/2000	NM	7.9	15	1.0	476	7	1
26/04/2000	11	7.9	15	1.1	480	NM	NM
27/04/2000	10.3	8.0	15	1.1	482	NM	NM
28/04/2000	10.9	8.1	15	1.0	481	NM	NM
02/05/2000	NM	7.9	10	1.0	481	0	0
03/05/2000	12.1	7.9	10	1.0	476	NM	NM
04/05/2000	NM	7.8	15	0.8	475	NM	NM
05/05/2000	NM	7.8	10	0.8	477	NM	NM
08/05/2000	NM	7.7	10	1.5	478	0	0
09/05/2000	12.4	7.7	5	0.9	474	NM	NM
10/05/2000	NM	7.8	7	0.8	477	NM	NM
11/05/2000	12.5	7.7	7	0.8	478	NM	NM
12/05/2000	10.8	7.7	7	0.9	482	NM	NM
15/05/2000	12	7.6	10	0.6	488	2	4
16/05/2000	13.2	7.7	10	0.6	490	NM	NM
17/05/2000	11.6	7.8	10	0.7	487	NM	NM
18/05/2000	12.1	7.7	10	0.8	490	NM	NM
19/05/2000	11.5	7.8	10	1.0	483	NM	NM
22/05/2000	NM	7.4	50	6.5	483	11	3
23/05/2000	11.7	7.6	10	0.8	478	NM	NM

NM: Not Measured

Analytical Data of Raw Water at Drumcliff WTP - 2000

Date	Temp (°C)	pH (pH units)	Colour (hazen)	Turbidity (N.T.U)	Conductivity (uS/cm)	Total Coliforms (No./100mls)	Faecal Coliforms (No./100mls)
24/05/2000	11.5	7.4	7	5.0	471	NM	NM
25/05/2000	11.7	7.8	13	5.0	473	NM	NM
26/05/2000	11.8	7.9	13	5.0	464	NM	NM
29/05/2000	12.8	7.9	15	1.4	460	NM	NM
30/05/2000	12	7.9	15	1.3	450	30	23
31/05/2000	12.8	7.9	15	1.0	449	NM	NM
01/06/2000	12.6	7.9	15	1.0	449	NM	NM
02/06/2000	12.8	7.0	15	1.2	449	NM	NM
06/06/2000	NM	7.7	17	1.1	446	14	8
07/06/2000	12	7.7	20	1.0	452	NM	NM
08/06/2000	12.5	7.6	15	1.0	453	NM	NM
09/06/2000	13	7.8	15	1.0	453	NM	NM
12/06/2000	NM	7.8	15	1.5	457	19	13
13/06/2000	13.5	7.7	15	1.0	456	NM	NM
14/06/2000	14	7.7	20	1.0	455	NM	NM
15/06/2000	14	7.7	15	1.0	450	NM	NM
16/06/2000	14.3	7.8	17	1.0	449	NM	NM
19/06/2000	13.1	7.6	15	1.0	457	11	10
20/06/2000	12.9	7.6	15	1.0	457	NM	NM
21/06/2000	NM	7.8	15	1.1	458	NM	NM
22/06/2000	NM	7.6	17	1.1	458	NM	NM
23/06/2000	13.2	7.6	15	1.0	464	NM	NM
26/06/2000	NM	7.6	15	1.0	453	NM	NM
27/06/2000	12.9	7.7	15	1.0	455	38	12
28/06/2000	NM	7.7	17	1.1	457	NM	NM
29/06/2000	NM	7.6	12	1.0	458	NM	NM
30/06/2000	13.2	7.6	12	1.1	459	NM	NM
03/07/2000	14.5	7.5	12	1.0	457	49	35
04/07/2000	15.1	7.5	150	15.0	336	NM	NM
05/07/2000	15.2	7.5	80	3.6	340	NM	NM
05/07/2000	NM	NM	80	3.6	NM	>1000	>1000
06/07/2000	NM	7.6	100	4.2	368	NM	NM
07/07/2000	15.6	7.5	60	2.5	398	NM	NM
10/07/2000	15.0	7.6	70	2.5	371	430	140
11/07/2000	NM	7.7	70	2.2	398	NM	NM
12/07/2000	NM	7.6	50	1.5	429	NM	NM
13/07/2000	14.0	8.2	40	1.2	444	NM	NM
14/07/2000	NM	7.8	30	1.2	454	NM	NM
17/07/2000	NM	7.8	20	1.0	455	NM	NM
18/07/2000	15.5	7.7	20	1.0	456	NM	NM
19/07/2000	15.7	7.8	17	1.0	460	80	20
20/07/2000	NM	7.9	15	0.9	459	NM	NM
21/07/2000	16.2	7.8	20	1.0	461	NM	NM
24/07/2000	NM	7.8	15	0.7	472	NM	NM
25/07/2000	16.5	7.8	15	0.5	474	11	7
26/07/2000	NM	8.0	12	0.6	477	NM	NM
27/07/2000	17.2	7.9	12	0.5	478	NM	NM

NM: Not Measured

Analytical Data of Raw Water at Drumcliff WTP - 2000

Date	Temp (°C)	pH (pH units)	Colour (hazen)	Turbidity (N.T.U)	Conductivity (uS/cm)	Total Coliforms (No./100mls)	Faecal Coliforms (No./100mls)
28/07/2000	NM	7.6	15	0.5	479	NM	NM
31/07/2000	NM	7.8	15	0.7	475	NM	NM
01/08/2000	NM	7.8	17	0.6	462	31	13
02/08/2000	15.9	7.8	20	0.6	462	NM	NM
03/08/2000	NM	8.1	35	0.7	443	NM	NM
04/08/2000	15.9	7.8	40	1.4	439	NM	NM
08/08/2000	NM	7.4	20	1.5	470	17	15
09/08/2000	NM	7.5	40	2.0	477	NM	NM
10/08/2000	NM	7.7	20	1.0	476	NM	NM
11/08/2000	NM	7.6	30	2.0	476	NM	NM
14/08/2000	NM	7.8	50	2.0	482	NM	NM
15/08/2000	NM	7.7	20	0.8	480	7	0
16/08/2000	NM	7.8	20	0.8	482	NM	NM
17/08/2000	NM	7.8	20	1.0	486	NM	NM
18/08/2000	NM	7.7	20	1.0	485	NM	NM
21/08/2000	NM	7.9	20	0.8	490	2	0
22/08/2000	NM	7.8	20	1.0	486	NM	NM
23/08/2000	15.8	7.8	15	1.0	489	NM	NM
24/08/2000	NM	7.7	15	0.9	564	NM	NM
25/08/2000	16.2	7.7	15	1.2	488	NM	NM
28/08/2000	NM	7.8	15	0.9	480	NM	NM
30/08/2000	16.4	7.4	10	1.1	477	NM	NM
31/08/2000	16.9	7.4	10	1.0	479	19	19
01/09/2000	16.7	7.7	10	1.0	480	NM	NM
04/09/2000	16.2	7.5	40	3.5	446	NM	NM
05/09/2000	17.2	7.5	40	3.9	457	>100	>100
06/09/2000	16.8	7.4	40	3.0	458	NM	NM
07/09/2000	17	7.6	35	3.5	462	NM	NM
08/09/2000	17.3	7.5	30	2.5	458	NM	NM
11/09/2000	17.8	7.8	70	3.5	410	NM	NM
12/09/2000	16.9	7.4	65	3.5	428	550	440
13/09/2000	17.2	7.6	50	2.0	447	NM	NM
14/09/2000	16.7	7.5	40	2.0	450	NM	NM
15/09/2000	NM	7.9	40	2.0	450	NM	NM
18/09/2000	15.8	7.7	40	2.0	459	NM	NM
19/09/2000	15.6	7.5	150	9.0	372	7200	5400
20/09/2000	15.2	7.5	80	7.0	429	NM	NM
21/09/2000	15.8	7.6	65	3.5	450	NM	NM
22/09/2000	16.4	7.7	70	3.5	444	NM	NM
25/09/2000	17.6	7.6	40	1.5	461	60	30
26/09/2000	17.1	7.6	45	2.3	477	NM	NM
27/09/2000	17.5	7.5	60	2.1	423	NM	NM
28/09/2000	16.9	7.5	175	20.0	354	NM	NM
29/09/2000	16.4	7.3	85	5.5	421	NM	NM
02/10/2000	16.4	7.5	40	2.0	496	NM	NM
03/10/2000	16.4	7.7	70	3.3	454	>100	NR
04/10/2000	16.3	7.5	50	2.5	501	150	70

NM: Not Measured NR: Not Recorded

Analytical Data of Raw Water at Drumcliff WTP - 2000

Date	Temp (°C)	pH (pH units)	Colour (hazen)	Turbidity (N.T.U)	Conductivity (uS/cm)	Total Coliforms (No./100mls)	Faecal Coliforms (No./100mls)
05/10/2000	13.7	7.3	45	2.0	488	NM	NM
06/10/2000	15.9	7.5	45	1.7	488	NM	NM
09/10/2000	16.2	7.5	30	NM	500	NM	NM
10/10/2000	13.6	7.5	80	14.0	393	2000	>1000
11/10/2000	13.6	7.4	60	3.5	484	NM	NM
12/10/2000	14.4	7.5	80	7.5	399	NM	NM
13/10/2000	15.1	7.5	40	2.0	494	NM	NM
16/10/2000	16.6	7.6	20	1.0	516	58	37
17/10/2000	16.2	7.6	35	1.4	496	NM	NM
18/10/2000	16.7	7.6	30	1.5	494	NM	NM
19/10/2000	16.3	7.6	40	2.5	473	NM	NM
20/10/2000	16.5	7.8	40	1.5	490	NM	NM
23/10/2000	16.2	7.5	30	1.3	509	NM	NM
24/10/2000	16.7	7.6	40	2.0	469	121	75
25/10/2000	16.8	7.7	30	1.4	499	NM	NM
26/10/2000	17.8	7.6	40	2.0	462	NM	NM
27/10/2000	18.1	7.6	25	2.0	516	NM	NM
31/10/2000	18.9	7.4	50	3.0	456	128	92
01/11/2000	NM	7.5	40	1.9	486	NM	NM
02/11/2000	NM	7.5	50	2.4	449	NM	NM
03/11/2000	NM	7.8	40	1.5	478	NM	NM
06/11/2000	NM	7.7	40	2.0	467	NM	NM
07/11/2000	NM	8	40	2.0	455	220	100
08/11/2000	NM	7.8	30	1.3	498	NM	NM
09/11/2000	NM	7.8	30	1.1	494	NM	NM
10/11/2000	NM	7.7	30	1.0	503	NM	NM
13/11/2000	NM	7.7	30	1.4	472	NM	NM
14/11/2000	NM	7.7	30	1.0	486	40	0
15/11/2000	NM	7.6	40	3.5	483	NM	NM
16/11/2000	NM	7.7	20	1.0	501	NM	NM
17/11/2000	NM	7.6	30	2.5	488	NM	NM
20/11/2000	NM	7.6	40	2.8	464	NM	NM
21/11/2000	NM	7.6	40	1.4	464	18	3
22/11/2000	NM	7.8	20	1.2	498	NM	NM
23/11/2000	NM	7.6	30	1.1	467	NM	NM
27/11/2000	NM	7.6	40	1.6	454	NM	NM
28/11/2000	NM	7.6	20	1.4	495	5	0
29/11/2000	NM	7.7	30	2.0	501	NM	NM
30/11/2000	NM	7.6	35	1.6	457	NM	NM
01/12/2000	NM	7.7	30	1.4	488	NM	NM
04/12/2000	NM	7.7	30	1.5	483	NM	NM
05/12/2000	NM	7.6	50	2.3	426	NM	NM
06/12/2000	NM	7.4	60	6.4	428	NM	NM
07/12/2000	NM	7.6	30	2.4	478	NM	NM
08/12/2000	NM	7.4	30	2.4	493	NM	NM
11/12/2000	NM	7.6	40	2.3	453	96	0
12/12/2000	NM	7.5	40	2.5	461	NM	NM

NM: Not Measured

Analytical Data of Raw Water at Drumcliff WTP - 2000

Date	Temp (°C)	pH (pH units)	Colour (hazen)	Turbidity (N.T.U)	Conductivity (uS/cm)	Total Coliforms (No./100mls)	Faecal Coliforms (No./100mls)
13/12/2000	NM	7.5	30	2.5	460	NM	NM
14/12/2000	NM	7.5	40	2.0	442	NM	NM
15/12/2000	NM	7.9	30	1.8	463	NM	NM
18/12/2000	NM	7.6	25	1.4	484	NM	NM
19/12/2000	NM	7.5	30	1.5	486	1	0
20/12/2000	NM	7.5	20	1.7	485	NM	NM
21/12/2000	NM	7.6	40	3.5	418	NM	NM
22/12/2000	NM	7.5	30	3.5	479	NM	NM

NM: Not Measured

Analytical Data of Raw Water at Drumcliff WTP - 2001

Date	Temp (°C)	pH (pH units)	Colour (hazen)	Turbidity (N.T.U)	Conductivity (uS/cm)	Total Coliforms (No./100mls)	Faecal Coliforms (No./100mls)	Iron (ug/L Fe)
02/01/2001	NM	7.5	60	4.5	405	NM	NM	NM
03/01/2001	NM	7.7	40	2.0	472	440	260	94
04/01/2001	9.7	7.7	30	2.0	477	NM	NM	NM
05/01/2001	9.1	7.8	40	2.0	455	NM	NM	NM
08/01/2001	11.8	7.6	20	1.4	485	NM	NM	NM
09/01/2001	11.0	7.6	25	1.3	490	39	20	78
10/01/2001	10.8	7.6	20	1.4	494	NM	NM	NM
11/01/2001	10.9	7.6	20	1.3	498	NM	NM	NM
12/01/2001	11.6	7.7	20	1.4	500	NM	NM	NM
15/01/2001	12.9	7.6	20	NM	513	NM	NM	NM
16/01/2001	13.1	7.7	17	1.9	520	38	4	NM
17/01/2001	NM	7.7	20	1.9	524	NM	NM	NM
18/01/2001	NM	7.6	20	1.5	520	NM	NM	NM
19/01/2001	NM	7.6	20	2.1	519	NM	NM	NM
22/01/2001	NM	7.7	20	3.0	490	NM	NM	NM
23/01/2001	NM	7.6	50	3.5	435	230	140	159
24/01/2001	8.2	7.6	70	7.8	460	NM	NM	NM
25/01/2001	8.7	7.6	65	4.0	436	NM	NM	170
26/01/2001	9.4	7.6	50	3.0	446	NM	NM	NM
29/01/2001	10.2	7.6	25	2.0	475	90	<100	NM
30/01/2001	10.4	7.6	20	1.7	480	NM	NM	NM
31/01/2001	8.5	7.6	30	2.7	469	NM	NM	NM
01/02/2001	10.4	7.6	20	1.9	478	NM	NM	NM
02/02/2001	10.6	7.6	20	1.7	483	NM	NM	NM
05/02/2001	10.8	7.6	60	4.0	411	NM	NM	NM
06/02/2001	11.8	7.5	40	2.1	465	21	14	106
07/02/2001	12.4	7.6	60	4.8	392	NM	NM	NM
08/02/2001	12.1	7.8	40	2.3	465	NM	NM	NM
09/02/2001	11.1	7.6	30	2.0	483	NM	NM	NM
12/02/2001	11.4	7.6	30	1.8	475	19	5	209
13/02/2001	12.9	7.6	30	1.6	482	NM	NM	NM
14/02/2001	13.5	7.6	30	1.5	481	NM	NM	NM
15/02/2001	15.4	7.7	20	1.5	484	NM	NM	NM
16/02/2001	NM	7.6	20	1.5	486	NM	NM	NM
19/02/2001	NM	7.6	15	1.5	494	2	0	NM
20/02/2001	NM	7.6	15	1.7	513	NM	NM	NM
21/02/2001	NM	7.6	15	1.5	506	NM	NM	NM
22/02/2001	NM	7.7	15	2.2	506	NM	NM	NM
23/02/2001	NM	7.6	15	2.6	514	NM	NM	NM
26/02/2001	NM	7.7	15	1.5	515	NM	NM	NM
27/02/2001	NM	7.7	15	1.7	515	0	0	NM
28/02/2001	NM	7.8	20	2.8	479	NM	NM	NM
01/03/2001	NM	7.7	15	4.0	521	NM	NM	NM
02/03/2001	NM	7.7	15	2.0	519	NM	NM	NM
12/03/2001	NM	7.6	100	24.0	311	NM	NM	NM
13/03/2001	NM	7.6	70	4.2	NM	NM	NM	NM
14/03/2001	NM	7.6	60	3.0	NM	50	0	NM

NM: Not Measured

Analytical Data of Raw Water at Drumcliff WTP - 2001

Date	Temp (°C)	pH (pH units)	Colour (hazen)	Turbidity (N.T.U)	Conductivity (uS/cm)	Total Coliforms (No./100mls)	Faecal Coliforms (No./100mls)	Iron (ug/L Fe)
15/03/2001	NM	7.9	30	2.0	NM	NM	NM	NM
16/03/2001	11.5	7.6	30	1.1	463	NM	NM	NM
20/03/2001	14.8	7.7	30	1.0	470	12	0	NM
21/03/2001	14.5	7.7	30	1.0	473	NM	NM	NM
22/03/2001	13.9	7.7	30	1.0	476	NM	NM	NM
23/03/2001	NM	7.7	15	1.4	484	NM	NM	NM
26/03/2001	17.8	7.6	20	1.0	475	8	0	NM
27/03/2001	17.1	7.6	30	1.0	480	NM	NM	NM
28/03/2001	18.4	7.8	30	2.0	444	NM	NM	NM
29/03/2001	18.5	7.7	40	1.5	463	NM	NM	NM
30/03/2001	NM	7.7	30	1.0	472	NM	NM	NM
02/04/2001	*21*	*7.6*	*20*	*0.4*	*474*	*NM*	*NM*	*NM*
03/04/2001	NM	7.7	30	2.0	453	12	1	NM
04/04/2001	13.4	7.7	20	1.3	460	NM	NM	NM
05/04/2001	15.3	7.9	20	1.4	473	NM	NM	NM
06/04/2001	21.3	7.7	50	4.1	382	NM	NM	NM
09/04/2001	*13.6*	*7.4*	*60*	*8.4*	*350*	*360*	*100*	*NM*
10/04/2001	15.0	7.6	50	2.6	439	NM	NM	NM
11/04/2001	14.1	7.6	50	5.9	439	NM	NM	NM
12/04/2001	13.5	7.6	30	5.6	466	NM	NM	NM
17/04/2001	22.1	7.6	60	13.0	471	TNTC	30	NM
18/04/2001	*14.8*	*7.7*	*20*	*1.3*	*476*	*NM*	*NM*	*NM*
19/04/2001	15.8	7.7	20	4.9	497	NM	NM	NM
20/04/2001	15.5	7.6	30	1.3	489	NM	NM	NM
23/04/2001	16.2	7.6	30	1.3	498	6	0	NM
24/04/2001	15.5	7.7	30	1.2	482	NM	NM	NM
25/04/1900	*15.5*	*7.7*	*30*	*2.3*	*442*	*NM*	*NM*	*NM*
26/04/2001	16.1	7.6	50	4.8	457	NM	NM	NM
27/04/2001	NM	7.7	50	1.4	473	NM	NM	NM
30/04/2001	18.5	7.6	20	1.6	452	NM	NM	NM
01/05/2001	19.1	7.7	30	1.3	466	NM	NM	NM
02/05/2001	20.9	7.7	30	1.2	471	9	0	NM
03/05/2001	13.8	7.6	20	1.5	474	NM	NM	NM
04/05/2001	15.7	7.7	30	1.4	482	NM	NM	NM
08/05/2001	19.1	7.8	20	1.3	504	6	0	NM
09/05/2001	21.9	7.7	20	1.1	509	NM	NM	NM
10/05/2001	19.2	7.7	50	5.9	491	NM	NM	NM
11/05/2001	22.6	7.8	20	1.4	510	NM	NM	NM
14/05/2001	24.8	7.7	40	1.0	520	11	8	NM
15/05/2001	27.1	7.6	40	3.7	508	NM	NM	NM
16/05/2001	*18.8*	*7.7*	*30*	*1.0*	*500*	*NM*	*NM*	*NM*
17/05/2001	23.1	7.7	20	1.2	504	NM	NM	NM
18/05/2001	23.5	7.8	20	1.2	484	NM	NM	NM
21/05/2001	25.9	7.6	20	1.5	503	NM	NM	NM
22/05/2001	24.4	7.6	20	1.5	502	4	0	NM
23/05/2001	NM	7.8	15	1.0	483	NM	NM	NM
24/05/2001	27.4	7.7	30	1.0	491	NM	NM	NM

NM: Not Measured TNTC: Too Numerous To Count

Analytical Data of Raw Water at Drumcliff WTP - 2001

Date	Temp (°C)	pH (pH units)	Colour (hazen)	Turbidity (N.T.U)	Conductivity (uS/cm)	Total Coliforms (No./100mls)	Faecal Coliforms (No./100mls)	Iron (ug/L Fe)
25/05/2001	29.5	7.5	40	5.0	552	NM	NM	114
28/05/2001	29.2	7.6	30	1.4	491	NM	NM	NM
29/05/2001	25.9	7.6	30	1.1	480	NR	NR	NM
30/05/2001	21.2	7.5	50	5.0	482	NM	NM	NM
31/05/2001	23.8	8.1	40	1.1	480	NM	NM	NM
01/06/2001	16.7	7.5	30	1.4	477	NM	NM	114
05/06/2001	16.4	7.6	20	1.3	491	4	4	NM
06/06/2001	16.9	7.6	20	1.2	467	NM	NM	NM
07/06/2001	16.2	7.5	15	1.3	482	NM	NM	NM
08/06/2001	16.1	8.1	20	1.4	480	NM	NM	NM
11/06/2001	17.6	7.6	20	1.3	453	NM	NM	NM
12/06/2001	*16.9*	*7.5*	*20*	*1.2*	*482*	*11*	*3*	*NM*
13/06/2001	18.1	7.5	20	1.2	472	NM	NM	NM
14/06/2001	18.2	7.5	20	1.2	471	NM	NM	NM
15/06/01	18.9	7.5	15	1.2	473	NM	NM	NM
18/06/2001	18	7.5	20	1.5	463	NM	NM	NM
19/06/2001	*18.6*	*7.5*	*20*	*1.5*	*461*	*NM*	*NM*	*NM*
20/06/2001	19.2	7.5	15	1.4	465	NM	NM	NM
21/06/2001	19.2	7.5	20	1.4	499	NM	NM	NM
22/06/01	19.6	7.6	30	1.4	472	NM	NM	NM
25/06/2001	19.7	7.51	20	1.4	461	NM	NM	NM
26/06/2001	*19.8*	*7.5*	*20*	*1.2*	*464*	*24*	*17*	*NM*
27/06/2001	20	7.53	20	1.3	454	NM	NM	NM
28/06/2001	20	7.55	20	1.3	454	NM	NM	NM
29/06/2001	20.1	7.42	30	1.3	456	NM	NM	NM
02/07/2001	20	7.5	30	1.3	452	NM	NM	NM
03/07/2001	*19.6*	*7.5*	*30*	*1.4*	*450*	*NM*	*NM*	*124*
04/07/2001	20.4	7.46	20	1.4	434	NM	NM	NM
05/07/2001	21.3	7.58	20	1.5	462	NM	NM	NM
06/07/2001	21.1	7.61	20	1.4	449	NM	NM	NM
09/07/2001	21.5	7.93	30	1.2	438	NM	NM	NM
10/07/2001	*21.0*	*7.6*	*30*	*1.3*	*440*	*11*	*0*	*100*
11/07/2001	20.2	7.55	20	1.4	440	NM	NM	NM
12/07/2001	21.5	7.56	30	1.4	451	NM	NM	NM
13/07/2001	21.3	7.56	30	1.4	464	NM	NM	NM
16/07/2001	22.6	7.6	40	2.5	448	NM	NM	NM
17/07/2001	*21.6*	*7.7*	*40*	*1.6*	*430*	*NM*	*NM*	*NM*
18/07/2001	21.3	7.6	40	1.7	442	NR	NR	NM
19/07/2001	18.3	7.5	70	3.6	398	NM	NM	NM
20/07/2001	18.2	7.7	60	2.2	417	NM	NM	251
23/07/2001	20.1	7.7	40	1.5	425	15	4	NM
24/07/2001	*20.1*	*7.6*	*40*	*1.5*	*428*	*NM*	*NM*	*NM*
25/07/2001	19.1	7.7	40	1.3	437	NM	NM	NM
26/07/2001	19.4	7.5	30	1.3	425	NM	NM	NM
27/07/2001	19.3	7.5	30	1.2	433	NM	NM	162
30/07/2001	20.7	7.6	30	1.0	440	NM	NM	NM
31/07/2001	*19.6*	*7.4*	*30*	*1.3*	*452*	*NM*	*NM*	*NM*

NM: Not Measured NR: Not Recorded TNTC: Too Numerous To Count

Analytical Data of Raw Water at Drumcliff WTP - 2001

Date	Temp (°C)	pH (pH units)	Colour (hazen)	Turbidity (N.T.U)	Conductivity (uS/cm)	Total Coliforms (No./100mls)	Faecal Coliforms (No./100mls)	Iron (ug/L Fe)
01/08/2001	19.7	7.8	20	1.0	449	3	2	NM
02/08/2001	20.2	7.4	20	1.1	449	NM	NM	NM
03/08/2001	19.5	7.5	20	1.2	453	NM	NM	162
07/08/2001	19.6	7.2	40	1.0	452	52	0	233
08/08/2001	19.6	7.4	20	1.0	453	NM	NM	NM
09/08/2001	19.1	7.4	20	1.0	444	NM	NM	NM
10/08/2001	19.0	7.4	20	1.0	450	NM	NM	NM
13/08/2001	19.4	7.4	30	1.2	462	NM	NM	NM
14/08/2001	19.6	7.4	40	1.3	456	61	38	NM
15/08/2001	20.2	7.4	30	1.6	450	NM	NM	NM
16/08/2001	19.6	7.7	85	3.5	425	NM	NM	NM
17/08/2001	20.4	7.5	85	2.0	408	NM	NM	NM
20/08/2001	20.1	7.8	40	2.2	422	45	15	NM
21/08/2001	20.2	7.7	40	2.1	454	NM	NM	NM
22/08/2001	16.9	7.4	125	9.7	322	NM	NM	80
23/08/2001	16.3	7.5	85	4.5	381	NM	NM	NM
24/08/2001	17.8	7.6	50	1.8	423	NM	NM	NM
27/08/2001	19.1	7.6	40	1.4	466	36	0	NM
28/08/2001	19.1	7.5	40	1.3	477	NM	NM	NM
29/08/2001	16.9	7.2	30	1.2	465	NM	NM	120
30/08/2001	19.2	7.6	30	1.2	469	NM	NM	NM
31/08/2001	18.8	7.6	30	1.2	482	NM	NM	NM
03/09/2001	19.8	7.5	30	1.1	486	NM	NM	NM
04/09/2001	19.6	7.8	30	1.1	476	29	0	NM
05/09/2001	19.7	7.8	30	1.2	473	NM	NM	64
06/09/2001	20.3	7.7	20	1.2	480	NM	NM	NM
07/09/2001	20.0	7.7	20	1.1	489	NM	NM	NM
10/09/2001	19.8	7.4	20	1.0	485	NM	NM	NM
11/09/2001	19.6	7.4	20	1.5	486	12	4	NM
12/09/2001	19.7	7.4	20	1.3	489	NM	NM	64
13/09/2001	20.3	7.4	20	1.5	498	NM	NM	NM
17/09/2001	19.5	7.4	15	1.4	489	8	4	NM
18/09/2001	20.1	7.4	20	1.3	488	NM	NM	NM
19/09/2001	15.6	7.3	15	1.5	487	NM	NM	NM
20/09/2001	17.1	7.2	20	4.3	472	NM	NM	NM
21/09/2001	17.4	7.4	20	1.3	487	NM	NM	NM
24/09/2001	19.6	7.5	20	1.2	484	NM	NM	102
25/09/2001	19.6	7.6	20	1.2	497	20	12	NM
26/09/2001	19.8	7.7	20	1.3	488	NM	NM	NM
27/09/2001	17	7.6	20	1.3	487	NM	NM	NM
01/10/2001	*18.2*	7.3	*85*	*4.4*	*390*	*NM*	*NM*	352
02/10/2001	18.3	7.3	85	4.5	363	424	280	NM
03/10/2001	18.6	7.3	60	2.5	NR	NM	NM	NM
04/10/2001	19.2	7.3	50	5.0	NR	NM	NM	NM
05/10/2001	20.7	7.6	50	1.6	NR	NM	NM	NM
08/10/2001	*20.6*	7.3	70	*2.5*	*NR*	*NM*	*NM*	*252*

NM: Not Measured

Analytical Data of Raw Water at Drumcliff WTP - 2001

Date	Temp (°C)	pH (pH units)	Colour (hazen)	Turbidity (N.T.U)	Conductivity (uS/cm)	Total Coliforms (No./100mls)	Faecal Coliforms (No./100mls)	Iron (ug/L Fe)
09/10/2001	19.8	7.3	50	1.6	NR	90	3	NM
10/10/2001	NR	7.1	50	1.4	NR	NM	NM	NM
11/10/2001	NR	7.2	40	1.5	NR	NM	NM	NM
12/10/2001	21.3	7.4	40	1.4	459	NM	NM	NM
15/10/2001	23.5	7.3	40	1.5	486	NM	NM	NM
16/10/2001	22.1	7.5	40	1.2	484	88	40	NM
17/10/2001	17.6	7.6	50	2.0	460	NM	NM	NM
18/10/2001	15.7	7.2	50	2.2	438	NM	NM	NM
19/10/2001	15.0	7.3	50	1.9	450	NM	NM	60
22/10/2001	14.3	7.2	40	1.5	486	NM	NM	NM
23/10/2001	14.1	7.3	40	1.5	483	60	34	367
24/10/2001	14.4	7.3	60	2.3	NFR	NM	NM	NM
25/10/2001	14.7	7.5	70	2.4	NFR	NM	NM	NM
26/10/2001	16.0	7.4	70	2.4	NFR	NM	NM	NM
30/10/2001	22.5	7.3	30	1.6	476	NR	NR	NM
31/10/2001	18.6	7.3	40	1.5	470	NM	NM	NM
01/11/2001	19.7	7.3	40	1.6	481	NM	NM	NM
02/11/2001	20.8	7.4	50	1.6	480	NM	NM	220
05/11/2001	19.6	7.2	40	1.1	480	NM	NM	NM
06/11/2001	15.4	7.4	40	1.2	482	38	16	NM
07/11/2001	15.8	7.1	60	3.7	488	NM	NM	200
08/11/2001	15	7.2	100	7.5	483	NM	NM	NM
09/11/2001	12.3	7.2	70	3.4	483	NM	NM	NM
12/11/2001	13.7	7.4	50	1.8	480	NM	NM	NM
13/11/2001	13.2	7.4	50	1.8	482	74	45	NM
14/11/2001	13.6	7.3	50	1.6	488	NM	NM	NM
15/11/2001	13.6	7.3	50	1.5	483	NM	NM	62
16/11/2001	13.8	7.3	60	1.5	483	NM	NM	NM
19/11/2001	13.8	7.4	50	1.3	484	NM	NM	NM
20/11/2001	13.6	7.4	50	1.3	468	24	19	NM
21/11/2001	13.7	7.3	60	1.5	483	NM	NM	NM
22/11/2001	13.5	7.3	60	1.6	480	NM	NM	NM
23/11/2001	13.6	7.3	50	1.4	480	NM	NM	62
26/11/2001	13.6	7.2	40	4.1	476	NM	NM	NM
27/11/2001	13.2	7.1	40	2.1	483	112	56	NM
28/11/2001	11.2	7.3	85	15.0	486	NM	NM	NM
29/11/2001	13.3	7.2	50	2.9	454	NM	NM	NM
30/11/2001	14.4	7.3	50	4.6	436	NM	NM	146
03/12/2001	13.2	7.2	20	2.0	493	NM	NM	NM
04/12/2001	14.2	7.2	40	9.5	441	360	0	NM
05/12/2001	13.5	7.1	50	7.0	433	NM	NM	NM
06/12/2001	13.9	7.0	30	4.0	455	NM	NM	NM
07/12/2001	14.4	7.1	20	3.0	467	NM	NM	155
10/12/2001	14.2	7.2	20	2.0	486	NM	NM	NM
11/12/2001	14.0	7.2	20	1.7	487	44	6	NM
12/12/2001	14.8	7.2	20	1.6	453	NM	NM	NM
13/12/2001	14.9	7.4	30	1.6	518	NM	NM	NM
14/12/2001	15.2	7.3	NM	2.0	496	NM	NM	220

NM: Not Measured

Analytical Data of Raw Water at Drumcliff WTP - 2002

Date	Temp (^oC)	pH (pH units)	Colour (hazen)	Turbidity (N.T.U)	Conductivity (uS/cm)	Total Coliforms (No./100mls)	Faecal Coliforms (No./100mls)	Iron (ug/L Fe)
07/01/2002	11.3	7.3	20	1.0	496	40	0	NM
08/01/2002	10.1	7.3	20	1.8	502	NM	NM	NM
09/01/2002	10.2	7.5	15	1.7	508	NM	NM	100
10/01/2002	10.3	7.3	20	1.7	511	NM	NM	NM
11/01/2002	9.7	7.4	15	1.7	515	NM	NM	NM
14/01/2002	10.8	7.3	30	1.8	514	NM	NM	NM
15/01/2002	10.8	7.3	30	2.4	495	NM	NM	NM
16/01/2002	10.1	7.5	30	3.2	462	NM	NM	110
17/01/2002	24.1	7.3	40	4.6	461	NM	NM	NM
18/01/2002	17.0	7.4	40	2.5	458	NM	NM	NM
21/01/2002	16.7	7.3	30	2.6	480	NM	NM	NM
22/01/2002	16.8	7.4	30	2.2	101	NM	NM	119
23/01/2002	10.0	7.1	20	3.0	462	NM	NM	NM
24/01/2002	n/r	7.2	85	15.0	461	NM	NM	NM
25/01/2002	16.3	7.3	50	4.0	466	NM	NM	NM
28/01/2002	12.3	7.3	60	6.0	419	NM	NM	NM
29/01/2002	10.6	7.4	50	5.0	472	NM	NM	99
30/01/2002	12.9	7.4	40	2.9	471	NM	NM	NM
31/01/2002	14.1	7.5	30	2.4	461	NM	NM	NM
01/02/2002	15.0	7.4	50	3.6	444	NM	NM	NM
04/02/2002	12.3	7.3	60	6.0	419	NM	NM	110
05/02/2002	10.6	7.4	50	5.0	472	NM	NM	NM
06/02/2002	12.9	7.4	40	2.9	471	NM	NM	NM
07/02/2002	14.1	7.5	30	2.4	461	NM	NM	NM
08/02/2002	15.0	7.4	50	3.6	444	NM	NM	NM
11/02/2002	14.8	7.4	50	3.0	441	NM	NM	NM
12/02/2002	14.4	7.5	50	3.2	470	NM	NM	NM
13/02/2002	14.1	7.5	40	2.5	471	60	10	NM
14/02/2002	14.1	7.5	30	1.9	469	NM	NM	NM
15/02/2002	13.7	7.5	30	1.7	480	NM	NM	NM
18/02/2002	13.7	7.7	30	1.6	470	NM	NM	NM
19/02/2002	11.5	7.5	30	1.8	469	30	0	NM
20/02/2002	11.7	7.3	30	2.2	479	NM	NM	NM
21/02/2002	10.1	7.6	50	4.0	450	NM	NM	NM
22/02/2002	18.0	7.4	30	2.2	459	NM	NM	NM
25/02/2002	11.4	7.4	50	3.5	481	170	0	NM
26/02/2002	11.1	7.3	30	3.2	496	NM	NM	NM
27/02/2002	12.0	7.4	40	3.5	495	NM	NM	NM
28/02/2002	12	7.7	30	2.5	469	NM	NM	NM
01/03/2002	12.0	7.4	30	2.5	470	NM	NM	NM
04/03/2002	15	7.6	20	1.5	482	NM	NM	NM
05/03/2002	12.0	7.4	50	1.6	499	40	0	NM
06/03/2002	18.5	7.6	20	1.5	480	NM	NM	NM
07/03/2002	16.8	7.6	20	2.6	474	NM	NM	NM
08/03/2002	10.9	7.4	20	1.9	480	NM	NM	NM
11/03/2002	11.2	7.4	40	3.1	481	220	0	NM
12/03/2002	18.6	7.5	40	1.7	NR	NM	NM	NM

NM: Not Measured

Analytical Data of Raw Water at Drumcliff WTP - 2002

Date	Temp (°C)	pH (pH units)	Colour (hazen)	Turbidity (N.T.U)	Conductivity (uS/cm)	Total Coliforms (No./100mls)	Faecal Coliforms (No./100mls)	Iron (ug/L Fe)
13/03/2002	NR	7.5	30	1.5	NR	NM	NM	NM
14/03/2002	19	7.5	85	25.0	489	NM	NM	NM
15/03/2002	14	7.4	30	1.5	470	NM	NM	NM
19/03/2002	14	7.5	40	8.5	476	NM	NM	NM
20/03/2002	12.8	7.4	15	1.5	474	NM	NM	NM
21/03/2002	10.7	7.4	20	1.6	484	8	0	NM
22/03/2002	11.6	7.6	40	1.6	96.8	NM	NM	NM
25/03/2002	13.5	7.7	30	1.6	498	0	0	130
26/03/2002	15.0	7.5	15	1.5	497	NM	NM	NM
27/03/2002	13.0	7.5	20	1.5	497	NM	NM	NM
28/03/2002	15.4	7.5	20	1.4	503	NM	NM	NM
02/04/2002	*10.6*	*7.5*	*70*	*2.7*	*484*	*NM*	*NM*	*NM*
03/04/2002	14.2	7.5	30	1.8	490	50	10	NM
04/04/2002	14.9	7.6	15	1.5	480	NM	NM	130
05/04/2002	13.1	7.4	20	2.1	498	NM	NM	NM
08/04/2002	14.5	7.7	30	1.6	499	14	0	130
09/04/2002	16.8	7.8	20	2.0	495	NM	NM	NM
10/04/2002	17.1	7.8	20	1.4	487	NM	NM	NM
11/04/2002	20.6	8.3	60	13.0	496	NM	NM	NM
12/04/2002	21.9	7.7	30	5.0	494	NM	NM	NM
15/04/2002	19	7.4	20	1.7	489	NM	NM	NM
16/04/2002	20.4	7.7	30	1.5	536	NM	NM	NM
17/04/2002	21.8	7.6	40	3.0	492	NM	NM	NM
18/04/2002	15.3	7.8	20	1.5	483	NM	NM	NM
19/04/2002	16.0	7.8	20	2.4	484	NM	NM	NM
22/04/2002	*19.0*	*7.4*	*15*	*1.7*	*479*	*NM*	*NM*	*NM*
23/04/2002	20.7	7.5	15	1.8	480	NM	NM	NM
24/04/2002	13.9	7.6	15	1.6	477	32	30	94
25/04/2002	14.4	7.7	20	1.6	480	NM	NM	NM
26/04/2002	13.6	7.6	15	1.7	477	NM	NM	NM
29/04/2002	13.3	7.6	70	5.0	400	140	93	NM
30/04/2002	11.4	7.5	50	8.0	393	NM	NM	NM
01/05/2002	15.1	7.6	40	2.9	444	430	0	NM
02/05/2002	14.0	7.5	40	2.5	450	NM	NM	NM
03/05/2002	14.0	7.5	30	1.6	463	NM	NM	NM
07/05/2005	18.0	7.6	20	1.5	480	NM	NM	NM
08/05/2005	15.2	7.6	15	1.5	476	160	0	NM
09/05/2005	14.9	7.6	20	1.5	479	NM	NM	NM
10/05/2005	15.1	nr	20	1.5	491	NM	NM	NM
13/05/2002	*16.7*	*7.8*	*30*	*1.5*	*478*	*NM*	*NM*	*NM*
14/05/2002	16.3	7.9	30	1.6	476	260	0	NM
15/05/2002	17.0	7.9	20	2.2	468	NM	NM	NM
16/05/2002	17.0	7.7	30	1.9	477	NM	NM	NM
17/05/2002	20.0	7.7	15	1.9	489	NM	NM	NM
20/05/2002	15.6	7.7	20	1.9	493	NM	NM	NM
21/05/2002	15.9	7.7	40	1.9	465	88	30	NM
22/05/2002	18.4	7.5	30	1.8	486	NM	NM	NM

NM: Not Measured

Analytical Data of Raw Water at Drumcliff WTP - 2002

Date	Temp (°C)	pH (pH units)	Colour (hazen)	Turbidity (N.T.U)	Conductivity (uS/cm)	Total Coliforms (No./100mls)	Faecal Coliforms (No./100mls)
23/05/2002	17.6	8.3	30	2.0	465	NM	NM
24/05/2002	18.2	7.9	60	3.5	456	NM	NM
27/05/2002	19.7	7.4	50	3.0	442	450	360
28/05/2002	20.9	8.3	40	2.1	486	NM	NM
29/05/2002	18.4	7.5	30	1.8	486	NM	NM
30/05/2002	17.0	7.5	40	2.0	482	NM	NM
31/05/2002	15.0	7.8	70	2.0	490	NM	NM
05/06/2002	16.4	7.6	20	1.7	515	NM	NM
06/06/2002	16.5	8.1	20	1.6	512	NM	NM
07/06/2002	18.1	8.0	15	1.9	516	NM	NM
10/06/2002	20.8	7.3	100	13.0	368	TNTC	TNTC
11/06/2002	21.7	7.3	70	6.0	480	NM	NM
12/06/2002	22.0	7.3	40	2.2	475	NM	NM
13/06/2002	NR	NR	30	3.5	NR	NM	NM
14/06/2002	NR	NR	30	2.1	NR	NM	NM
17/06/2002	25.9	7.6	20	2.5	483	690	5
18/06/2002	26.2	7.6	30	2.2	485	NM	NM
19/06/2002	26.6	7.8	30	2.0	506	NM	NM
20/06/2002	26.1	7.7	30	2.1	509	NM	NM
21/06/2002	27.2	7.7	30	2.2	515	NM	NM
24/06/2002	30.7	7.6	20	2.1	513	NM	NM
25/06/2002	19.5	7.8	30	2.0	520	NM	NM
26/06/2002	20.0	8.0	20	2.0	523	19	0
27/06/2002	20.7	7.4	20	2.0	526	NM	NM
28/06/2002	20.8	7.7	15	1.9	521	NM	NM
01/07/2002	18.4	7.7	20	2.0	524	NM	NM
02/07/2002	19.1	7.1	60	5.9	421	NM	NM
03/07/2002	20.2	8.1	60	2.6	463	NM	NM
04/07/2002	21.3	7.8	50	1.9	485	NM	NM
05/07/2002	22	7.8	30	1.5	490	NM	NM
08/07/2002	20	7.4	30	1.8	480	0	0
09/07/2002	20	7.3	30	1.7	478	NM	NM
10/07/2002	19.9	7.5	30	1.5	470	NM	NM
11/07/2002	NR	7.5	30	1.5	NR	NM	NM
12/07/2002	24.9	7.4	20	1.4	505	NM	NM
15/07/2002	19	8.0	40	5.1	510	NM	NM
16/07/2002	25.8	8.1	85	24.0	530	370	0
17/07/2002	17.1	8.1	20	1.7	522	NM	NM
18/07/2002	16.1	8.1	15	2.0	527	NM	NM
19/07/2002	16.6	8.1	15	1.7	537	NM	NM
22/07/2002	16.5	7.5	15	2.0	541	NM	NM
23/07/2002	16.4	8.1	10	2.0	534	NM	NM
24/07/2002	17.3	7.5	10	1.9	529	NM	NM
25/07/2002	19.6	7.5	30	2.2	526	NM	NM
26/07/2002	17.3	7.5	10	1.6	527	7	0
29/07/2002	18.1	7.7	15	1.7	523	NM	NM
30/07/2002	16.5	7.3	10	1.5	522	1	0

NM: Not Measured NR: Not Recorded TNTC: Too Numerous To Count

Analytical Data of Raw Water at Drumcliff WTP - 2002

Date	Temp (°C)	pH (pH units)	Colour (hazen)	Turbidity (N.T.U)	Conductivity (uS/cm)	Total Coliforms (No./100mls)	Faecal Coliforms (No./100mls)
31/07/2002	16.8	8.2	10	2.0	520	NM	NM
01/08/2002	17.4	7.8	5	1.8	523	NM	NM
02/08/2002	16.3	8.4	15	1.9	521	NM	NM
06/08/2002	17.3	7.4	15	1.8	518	10	0
07/08/2002	17.2	7.6	10	1.6	516	NM	NM
08/08/2002	17.9	7.6	10	1.6	519	NM	NM
09/08/2002	17.6	7.3	85	13.0	465	NM	NM
12/08/2002	21.6	7.6	40	2.3	479	92	38
13/08/2002	21.4	7.6	15	1.5	491	0	0
14/08/2002	22.1	7.8	100	4.1	403	NM	NM
15/08/2002	22.9	8.8	70	2.6	456	NM	NM
19/08/2002	*17.5*	*8.1*	*20*	*1.7*	*515*	*14*	*0*
20/08/2002	17.4	8.2	5	1.9	518	NM	NM
22/08/2002	17.3	7.6	30	2.1	525	NM	NM
26/08/2002	19.4	7.4	30	1.3	537	NM	NM
27/08/2002	19.4	7.3	15	1.4	536	10	0
28/08/2002	19.5	7.4	15	1.5	538	NM	NM
29/08/2002	22.1	7.9	20	4.0	540	NM	NM
30/08/2002	21	8.0	20	1.4	536	NM	NM
02/09/2002	15.8	7.1	30	1.5	516	NM	NM
03/09/2002	16.3	7.2	15	1.5	528	8	8
04/09/2002	16.2	7.4	15	1.5	527	NM	NM
05/09/2002	16.8	7.4	30	1.3	525	NM	NM
06/09/2002	16.4	7.4	30	1.3	529	NM	NM
09/09/2002	16.8	7.4	20	1.5	519	26	6
10/09/2002	*16.2*	*7.4*	*50*	*5.6*	*451*	*NM*	*NM*
11/09/2002	16.2	7.4	40	3.1	476	0	0
12/09/2002	18.5	7.2	50	2.5	478	NM	NM
13/09/2002	19.0	7.3	50	2.0	474	NM	NM
16/09/2002	17.4	7.3	30	1.8	512	NM	NM
17/09/2002	17.3	7.2	30	1.7	508	11	0
18/09/2002	18.3	7.3	20	1.7	510	NM	NM
19/09/2002	16.7	7.2	15	1.5	516	NM	NM
20/09/2002	16.7	7.3	15	1.8	517	NM	NM
23/09/2002	16.3	7.2	15	1.6	522	14	0
24/09/2002	16.2	7.3	15	1.6	521	NM	NM
25/09/2002	16.0	7.2	15	1.5	522	NM	NM
26/09/2002	16.1	7.3	15	1.6	522	NM	NM
27/09/2002	16.4	7.1	10	1.7	521	NM	NM
30/09/2002	18.0	7.1	10	1.4	524	1	0
01/10/2002	19.0	7.1	10	1.5	525	NM	NM
02/10/2002	19.9	7.3	15	1.5	524	NM	NM
03/10/2002	19.5	7.9	10	1.5	524	NM	NM
04/10/2002	18.7	7.6	20	1.2	525	NM	NM
07/10/2002	*20.5*	*7.2*	*20*	*1.0*	*525*	*NM*	*NM*
08/10/2002	19.1	7.3	30	1.1	NR	9	0
09/10/2002	19.0	7.2	30	1.1	NR	NM	NM

NM: Not Measured   NR: Not Recorded

Analytical Data of Raw Water at Drumcliff WTP - 2002

Date	Temp (°C)	pH (pH units)	Colour (hazen)	Turbidity (N.T.U)	Conductivity (uS/cm)	Total Coliforms (No./100mls)	Faecal Coliforms (No./100mls)
10/10/2002	21.3	7.2	15	1.3	537	NM	NM
11/10/2002	nr	7.5	30	1.5	nr	NM	NM
14/10/2002	21.5	7.3	40	2.5	nr	NM	NM
15/10/2002	21.3	7.2	40	5.0	502	NM	NM
16/10/2002	12.6	7.4	20	1.4	526	1	0
17/10/2002	12.4	7.3	15	1.6	522	NM	NM
18/10/2002	12.5	7.2	20	1.3	527	NM	NM
21/10/2002	14.2	7.4	30	4.0	504	NM	NM
22/10/2002	15.9	7.1	125	13.0	358	2200	1550
23/10/2002	12.7	7.2	70	12.0	421	NM	NM
24/10/2002	12.0	7.1	50	4.0	459	400	800
25/10/2002	12.4	7.2	50	2.5	481	NM	NM
29/10/2002	13.3	7.3	40	2.0	513	0	1
30/10/2002	13.2	7.1	100	12.0	369	NM	NM
31/10/2002	14.0	7.2	100	40.0	471	NM	NM
01/11/2002	13.3	7.4	20	2.4	488	NM	NM
04/11/2002	15.5	7.3	60	3.5	442	TNTC	TNTC
05/11/2002	15.3	7.4	40	3.0	489	NM	NM
06/11/2002	15.0	7.4	30	1.8	501	NM	NM
07/11/2002	17.9	7.4	40	1.4	495	NM	NM
08/11/2002	18.4	7.3	40	1.5	500	40	30
11/11/2002	13.8	7.3	60	7.4	442	7	0
12/11/2002	12.8	7.3	40	2.5	479	NM	NM
13/11/2002	13.1	7.3	30	2.9	494	NM	NM
14/11/2002	13.0	7.4	30	1.6	506	NM	NM
15/11/2002	13.4	7.3	15	1.6	509	NM	NM
18/11/2002	12.7	7.3	30	1.3	508	10	24
19/11/2002	12.3	7.4	20	1.4	513	NM	NM
20/11/2002	12.5	7.3	20	1.5	514	NM	NM
21/11/2002	12.1	7.3	20	1.6	519	NM	NM
22/11/2002	13.0	7.3	15	1.5	512	NM	NM
25/11/2002	13.2	7.3	20	1.4	520	NM	NM
26/11/2002	10.1	7.3	20	1.5	521	NM	NM
27/11/2002	10.7	7.3	30	1.6	521	NM	NM
28/11/2002	11.0	7.3	70	7.5	416	670	NR
29/11/2002	10.7	7.4	50	5.6	442	NM	NM
02/12/2002	16.9	7.1	125	11.0	460	210	50
03/12/2002	19.7	7.3	20	2.5	521	NM	NM
04/12/2002	18.8	7.4	20	2.0	528	55	0
05/12/2002	19.0	7.3	15	2.0	531	NM	NM
06/12/2002	18.7	7.4	15	2.0	523	NM	NM
09/12/2002	18.2	7.3	15	3.5	528	4	0
10/12/2002	17.7	7.2	15	2.4	533	NM	NM
11/12/2002	18.0	7.4	10	1.0	541	NM	NM
12/12/2002	18.3	7.4	10	1.0	535	NM	NM
13/12/2002	18.8	7.3	15	1.1	535	NM	NM

NM: Not Measured NR: Not Recorded TNTC: Too Numerous To Count

Analytical Data of Raw Water at Drumcliff WTP - 2002

Date	Temp (°C)	pH (pH units)	Colour (hazen)	Turbidity (N.T.U)	Conductivity (uS/cm)	Total Coliforms (No./100mls)	Faecal Coliforms (No./100mls)
16/12/2002	18.5	7.3	10	1.5	555	NM	NM
17/12/2002	18.9	7.3	10	1.5	560	NM	NM
18/12/2002	21.7	7.3	10	1.3	560	10	1
19/12/2002	17.3	7.4	15	30.0	561	NM	NM
20/12/2002	17.5	7.4	15	1.3	570	NM	NM
23/12/2002	15.0	7.4	20	1.9	399	NM	NM
30/12/2002	10.9	7.4	30	9.0	356	NM	NM
31/12/2002	13.1	7.4	15	3.0	467	NM	NM

NM: Not Measured

Analytical Data of Raw Water at Drumcliff WTP - 2003

Date	Temp (°C)	pH (pH units)	Colour (hazen)	Turbidity (N.T.U)	Conductivity (uS/cm)	Total Coliforms (No./100mls)	Faecal Coliforms (No./100mls)
02/01/2003	14	7.2	15	3	465	NM	NM
03/01/2003	13.8	7.3	20	3	501	NM	NM
06/01/2003	6.3	7.3	30	1.8	544	NM	NM
07/01/2003	6.0	7.3	30	1.8	541	4	0
08/01/2003	7.3	7.4	20	2.0	533	NM	NM
09/01/2003	6.6	7.4	10	1.8	541	NM	NM
10/01/2003	6.5	7.4	10	1.8	547	NM	NM
13/01/2003	7.6	7.4	15	2.3	552	NM	NM
14/01/2003	8.8	7.3	15	2.0	552	NM	NM
15/01/2003	9.7	7.3	15	2.0	546	NM	NM
16/01/2003	9.4	7.3	30	5.0	499	NM	NM
17/01/2003	9.8	7.3	30	3.9	500	NM	NM
20/01/2003	10.7	7.4	20	4.0	494	NM	NM
21/01/2003	10.7	7.3	30	2.6	501	10	1
22/01/2003	10.7	7.4	40	3.8	496	NM	NM
23/01/2003	10.5	7.4	15	1.9	500	NM	NM
24/01/2003	11.5	7.4	10	1.8	507	NM	NM
27/01/2003	13.9	7.4	20	2.6	510	NM	NM
28/01/2003	13.7	7.4	10	2.0	502	NM	NM
29/01/2003	13.7	7.3	20	2.3	511	NM	NM
30/01/2003	13.5	7.4	20	2.0	510	NM	NM
31/01/2004	13.6	7.4	20	1.8	512	NM	NM
03/02/2003	18.1	7.4	30	3.0	416	NM	NM
04/02/2003	18.0	7.4	20	2.1	448	104	0
05/02/2003	18.1	7.5	20	2.2	507	NM	NM
06/02/2003	19.3	7.3	5	1.5	513	NM	NM
07/02/2003	19.8	7.1	5	1.4	510	NM	NM
10/02/2003	19.5	7.2	5	1.4	509	NM	NM
11/02/2003	20.4	7.2	10	1.8	461	0	0
12/02/2003	20.2	7.2	10	1.6	508	NM	NM
13/02/2003	18.7	7.3	10	1.5	518	NM	NM
14/02/2003	11.8	7.3	5	1.2	521	NM	NM
17/02/2003	16.5	7.4	20	2.0	539	6	0
18/02/2003	17.0	7.4	20	1.8	545	NM	NM
19/02/2003	17.8	7.4	20	1.9	544	NM	NM
20/02/2003	20.7	7.4	20	2.1	550	NM	NM
21/02/2003	20.5	7.5	10	1.6	554	NM	NM
03/03/2003	14.6	7.4	5	2.5	504	NM	NM
04/03/2003	15.8	7.4	5	2.0	508	NM	NM
05/03/2003	14.7	7.4	40	4.0	421	NM	NM
06/03/2003	14.9	7.4	20	2.5	467	NM	NM
07/03/2003	15.5	7.4	20	2.2	489	NM	NM
10/03/2003	12.8	7.3	30	4.2	415	NM	NM
11/03/2003	12.7	7.4	15	3.0	450	NM	NM
12/03/2003	12.9	7.5	15	2.0	477	NM	NM
13/03/2003	13.0	7.5	5	1.5	487	NM	NM
14/03/2003	NM	7.5	5	1.8	491	NM	NM

NM: Not Measured

Analytical Data of Raw Water at Drumcliff WTP - 2003

Date	Temp (°C)	pH (pH units)	Colour (hazen)	Turbidity (N.T.U)	Conductivity (uS/cm)	Total Coliforms (No./100mls)	Faecal Coliforms (No./100mls)
18/03/2003	16.5	7.6	5	2.9	510	NM	NM
19/03/2003	16.7	7.5	5	1.4	513	NM	NM
20/03/2003	18.7	7.6	10	1.0	522	NM	NM
21/03/2003	18	7.6	5	2.0	526	NM	NM
24/03/2003	18.7	7.5	5	2.3	536	NM	NM
25/03/2003	18.4	7.5	5	1.5	550	NM	NM
26/03/2003	19.7	7.6	5	1.6	551	NM	NM
27/03/2003	20.1	7.5	5	1.6	555	NM	NM
28/03/2003	20.5	7.5	5	1.8	554	NM	NM
31/03/2003	21.9	7.5	5	2.4	560	NM	NM
01/04/2003	22.1	7.5	5	1.6	557	NM	NM
02/04/2003	19	7.5	5	1.5	541	NM	NM
03/04/2003	16.5	7.5	5	1.6	539	NM	NM
04/04/2003	20.2	7.5	5	1.6	538	NM	NM
07/04/2003	22.2	7.5	5	1.4	526	NM	NM
08/04/2003	23.2	7.5	5	1.4	531	NM	NM
09/04/2003	23.5	7.5	5	1.5	521	NM	NM
10/04/2003	23.8	7.5	5	1.6	522	NM	NM
11/04/2003	23.4	7.6	5	1.3	521	NM	NM
14/04/2003	24.2	7.5	5	1.6	522	NM	NM
15/04/2003	14.7	7.5	5	1.5	500	NM	NM
16/04/2003	14.9	7.5	15	1.5	514	NM	NM
17/04/2003	15.6	7.5	5	1.5	524	NM	NM
22/04/2003	16.6	7.5	5	1.2	501	NM	NM
23/04/2003	16.6	7.5	5	1.0	500	NM	NM
24/04/2003	18.1	7.5	10	1.1	500	NM	NM
25/04/2003	19.3	7.4	5	1.5	499	NM	NM
28/04/2003	15.9	7.5	30	1.1	483	NM	NM
29/04/2003	18.0	7.6	5	1.4	491	NM	NM
30/04/2003	17.9	7.7	10	1.5	479	NM	NM
01/05/2003	18.5	7.6	10	1.5	477	NM	NM
02/05/2003	19.8	7.8	20	1.7	462	NM	NM
06/05/2003	17.4	7.7	40	1.4	415	NM	NM
07/05/2003	16.7	7.3	20	2.0	452	152	84
08/05/2003	17.0	7.6	30	1.7	460	NM	NM
09/05/2003	18.1	7.6	20	1.5	474	NM	NM
12/05/2003	20.2	7.7	15	1.3	474	NM	NM
13/05/2003	17.3	7.7	30	2.5	460	50	0
14/05/2003	16.3	7.6	30	1.6	436	NM	NM
15/05/2003	14.9	7.6	30	1.5	459	NM	NM
16/05/2003	14.5	7.6	20	1.4	478	NM	NM
19/05/2003	14.7	7.5	50	3.5	468	NM	NM
20/05/2003	14.3	7.4	40	2.0	436	NM	NM
21/05/2003	14.5	7.5	50	1.7	456	97	9
22/05/2003	14.5	7.5	40	1.7	463	NM	NM
23/05/2003	14.2	7.3	70	4.3	379	NM	NM
26/05/2003	15.2	7.6	40	1.3	485	55	0

NM: Not Measured

Analytical Data of Raw Water at Drumcliff WTP - 2003

Date	Temp (°C)	pH (pH units)	Colour (hazen)	Turbidity (N.T.U)	Conductivity (uS/cm)	Total Coliforms (No./100mls)	Faecal Coliforms (No./100mls)
27/05/2003	17.3	7.5	40	1.2	490	NM	NM
28/05/2003	15.3	7.5	40	2.3	473	NM	NM
29/05/2003	15	7.5	30	1.5	499	NM	NM
30/05/2003	15.9	7.5	30	1.5	492	NM	NM
03/06/2003	17.5	7.5	30	1.4	501	NM	NM
04/06/2003	17.1	7.4	50	3.5	453	n/a	n/a
05/06/2003	16.2	7.4	50	2.5	458	NM	NM
06/06/2003	17.6	7.4	30	1.6	467	NM	NM
09/06/2003	16.9	7.3	30	2.6	516	NM	NM
10/06/2003	16.9	7.3	40	4.8	497	0	0
11/06/2003	15.9	7	70	4.0	438	NM	NM
12/06/2003	17.2	7.1	60	3.0	431	NM	NM
13/06/2003	17.8	7.4	50	3.3	475	NM	NM
16/06/2003	17.2	7.5	30	1.3	538	NM	NM
17/06/2003	20.5	7.4	30	1.3	512	NM	NM
18/06/2003	19.2	7.4	20	1.3	557	NM	NM
19/06/2003	19.6	7.5	30	1.3	532	NM	NM
20/06/2003	19.9	7.4	20	1.4	555	NM	NM
23/06/2003	17.5	7.5	20	1.5	581	23	0
24/06/2003	18.1	7.5	15	1.4	562	NM	NM
25/06/2003	18.9	7.1	20	1.7	525	NM	NM
26/06/2003	20	7.4	20	1.4	570	NM	NM
27/06/2003	20.5	7.4	20	1.5	573	NM	NM
30/06/2003	18.9	7.5	30	1.3	563	NM	NM
01/07/2003	18.7	7.2	70	7.3	357	160	86
02/07/2003	18.0	7.2	60	3.1	431	NM	NM
03/07/2003	19.5	7.3	40	2.0	478	NM	NM
04/07/2003	20.2	7.4	30	1.5	517	NM	NM
07/07/2003	22.3	7.4	20	1.7	540	NM	NM
08/07/2003	21.5	7.4	15	1.5	548	22	7
09/07/2003	19.3	7.4	20	1.5	551	NM	NM
10/07/2003	18.3	7.3	15	1.7	552	NM	NM
11/07/2003	19.5	7.4	15	1.5	535	NM	NM
14/07/2003	23	7.3	20	1.3	553	NM	NM
15/07/2003	25	7.3	20	1.4	544	NM	NM
16/07/2003	22	7.3	15	3.6	526	53	30
17/07/2003	20	7.5	15	1.3	527	NM	NM
18/07/2003	20	7.4	60	2.9	450	NM	NM
21/07/2003	19	7.3	30	1.5	492	NM	NM
22/07/2003	20	7.2	60	2.3	455	NM	NM
23/07/2003	20	7.3	40	1.9	489	104	45
24/07/2003	19	7.3	30	1.6	501	NM	NM
25/07/2003	18	7.5	40	1.6	504	NM	NM
28/07/2003	18.9	7.4	30	1.5	635	NM	NM
29/07/2003	20.7	7.4	40	1.5	528	33	18
30/07/2003	20.2	7.3	30	1.6	512	NM	NM
31/07/2003	19.3	7.4	50	1.9	493	NM	NM

NM: Not Measured

Analytical Data of Raw Water at Drumcliff WTP - 2003

Date	Temp (°C)	pH (pH units)	Colour (hazen)	Turbidity (N.T.U)	Conductivity (uS/cm)	Total Coliforms (No./100mls)	Faecal Coliforms (No./100mls)
01/08/2003	18.8	7.4	30	1.8	483	NM	NM
05/08/2003	20	7.3	20	1.45	537	NM	NM
06/08/2003	20.5	7.3	10	1.5	542	NM	NM
07/08/2003	21.0	7.3	15	1.5	545	NM	NM
08/08/2003	20.5	7.3	20	1.5	552	NM	NM
11/08/2003	21.3	7.3	15	1.4	550	NM	NM
12/08/2003	20.9	7.4	10	1.3	546	NM	NM
13/08/2003	20.3	7.3	10	1.2	544	NM	NM
14/08/2003	20.8	7.3	15	1.1	543	NM	NM
15/08/2003	20.2	7.3	15	1.2	544	NM	NM
18/08/2003	22.4	7.4	10	1.1	521	NM	NM
19/08/2003	20.4	7.2	10	1.2	538	NM	NM
20/08/2003	18.4	7.2	10	1.2	554	19	11
21/08/2003	19.2	7.2	10	1.1	553	NM	NM
22/08/2003	20.8	7.3	10	1.5	540	NM	NM
25/08/2003	21.8	7.2	20	1.0	533	NM	NM
26/08/2003	19.3	7.2	15	1.1	554	3	2
27/08/2003	20.6	7.2	10	1.3	527	NM	NM
28/08/2003	18.5	7.2	15	1.1	541	NM	NM
29/08/2003	17.8	7.1	15	1.1	547	NM	NM
01/09/2003	18.4	7.5	10	1.0	535	NM	NM
02/09/2003	20.3	7.3	15	1.1	508	NM	NM
03/09/2003	16.8	7.1	15	1.2	550	20	4
04/09/2003	18.3	7.2	20	1.2	573	NM	NM
05/09/2003	15.7	7.2	30	1.4	551	NM	NM
08/09/2003	17.5	7.2	15	1.3	521	NM	NM
09/09/2003	15.7	7.2	15	1.4	538	NM	NM
10/09/2003	16.5	7.2	20	1.2	535	NM	NM
11/09/2003	16.7	7.2	20	1.3	548	6	1
12/09/2003	16.4	7.2	20	1.3	541	NM	NM
15/09/2003	23.4	7.1	10	2.2	539	NM	NM
16/09/2003	23.6	7.1	10	2.2	542	20	0
17/09/2003	23.1	7.1	10	1.3	538	NM	NM
18/09/2003	23.2	7.1	10	1.3	540	NM	NM
19/09/2003	25.8	7.1	10	1.3	528	NM	NM
22/09/2003	18.9	7.2	10	1.2	525	3	4
23/09/2003	18.6	7.1	15	1.2	530	NM	NM
24/09/2003	18.3	7.1	20	1.5	537	NM	NM
25/09/2003	18.4	7.2	15	1.5	533	NM	NM
26/09/2003	18.4	7.2	20	1.4	519	NM	NM
29/09/2003	19.6	7.3	20	1.5	524	NM	NM
30/09/2003	16.2	7.3	20	1.5	443	NM	NM
01/10/2003	16.8	8.2	15	1.5	574	24	16
02/10/2003	17.6	7.3	15	1.5	432	NM	NM
03/10/2003	17.0	7.2	10	1.4	426	NM	NM
06/10/2003	17.8	7.2	15	1.4	479	NM	NM
07/10/2003	17.8	7.1	10	1.5	468	3	6

NM: Not Measured

Analytical Data of Raw Water at Drumcliff WTP - 2003

Date	Temp (°C)	pH (pH units)	Colour (hazen)	Turbidity (N.T.U)	Conductivity (uS/cm)	Total Coliforms (No./100mls)	Faecal Coliforms (No./100mls)
09/10/2003	20.6	7.3	15	1.5	460	NM	NM
10/10/2003	17.4	7.5	15	1.6	498	NM	NM
13/10/2003	16.4	7.2	20	1.8	494	NM	NM
14/10/2003	17.8	7.2	15	1.6	508	4	2
15/10/2003	18.5	7.3	20	1.5	458	NM	NM
16/10/2003	17.7	7.2	20	1.7	494	NM	NM
17/10/2003	16.9	7.2	15	1.8	496	NM	NM
20/10/2003	16.5	NR	NR	NR	NR	NM	NM
21/10/2003	16.0	7.3	30	8.0	444	NM	NM
22/10/2003	13.8	7.2	15	2.0	498	0	0
23/10/2003	13.7	7.1	20	2.0	497	NM	NM
24/10/2003	14.1	7.2	30	1.9	469	NM	NM
28/10/2003	14.6	7.2	20	2.0	521	8	0
29/10/2003	15.3	7.3	15	1.8	472	NM	NM
30/10/2003	18.4	7.2	30	2.0	508	NM	NM
31/10/2003	16.1	7.3	20	3.9	522	NM	NM
03/11/2003	11.3	7.2	70	6.0	412	NM	NM
04/11/2003	14.7	7.3	85	6.5	406	NM	NM
05/11/2003	12.9	7.4	50	3.4	462	NM	NM
06/11/2003	13.7	7.4	40	2.6	487	NM	NM
07/11/2003	14.2	7.5	30	3.4	424	240	165
10/11/2003	17.6	7.3	30	2.0	493	NM	NM
11/11/2003	13.6	7.4	50	9.0	411	NM	NM
12/11/2003	15.4	7.3	20	2.3	452	165	0
13/11/2003	15.4	7.3	60	4.4	405	NM	NM
14/11/2003	13.9	7.3	60	3.3	440	NM	NM
17/11/2003	14.3	7.3	50	2.5	474	NM	NM
18/11/2003	16.8	7.3	40	3.0	472	48	0
19/11/2003	17.8	7.3	50	1.6	419	NM	NM
20/11/2003	18.6	7.3	50	1.6	465	NM	NM
21/11/2003	17.5	7.3	60	2.1	439	NM	NM
24/11/2003	12	7.3	30	1.5	466	NM	NM
25/11/2003	12.2	7.4	30	1.3	471	NM	NM
26/11/2003	12.6	7.4	30	1.1	481	35	0
27/11/2003	12.4	8.3	50	2.0	473	NM	NM
28/11/2003	11.5	7.2	30	1.6	462	NM	NM
01/12/2003	12.2	7.2	30	1.5	460	NM	NM
02/12/2003	11.8	7.4	30	1.4	472	NM	NM
03/12/2003	11.8	7.4	30	1.2	471	8	0
04/12/2003	11.9	7.4	30	1.2	471	NM	NM
05/12/2003	11.8	7.5	30	1.2	495	NM	NM
08/12/2003	12.1	7.6	20	1.2	487	NM	NM
09/12/2003	12.3	7.5	30	1.1	497	15	0
10/12/2003	14.3	7.4	30	3	574	NM	NM
11/12/2003	16.1	7.4	20	1.0	517	NM	NM
12/12/2003	16.1	7.3	20	1.0	500	NM	NM
15/12/2003	14.5	7.4	30	1.5	475	NM	NM

NM: Not Measured NR: Not Recorded

Analytical Data of Raw Water at Drumcliff WTP - 2003

Date	Temp (°C)	pH (pH units)	Colour (hazen)	Turbidity (N.T.U)	Conductivity (uS/cm)	Total Coliforms (No./100mls)	Faecal Coliforms (No./100mls)
16/12/2003	11.4	7.4	30	1.7	473	36	0
17/12/2003	13.2	7.3	30	1.6	508	NM	NM
18/12/2003	11.8	7.5	20	1.5	506	NM	NM
19/12/2003	11.5	7.4	20	1.5	504	NM	NM
22/12/2003	11.4	7.3	40	2	472	NM	NM
23/12/2003	11.9	7.3	40	1.6	504	NM	NM
29/12/2003	14.6	7.4	40	1.5	466	NM	NM
30/12/2003	11.8	7.1	50	1.9	460	NM	NM
31/12/2003	12.2	7.4	30	1.6	462	NM	NM

NM: Not Measured

Analytical Data of Raw Water at Drumcliff WTP - 2004

Date	Temp (°C)	pH (pH units)	Colour (hazen)	Turbidity (N.T.U)	Conductivity (uS/cm)	Total Coliforms (No./100mls)	Faecal Coliforms (No./100mls)
05/01/2004	14	7.4	20	1.5	465	NM	NM
06/01/2004	16.1	7.3	20	1.2	460	NM	NM
07/01/2004	13.8	7.4	30	1.5	479	NM	NM
08/01/2004	19.6	7.5	30	1.3	470	NM	NM
09/01/2004	12.1	7.3	40	2.0	462	NM	NM
12/01/2004	10.2	7.2	40	2	449	NM	NM
13/01/2004	11	7.5	40	1.8	449	83.1	32.4
14/01/2004	11.3	7.5	30	2.2	483	NM	NM
15/01/2004	11.4	7.3	50	3.0	426	NM	NM
16/01/2004	11.9	7.4	50	12.0	389	NM	NM
19/01/2004	15.2	7.3	30	1.9	455	NM	NM
20/01/2004	15.7	7.4	40	2.1	474	NM	NM
21/01/2004	7.7	7.3	20	1.5	462	NM	NM
22/01/2004	21.8	7.6	30	1.5	619	90.6	72
23/01/2004	21.9	7.4	20	2.5	484	NM	NM
26/01/2004	21.2	7.5	30	1.5	480	NM	NM
27/01/2004	15.6	7.6	20	1.5	621	70.3	6.2
28/01/2004	16.1	7.4	30	1.1	465	NM	NM
29/01/2004	7.8	7.5	30	1.1	500	NM	NM
30/01/2004	9.4	7.4	20	1.3	501	NM	NM
02/02/2004	10.8	7.4	40	2.5	436	NM	NM
03/02/2004	12.1	7.4	70	9	399	NM	NM
04/02/2004	13.2	7.3	50	3	414	78.2	31.1
05/02/2004	14	7.6	40	2.5	464	NM	NM
06/02/2004	13.4	7.5	30	1.7	427	NM	NM
09/02/2004	12.4	7.3	20	1.5	453	NM	NM
10/02/2004	10.4	7.6	20	2.7	462	28.2	6.3
11/02/2004	10.4	7.3	20	1.5	470	NM	NM
12/02/2004	10.8	7.3	20	1.3	474	NM	NM
13/02/2004	11.2	7.5	20	1.3	457	NM	NM
16/02/2004	12.8	7.3	20	1.4	493	NM	NM
17/02/2004	13.6	7.8	20	1.4	508	NM	NM
18/02/2004	14.8	7.7	20	1.6	492	NM	NM
19/02/2004	14.4	7.3	20	1.5	474	14.6	4
20/02/2004	8.8	7.4	10	1.6	503	NM	NM
23/02/2004	9	7.4	15	1.8	521	NM	NM
24/02/2004	8.9	7.4	20	2	530	NM	NM
25/02/2004	9.5	7.6	15	1.7	531	51.2	8
26/02/2004	9.7	7.6	20	1.5	525	NM	NM
27/02/2004	9.6	7.6	20	5.5	528	NM	NM
01/03/2004	9.6	7.6	20	2	526	20.3	7.4
02/03/2004	9.7	7.6	15	2	520	NM	NM
03/03/2004	9.6	7.7	30	2.1	517	NM	NM
04/03/2004	10.9	7.7	15	1.8	516	NM	NM
05/03/2004	15.1	7.6	20	4.5	512	NM	NM
08/03/2004	13.1	7.6	20	1.9	502	NM	NM
09/03/2004	16.1	7.7	20	1.6	467	NM	NM

NM: Not Measured

Analytical Data of Raw Water at Drumcliff WTP - 2004

Date	Temp (°C)	pH (pH units)	Colour (hazen)	Turbidity (N.T.U)	Conductivity (uS/cm)	Total Coliforms (No./100mls)	Faecal Coliforms (No./100mls)
10/03/2004	15.1	7.5	20	3	501	NM	NM
11/03/2004	12.2	7.6	15	1.6	485	NM	NM
12/03/2004	12.9	7.5	15	1.7	471	NM	NM
15/03/2004	10.8	7.5	70	9.5	393	791.5	344.1
16/03/2004	15.5	7.5	40	3.5	440	NM	NM
18/03/2004	20.3	7.4	50	4	439	NM	NM
19/03/2004	17.3	7.3	40	1.6	477	NM	NM
22/03/2004	12.4	7.5	40	3.1	398	307.6	41.9
23/03/2004	12.2	7.3	30	2	457	NM	NM
24/03/2004	11.3	7.5	30	1.5	491	NM	NM
25/03/2004	12.2	7.5	20	1.8	455	NM	NM
26/03/2004	12.6	7.4	30	2.5	466	NM	NM
29/03/2004	19.3	7.6	10	1.3	475	NM	NM
30/03/2004	21.5	7.5	20	1.1	498	90.6	2
31/03/2004	22.2	7.4	20	0.75	481	NM	NM
01/04/2004	14.5	7.4	20	1.5	467	NM	NM
02/04/2004	13.1	7.5	20	1.4	487	NM	NM
26/05/2004	15.1	7.4	15	1.5	473	NM	NM
27/05/2004	14.8	7.4	10	1.5	468	NM	NM
28/05/2004	15.1	7.4	15	1.0	474	NM	NM
31/05/2004	17.9	7.2	10	1	480	85.7	11
01/06/2004	17.8	7.3	10	1.3	493	NM	NM
02/06/2004	18	7.4	10	1.1	468	NM	NM
03/06/2004	17.9	7.3	10	1.0	473	NM	NM
04/06/2004	18.6	7.4	10	1.0	468	NM	NM
08/06/2004	14.2	7.4	10	1	472	42.6	19.9
09/06/2004	17.3	7.3	15	1	467	NM	NM
10/06/2004	17.4	7.4	10	0.72	467	NM	NM
11/06/2004	17.5	7.4	15	0.7	466	NM	NM
14/06/2004	18.1	7.3	10	0.5	491	NM	NM
15/06/2004	18	7.4	10	0.52	481	NM	NM
16/06/2004	18.2	7.4	10	0.65	480	NM	NM
17/06/2004	18.9	7.4	10	0.58	479	17.5	12.2
18/06/2004	18	7.4	15	0.75	478	NM	NM
21/06/2004	17.9	7.3	10	0.96	478	22.8	16
22/06/2004	19.1	7.1	10	0.46	488	NM	NM
23/06/2004	16.4	7.4	15	0.50	479	NM	NM
24/06/2004	16.9	7.3	10	1.30	514	NM	NM
25/06/2004	18.1	6.8	70	3.10	452	NM	NM
28/06/2004	18.4	7.3	40	1.50	438	1299.7	275.5
29/06/2004	18.6	7.5	30	1.60	441	NM	NM
30/06/2004	18.6	7.4	20	1.30	442	NM	NM
01/07/2004	20	7.3	20	1.20	444	NM	NM
02/07/2004	20.5	7.6	30	1.30	440	NM	NM
05/07/2004	20.6	7.3	30	1.50	451	547.5	488.4
06/07/2004	19.6	7.4	30	1.60	458	NM	NM
07/07/2004	24.3	7.4	20	1.50	470	NM	NM

NM: Not Measured

Analytical Data of Raw Water at Drumcliff WTP - 2004

Date	Temp (°C)	pH (pH units)	Colour (hazen)	Turbidity (N.T.U)	Conductivity (uS/cm)	Total Coliforms (No./100mls)	Faecal Coliforms (No./100mls)
08/07/2004	23.8	7.3	20	1.20	465	NM	NM
09/07/2004	25	7.5	20	0.91	462	NM	NM
12/07/2004	21.3	7.4	15	1.60	452	86.2	78
13/07/2004	22	7.3	15	1.20	449	NM	NM
14/07/2004	23.2	7.3	15	0.78	453	NM	NM
15/07/2004	24.2	7.3	15	0.75	460	NM	NM
16/07/2004	23.8	7.3	15	0.60	459	NM	NM
19/07/2004	19.2	7.3	20	1.20	455	29.5	16
20/07/2004	21.3	7.3	20	0.70	465	NM	NM
21/07/2004	19.8	7.24	20	0.70	466	NM	NM
22/07/2004	18.2	7.2	20	0.82	457	NM	NM
23/07/2004	19.1	7.2	15	0.65	456	NM	NM
26/07/2004	19.5	7.2	15	0.62	466	NM	NM
27/07/2004	19.7	7.4	15	0.65	459	25	16
28/07/2004	19.9	7.2	15	0.70	462	NM	NM
29/07/2004	20.3	7.2	15	0.62	466	NM	NM
30/07/2004	20.5	7.3	15	0.60	459	NM	NM
03/08/2004	22.5	7.3	15	0.55	460	27.5	19.9
04/08/2004	22.7	7.1	15	0.50	458	NM	NM
05/08/2004	23.2	7.3	20	0.55	458	NM	NM
06/08/2004	23.7	7.3	15	0.55	448	NM	NM
09/08/2004	24.7	7	5	1.10	457	17.8	16.4
10/08/2004	24	6.9	5	1.00	462	NM	NM
12/08/2004	24	7.1	5	1.40	475	NM	NM
13/08/2004	24.4	7.1	5	1.50	493	NM	NM
16/08/2004	24.0	7.1	5	1.50	472	NM	NM
17/08/2004	23.0	7.2	5	1.30	470	NM	NM
18/08/2004	28.0	7.2	20	2.20	476	NM	NM
19/08/2004	25.4	7.2	20	1.90	482	73.8	40.6
20/08/2004	20.0	7.2	5	1.00	472	NM	NM
23/08/2004	24.5	7.3	5	1.40	471	>200	>200
24/08/2004	18.6	7.2	30	2.40	481	NM	NM
25/08/2004	24.6	7.3	100	5.00	470	NM	NM
26/08/2004	23.8	7.3	70	2.90	479	NM	NM
27/08/2004	19.7	n/r	70	2.00	n/r	NM	NM
30/08/2004	20.4	7.2	250	50.0	478	83.1	36.4
31/08/2004	31.6	7.2	60	15.0	481	NM	NM
01/09/2004	22.0	7.3	<5	2.0	486	NM	NM
02/09/2004	17.5	7.3	20	1.7	491	NM	NM
03/09/2004	18.1	7.5	15	2.0	481	NM	NM
06/09/2004	19.2	7.14	20	2.5	449	NM	NM
07/09/2004	19.9	7.2	15	1.6	444	NM	NM
08/09/2004	21.0	7.0	15	1.2	449	29	5
09/09/2004	21.2	7.2	20	1.3	484	NM	NM
10/09/2004	21.5	7.2	15	0.8	491	NM	NM
13/09/2004	20.6	7.3	15	1.2	452	1203.3	204.6
14/09/2004	19.9	7.4	125	7.3	361	NM	NM

NM: Not Measured

Analytical Data of Raw Water at Drumcliff WTP - 2004

Date	Temp (°C)	pH (pH units)	Colour (hazen)	Turbidity (N.T.U)	Conductivity (uS/cm)	Total Coliforms (No./100mls)	Faecal Coliforms (No./100mls)
15/09/2004	16.7	7.1	125	6.0	355	4721	1553
16/09/2004	16.9	7.3	85	3.0	365	NM	NM
17/09/2004	17.3	7.4	50	1.7	416	NM	NM
20/09/2004	17.9	7.19	20	4.2	430	2359	121
21/09/2004	18.4	7.19	125	6.1	350	NM	NM
22/09/2004	18.0	7.3	50	2.0	434	NM	NM
23/09/2004	18.8	7.34	30	1.6	433	NM	NM
24/09/2004	17.8	7.3	50	1.9	415	NM	NM
27/09/2004	19.6	7.4	30	1.1	448	384	384
28/09/2004	19.9	7.4	30	1.5	430	NM	NM
29/09/2004	17.6	7.3	30	1.3	445	NM	NM
30/09/2004	18.1	7.3	30	1.4	445	NM	NM
01/10/2004	18.4	7.3	30	1.3	434	NM	NM
04/10/2004	17.0	7.2	50	2.0	425	>2419.2	187.2
05/10/2004	20.1	7.3	85	6.2	404	NM	NM
06/10/2004	17.2	7.2	70	3.0	406	NM	NM
07/10/2004	17.9	7.3	70	3.0	409	NM	NM
08/10/2004	18.6	7.3	40	2.0	427	NM	NM
11/10/2004	14.5	7.36	15	1.7	455	48	16
12/10/2004	16.1	7.3	30	0.9	456	NM	NM
13/10/2004	15.0	7.4	20	1.5	437	NM	NM
14/10/2004	15.5	7.3	15	1.8	463	NM	NM
15/10/2004	16.0	7.3	20	1.5	463	NM	NM
18/10/2004	13.2	7.2	15	1.5	479	70	11
19/10/2004	15.9	7.3	20	1.5	473	NM	NM
20/10/2004	13.8	7.4	40	2.0	435	NM	NM
21/10/2004	13.9	7.2	25	2.0	449	NM	NM
22/10/2004	13.0	7.2	85	4.5	427	NM	NM
26/10/2004	16.0	7.3	40	1.9	425	131	28
27/10/2004	13.0	7.2	20	2.3	463	NM	NM
28/10/2004	14.0	7.4	20	2.0	468	NM	NM
29/10/2004	15.1	7.2	30	2.6	435	NM	NM
01/11/2004	15.5	7.2	30	2.0	472	276	59
02/11/2004	16.4	7.2	20	1.5	466	NM	NM
03/11/2004	16.6	7.4	20	1.8	470	NM	NM
04/11/2004	14.7	7	30	14.0	469	NM	NM
05/11/2004	20.8	7.1	20	3.5	445	NM	NM
08/11/2004	14.5	7.2	20	2.0	398	NM	NM
09/11/2004	15.7	7.3	<5	2.0	496	NM	NM
10/11/2004	18.4	7.5	20	1.8	518	68	9
11/11/2004	14.2	7.4	20	1.8	478	NM	NM
12/11/2004	14.1	7.5	15	2.1	493	NM	NM
15/11/2004	15.5	7.4	20	1.7	470	NM	NM
16/11/2004	18.5	7.6	30	4.0	482	165	6
17/11/2004	15.5	7.2	30	1.7	455	NM	NM
18/11/2004	15.2	7.3	85	8.0	339	NM	NM
19/11/2004	14.1	7.2	125	10.1	456	NM	NM

NM: Not Measured

Analytical Data of Raw Water at Drumcliff WTP - 2004

Date	Temp (°C)	pH (pH units)	Colour (hazen)	Turbidity (N.T.U)	Conductivity (uS/cm)	Total Coliforms (No./100mls)	Faecal Coliforms (No./100mls)
22/11/2004	15.3	7.4	40	2.5	465	>200.5	45
23/11/2004	19.8	7.2	30	3.0	455	NM	NM
24/11/2004	-	-	20	2	-	NM	NM
25/11/2004	-	-	30	2.0	-	NM	NM
26/11/2004	23.8	7.5	20	6.5	455	NM	NM
29/11/2004	14.3	7.3	10	3.0	452	345	20
30/11/2004	16.3	7.4	5	1.5	458	NM	NM
01/12/2004	9.3	7.3	30	1.1	456	NM	NM
02/12/2004	17.7	7.4	5	2.0	470	NM	NM
03/12/2004	17.5	7.3	30	9.5	479	NM	NM
06/12/2004	14.3	7.4	10	2.3	459	260	17
07/12/2004	15.1	7.3	30	1.5	431	NM	NM
08/12/2004	15.1	7.3	15	1.5	461	NM	NM
09/12/2004	14.7	7.4	20	1.5	452	NM	NM
10/12/2004	21.9	7.4	10	1.5	524	NM	NM
13/12/2004	15.8	7.5	10	1.5	500	NM	NM
15/12/2004	17.9	7.3	10	2	477	NM	NM
16/12/2004	13.5	7.2	40	3.2	495	2419	228
17/12/2004	17.3	NT	40	3.6	448	NM	NM
20/12/2004	18.9	7.4	40	4.0	459	NM	NM
21/12/2004	19.0	7.4	15	2.3	461	397	65
22/12/2004	13	7.4	20	2.6	452	NM	NM

NM: Not Measured

Appendix B

ANALYTICAL DATA FOR DRUMCLIFF SPRINGS 1998 - 2004

Analytical Data of Drumcliff Springs 1998

Date	Temp (°C)	pH (pH units)	Odour	Colour (hazen)	Turbidity (N.T.U)	Conductivity (uS/cm)	Iron (ug/L Fe)	Nitrate (mg/l NO3)
12/01/1998	8.0	7.9	None	40	2.6	458	90	4.9
30/01/1998	7.9	7.7	None	40	2.5	395	140	6.3
13/02/1998	8.5	7.9	None	20	2.4	410	70	7.3
11/03/1998	9.9	7.9	None	50	2	No meter	100	4
31/03/1998	10.1	7.7	None	60	2.3	No meter	130	4.1
17/04/1998	10.9	7.4	None	25	1.1	441	80	5.1
29/04/1998	12.4	7.5	None	60	2.5	443	140	4
15/05/1998	14.1	7.3	None	30	0.9	410	80	4.4
11/06/1998	15.3	7.5	None	40	1.6	453	100	5.6
24/06/1998	17.3	7.5	None	35	1.6	380	100	1.5
01/09/1998	Not tested	7.0	None	50	3.1	395	180	2.2
18/09/1998	14.0	7.1	None	50	1.5	502	120	8
14/10/1998	14.5	7.4	None	50	1.4	497	190	4
28/10/1998	11.3	7.2	None	60	6.3	451	150	3.5
02/12/1998	9.0	7.4	None	15	2	524	60	<0.4

Analytical Data of Drumcliff Springs 1999

Date	Temp (°C)	pH (pH units)	Odour	Colour (hazen)	Turbidity (N.T.U)	Conductivity (uS/cm)	Iron (ug/L Fe)	Nitrate (mg/l NO3)
06/01/1999	7.5	7.3	None	10	1.5	492	60	1.7
11/02/1999	7.8	7.5	None	25	1.6	513	140	2.6
05/03/1999	8.2	7.5	None	35	1.7	479	60	0.8
18/03/1999	9.5	7.6	None	20	1.4	512	70	1.8
31/03/1999	10.2	7.6	None	35	1.8	498	60	1.3
30/04/1999	11.9	7.5	None	20	1.0	522	40	1.6
21/05/1999	12.7	7.6	None	15	1.0	511	70	1.2
16/06/1999	15.2	7.6	None	25	1.0	489	70	1.5
04/08/1999	17.7	7.5	None	20	1.0	510	60	1.7
20/08/1999	16.4	7.5	None	25	1.1	502	80	2.1
01/09/1999	16.3	7.6	None	35	1.6	487	120	2.5
29/09/1999	13.5	7.6	None	50	1.6	483	160	2.4
28/10/1999	10.8	7.5	None	20	1.0	547	70	2.2
19/11/1999	10.2	7.6	None	40	2.3	493	150	1.3

Analytical Data of Drumcliff Springs 2000 - 2001

Date	Temp (°C)	pH (pH units)	Odour	Colour (hazen)	Turbidity (N.T.U)	Conductivity (uS/cm)	Iron (ug/L Fe)	Nitrate (mg/l NO3)	Ammonia (mgl NH3-N)	Phosphate (mg/l P)	Nitrite (mg/l NO2-N)
22/02/2000	NR	7.7	N/D	15	1.5	462	40	0.9	<0.03	.....	.....
29/03/2000	NR	7.6	N/D	10	1.0	497	67	0.8	0.03	0.031	.....
19/04/2000	NR	7.7	N/D	10	1.0	81	81	0.4	<0.03	0.021	.....
31/05/2000	NR	7.6	N/D	10	1.0	394	65	0.5	<0.03	0.016	.....
19/06/2000	NR	7.6	N/D	15	0.9	456	86	0.6	<0.03	0.011	.....
12/07/2000	NR	7.6	N/D	45	1.6	442	115	0.6	<0.03	0.019	.....
28/08/2000	NR	7.4	N/D	15	1.5	477	32	0.3	.....	.....	.....
26/09/2000	NR	7.5	N/D	30	1.5	482	94	0.6	.....	.....	.....
31/10/2000	NR	7.4	N/D	50	3.0	456	125	0.1	<0.03	.....	.....
28/11/2000	NR	7.6	N/D	17	1.4	499	88	0.8	<0.03	.....	<0.001
18/12/2000	NR	7.7	N/D	20	1.4	482	136	0.9	<0.03	.....	<0.001

Date	Temp (°C)	pH (pH units)	Odour	Colour (hazen)	Turbidity (N.T.U)	Conductivity (uS/cm)	Iron (ug/L Fe)	Nitrate (mg/l NO_3)	Ammonia (mgl NH_3-N)	Phosphate (mg/l P)	Nitrite (mg/l NO_2-N)
17/01/2001	7.0	7.8	N/D	10	1.6	516	87	0.8	0.0012	0.001	.....
13/02/2001	10.1	7.7	N/D	20	1.5	479	104	0.8	0.0049	0.000	.....
27/06/2001	12.4	7.6	N/D	20	1.2	439	49	1.8	0.04	.....	0.004
19/07/2001	15.4	7.7	N/D	60	1.5	427	188	1.3	0.07	.....	0.001
28/08/2001	18.7	7.6	N/D	30	1.4	481	72	0.8	0.02	.....	0.006
28/09/2001	15.4	7.3	N/D	10	1.5	471	2	N/D	0.002	.....	<0.001
09/10/2001	16.0	7.6	N/D	50	0.9	464	96	0.9	0.069	.....	0.004
31/10/2001	12.7	7.8	N/D	40	2.4	513	81	3.1	0.04	0.004	.....
27/11/2001	9.4	7.3	N/D	30	0.7	347	131	0.9	<0.03	0.002	.....
11/12/2001	9.0	7.3	N/D	30	1.6	507	148	5.3	0.04	0.010	.....

NR: Not recorded N/D: Not detected

Analytical Data of Drumcliff Springs 2002

Date	Temp (°C)	pH (pH units)	Odour	Colour (hazen)	Turbidity (N.T.U)	Conductivity (uS/cm)	Iron (ug/L Fe)	Nitrate (mg/l NO_3)	Ammonia (mg/l NH_3-N)	Nitrite (mg/l NO_2-N)
01/02/2002	N/S	N/S	N/S	N/S	N/S	N/S	N/S	N/S	N/S	N/S
06/03/2002	13.8	7.8	Sl.earthy	40	3	456	35	0.6	0.03	<0.001
21/03/2002	9.2	7.5	N/D	20	1.7	477	55	1.0	<0.03	0.003
07/05/2002	12.7	7.4	N/D	15	1.5	490	98	0.2	0.03	0.003
23/05/2002	11.8	7.7	N/D	20	2.5	500	95	1.1	0.03	0.004
05/06/2002	15	7.5	N/D	20	1.7	502	108	0.5	0.05	0.006
19/06/2002	15	7.5	N/D	60	3.3	487	346	0.5	0.08	0.005
08/07/2002	16.3	7.4	N/D	30	5.4	486	307	1.7	0.04	0.01
16/07/2002	N/S	N/S	N/S	N/S	N/S	N/S	N/S	N/S	N/S	N/S
14/08/2002	16.4	7.7	N/D	40	2.1	439	74	<0.10	N/R	<0.001
03/09/2002	14.9	7.4	N/D	5	1.3	528	57	<0.10	0.11	0.001
18/09/2002	13.7	7.3	N/D	15	2.5	509	113	0.4	0.10	<0.001
23/09/2002	13.1	7.5	N/D	10	2	516	59	1.6	0.21	0.001
10/10/2002	N/S	N/S	N/S	N/S	N/S	N/S	N/S	N/S	N/S	N/S
05/11/2002	11	7.8	N/D	20	2.0	476	81	0.9	0.65	<0.001
04/12/2002	9.1	7.6	N/D	20	1.6	527	76	1.0	0.03	0.001
16/12/2002	7.3	7.6	N/D	40	40	562	602	1.6	0.22	<0.001

N/D: Not detected N/S: No Sample

Analytical Data of Drumcliff Springs 2003 - 2004

Date	Temp (°C)	pH (pH units)	Odour	Colour (hazen)	Turbidity (N.T.U)	Conductivity (uS/cm)	Iron (ug/L Fe)	Nitrate (mg/l NO_3)	Ammonia (mgl NH_3-N)	Nitrite (mg/l NO_2-N)
24/02/2003	----	7.61	----	5	15	553	174	3.98	0.01	0.048
25/03/2003	17.3	7.56	Earthy	5	0.8	550	38	4.86	0.02	0.05
08/04/2003	N/S	N/S	N/S	N/S	N/S	N/S	N/S	N/S	N/S	N/S
14/05/2003	14	7.5	N/D	20	2.1	470	101	0.7	0.01	0.012
17/06/2003	15.2	7.5	N/D	30	1.6	158	65	0.6	0.02	0.003
17/07/2003	16.8	7.3	N/D	15	1.9	378	N/R	3.18	0.03	0.007
27/08/2003	N/S	N/S	N/D	N/S	N/S	N/S	N/S	N/S	N/S	N/S
01/10/2003	15.8	7.3	N/D	15	1.7	426	51	1.64	0.03	0.017
29/10/2003	9.4	7.4	N/D	40	8	348	971	1.35	0.21	0.018
24/11/2003	9.2	7.31	N/D	10	1.0	486	49	10.21	0.04	<0.003
17/12/2003	9.2	7.57	N/D	10	1.0	582	110	1.59	0.03	0.02

Date	Temp (°C)	pH (pH units)	Odour	Colour (hazen)	Turbidity (N.T.U)	Conductivity (uS/cm)	Iron (ug/L Fe)	Nitrate (mg/l NO_3)	Ammonia (mgl NH_3-N)	Nitrite (mg/l NO_2-N)
21/01/2004	8.8	7.91	N/D	5	1.1	500	99	7.96	0.03	0.073
24/02/2004	8.9	7.52	N/D	5	0.9	483	51	1.6	0.13	<0.001
24/03/2004	9	7.56	N/D	10	1.2	461	56	1.9	NR	0.001
27/04/2004	12.8	7.62	N/D	15	0.8	452	62	4.51	0.02	0.001
03/06/2004	12.4	7.44	N/D	5	0.6	453	86	0.99	0.03	0.005
16/06/2004	14.2	7.56	N/D	5	0.6	454	25	1.12	0.01	0.006
08/07/2004	14.3	7.44	N/D	5	0.8	431	34	0.42	0.003	0.005
05/08/2004	13.5	7.43	N/D	40	3.20	425	244	0.74	0.06	0.007
29/09/2004	14.1	7.50	N/D	10	0.85	452	108	0.6	0.07	0.002
28/10/2004	11	7.65	N/D	15	0.80	383	110	1.7	0.03	0.011
30/11/2004	9.6	7.60	N/D	30	2.00	471	84	0.35	0.02	<0.001

N/D: Not detected N/S: No Sample NR: Not Recorded

Analytical Data of Poulacorey Swallow Hole 1998

Date	Temp (°C)	pH (pH units)	Odour	Colour (hazen)	Turbidity (N.T.U)	Conductivity (uS/cm)	Iron (ug/L Fe)	Nitrate (mg/l NO3)
12/01/1998	8.0	7.7	None	40	2.9	484	120	4.3
30/01/1998	8.0	7.7	None	40	2.4	400	120	5.8
13/02/1998	8.4	7.6	None	40	2.5	485	130	4.5
11/03/1998	9.5	7.8	None	40	2	No meter	100	4.3
31/03/1998	1.5	7.7	None	50	2.1	No meter	90	4.9
17/04/1998	10.8	7.4	None	30	1	403	100	4.1
29/04/1998	12.3	7.5	None	40	1.9	412	100	4.9
15/05/1998	14.3	7.3	None	30	1	405	90	4.3
11/06/1998	15.1	7.3	None	35	1.1	431	90	4.1
24/06/1998	16.3	7.4	None	25	1.5	400	90	3.2
01/09/1998	Not tested	7.2	None	150	10.2	399	520	4.4
18/09/1998	14.0	7.1	None	50	1.7	468	160	6.1
14/10/1998	13.2	7.2	None	70	4	421	380	4
28/10/1998	10.4	7.6	None	70	9.5	415	170	3.5
02/12/1998	8.3	7.4	None	20	1.5	508	110	<0.4

Analytical Data of Poulacorey Swallow Hole 1999

Date	Temp (°C)	pH (pH units)	Odour	Colour (hazen)	Turbidity (N.T.U)	Conductivity (uS/cm)	Iron (ug/L Fe)	Nitrate (mg/l NO3)
06/01/1999	7.2	7.5	None	15	2.5	453	80	2.2
11/02/1999	6.1	7.6	None	40	2.4	506	190	2.7
05/03/1999	7.7	8.0	None	40	2.0	460	100	0.4
18/03/1999	10.6	8.0	None	35	2.2	507	180	1.3
31/03/1999	10.5	7.9	None	45	2.3	490	100	1.8
30/04/1999	12.8	7.8	None	35	1.7	499	90	1.7
21/05/1999	14.7	8.1	None	35	2.2	497	80	1.6
16/06/1999	14.9	8.1	None	30	1.7	482	50	1.7
04/08/1999	17.8	7.8	None	40	2.2	506	50	3
20/08/1999	17.5	7.8	None	40	1.8	489	60	2.8
01/09/1999	17.6	7.9	None	50	1.7	491	50	2.3
29/09/1999	16	7.7	None	70	1.8	428	130	2.1
28/10/1999	9.8	7.8	None	35	1.8	525	70	2.1
19/11/1999	7.8	7.8	None	60	3.3	488	140	1.8

Analytical Data of Poulacorey Swallow Hole 2000 - 2001

Date	Temp (°C)	pH (pH units)	Odour	Colour (hazen)	Turbidity (N.T.U)	Conductivity (uS/cm)	Iron (ug/L Fe)	Nitrate (mg/l NO3)	Ammonia (mgl NH3-N)	Phosphate (mg/l P)	Nitrite (mg/l NO2-N)
22/02/2000	NR	8.0	N/D	15	2.1	443	84	0.6	0.04	.....	.....
29/03/2000	NR	8.0	N/D	25	2.5	493	178	0.7	0.03	0.026	.....
19/04/2000	NR	8.1	N/D	15	2.5	490	171	0.3	<0.03	<0.01	.....
31/05/2000	NR	8.0	sl.musty	20	2.5	463	217	0.2	<0.03	0.013	.....
19/06/2000	NR	8.2	N/D	20	1.5	453	233	0.3	<0.03	0.023	.....
12/07/2000	NR	7.9	N/D	60	2.0	438	176	0.4	<0.03	0.016	.....
28/08/2000	NR	7.7	N/D	40	2.5	511	255	0.1	.....	.....	.....
26/09/2000	NR	8.0	N/D	50	2.5	475	108	0.2	.....	.....	.....
31/10/2000	NR	7.9	N/D	60	4.4	413	148	1.0	<0.03	.....	.....
28/11/2000	NR	7.9	N/D	20	1.5	457	103	0.7	0.04	.....	0.005
18/12/2000	NR	7.9	N/D	40	2	454	104	0.7	0.03	.....	0.001

Date	Temp (°C)	pH (pH	Odour	Colour	Turbidity	Conductivity	Iron (ug/L Fe)	Nitrate (mg/l	Ammonia	Phosphate	Nitrite (mg/l
17/01/2001	6.0	7.8	N/D	40	6.7	515	282	0.9	0.0201	0.005	.....
13/02/2001	9.0	7.9	N/D	30	2.0	468	116	0.7	0.0139	0.001	.....
27/06/2001	N/S	N/S	N/S	N/S	N/S	N/S	N/S	N/S	N/S	N/S	N/S
19/07/2001	17.1	8.1	N/D	70	1.8	405	298	0.5	0.08	.....	0.062
28/08/2001	19.6	7.8	slight	70	2	464	130	0.9	0.08	.....	0.006
28/09/2001	16.2	7.7	N/D	70	14	527	696	0.3	0.047	.....	0.005
09/10/2001	15.9	7.5	N/D	50	1.4	444	142	0.5	0.124	.....	0.005
31/10/2001	13.3	7.9	slight	60	2.6	431	153	1.8	0.04	<0.001	.....
27/11/2001	10.3	7.5	N/D	20	0.5	291	97	0.8	<0.03	<0.001	.....
11/12/2001	8.1	7.5	N/D	40	2.5	487	82	4.0	0.04	0.013	.....

NR: Not Recorded N/S: No Sample N/D: Not Detected

Analytical Data of Poulacorey Swallow Hole 2002

Date	Temp (°C)	pH (pH units)	Odour	Colour (hazen)	Turbidity (N.T.U)	Conductivity (uS/cm)	Iron (ug/L Fe)	Nitrate (mg/l NO_3)	Ammonia (mgl NH_3-N)	Nitrite (mg/l NO_2-N)
01/02/2002	N/S	N/S	N/S	N/S	N/S	N/S	N/S	N/S	N/S	N/S
06/03/2002	13	8	Sl.earthy	20	1.9	409	63	0.5	0.03	0.006
21/03/2002	N/S	N/S	N/S	N/S	N/S	N/S	N/S	N/S	N/S	N/S
07/05/2002	14.7	8.2	N/D	30	2.5	445	121	0.6	0.04	0.006
23/05/2002	N/S	N/S	N/S	N/S	N/S	N/S	N/S	N/S	N/S	N/S
05/06/2002	16	8	N/D	40	2.4	473	98	0.4	0.07	0.005
19/06/2002	N/S	N/S	N/S	N/S	N/S	N/S	N/S	N/S	N/S	N/S
08/07/2002	16.5	7.3	N/D	70	6.8	499	1418	1.0	0.04	<0.001
16/07/2002	17.6	8.0	N/D	20	2.0	416	109	0.5	0.06	0.004
14/08/2002	17	8.0	N/D	40	2.1	299	86	0.10	N/R	0.002
03/09/2002	15	7.8	N/D	20	4.0	513	99	<0.10	0.11	0.001
18/09/2002	15.4	7.6	N/D	30	2.5	504	243	<0.10	0.14	<0.001
23/09/2002	N/S	N/S	N/S	N/S	N/S	N/S	N/S	N/S	N/S	N/S
10/10/2002	N/S	N/S	N/S	N/S	N/S	N/S	N/S	N/S	N/S	N/S
05/11/2002	N/S	N/S	N/S	N/S	N/S	N/S	N/S	N/S	N/S	N/S
04/12/2002	N/S	N/S	N/S	N/S	N/S	N/S	N/S	N/S	N/S	N/S
16/12/2002	N/S	N/S	N/S	N/S	N/S	N/S	N/S	N/S	N/S	N/S

NR: Not Recorded N/S: No Sample N/D: Not Detected

Analytical Data of Poulacorey Swallow Hole 2003 - 2004

Date	Temp (°C)	pH (pH units)	Odour	Colour (hazen)	Turbidity (N.T.U)	Conductivity (uS/cm)	Iron (ug/L Fe)	Nitrate (mg/l NO_3)	Ammonia (mgl NH_3-N)	Nitrite (mg/l NO_2-N)
24/02/2003	---	8.05	N/D	5	8	558	282	4.42	0.01	0.048
25/03/2003	17.5	7.84	Earthy	10	3.2	543	183	3.98	0.03	0.011
08/04/2003	N/S	N/S	N/S	N/S	N/S	N/S	N/S	N/S	N/S	N/S
14/05/2003	15.8	7.9	N/D	30	2.9	434	215	1.2	0.01	0.007
17/06/2003	17.9	7.8	N/D	40	2.5	504	208	0.5	0.02	0.006
17/07/2003	17.6	7.5	N/D	40	5.2	767	N/R	3.14	0.22	0.043
27/08/2003	16.9	7.6	N/D	40	5.5	560	497	0.38	0.07	0.045
01/10/2003	17.2	7.6	N/D	40	9.8	483	423	1.02	0.2	0.047
29/10/2003	7.9	7.9	N/D	30	13	367	582	0.44	0.45	0.022
24/11/2003	6.9	7.43	N/D	10	1.1	438	97	7.74	0.09	0.013
17/12/2003	7.8	7.75	N/D	15	1.7	489	94	1.28	0.04	0.03

Date	Temp (°C)	pH (pH units)	Odour	Colour (hazen)	Turbidity (N.T.U)	Conductivity (uS/cm)	Iron (ug/L Fe)	Nitrate (mg/l NO_3)	Ammonia (mgl NH_3-N)	Nitrite (mg/l NO_2-N)
21/01/2004	7.5	7.76	N/D	5	1.1	457	65	4.86	0.04	0.017
24/02/2004	6.3	7.84	N/D	10	2	495	152	1.23	0.07	<0.001
24/03/2004	8.1	7.86	N/D	15	1.3	441	84	1	n/r	<0.001
27/04/2004	13	7.96	N/D	10	1.4	439	146	2.52	0.05	0.003
03/06/2004	16.9	7.74	N/D	20	3.5	439	482	0.57	0.02	0.015
16/06/2004	21.1	7.92	N/D	20	3.6	439	432	0.12	0.06	0.008
08/07/2004	16.5	7.72	N/D	20	0.85	419	145	0.17	0.003	0.003
05/08/2004	16.9	7.50	N/D	50	7.20	439	536	0.12	0.07	<0.001
29/09/2004	14.6	7.62	N/D	5	0.66	427	129	<0.10	0.008	0.001
28/10/2004	11.1	8.00	N/D	20	1.50	418	132	1	0.03	0.009
30/11/2004	8.7	7.75	N/D	50	1.50	460	93	<0.1	0.08	0.0049

N/S: No Sample N/D: Not Detected

Analytical Data of Drumcarronmore Swallow Hole 1998

Date	Temp (°C)	pH (pH units)	Odour	Colour (hazen)	Turbidity (N.T.U)	Conductivity (uS/cm)	Iron (ug/L Fe)	Nitrate (mg/l NO3)
12/01/1998	7.9	7.8	None	40	2.5	429	110	3.5
30/01/1998	8.1	7.7	None	40	2	385	150	7.5
13/02/1998	8.6	7.5	None	20	2.3	429	100	8.6
11/03/1998	9.6	7.8	None	40	2.6	No meter	120	5.1
31/03/1998	10.4	7.8	None	50	2.4	No meter	100	4.7
17/04/1998	10.9	7.3	None	30	0.9	401	70	5
29/04/1998	12.0	7.5	None	50	2	403	130	4
15/05/1998	(No sample - dried up)		---	---	---	---	---	---
11/06/1998	(No sample - dried up)		---	---	---	---	---	---
24/06/1998	16.0	7.4	None	35	1.3	383	80	1.6
01/09/1998	Not Tested	7.2	None	125	6	397	350	1.3
18/09/1998	17.0	8.0	None	70	2	514	50	5.7
14/10/1998	12.3	7.2	None	150	14	320	740	3.5
28/10/1998	10.0	8.0	None	70	5.4	453	150	3.5
02/12/1998	8.0	7.6	None	40	3.5	496	150	0.9

Analytical Data of Drumcarronmore Swallow Hole 1999

Date	Temp (°C)	pH (pH units)	Odour	Colour (hazen)	Turbidity (N.T.U)	Conductivity (uS/cm)	Iron (ug/L Fe)	Nitrate (mg/l NO3)
06/01/1999	6.5	7.7	None	30	2.5	452	110	3.1
11/02/1999	5.5	8.0	None	50	2.3	486	210	1.3
05/03/1999	7.9	8.2	None	60	3.3	397	140	0.8
18/03/1999	11.1	7.9	None	65	4.0	528	260	1.3
31/03/1999	9.9	7.6	None	60	4.3	551	220	2.6
30/04/1999	11	7.7	None	50	7.5	610	180	1.4
21/05/1999	15.8	8.0	None	50	12.0	636	250	1.7
16/06/1999	No Sample - Dried Up		----	----	----	----	----	----
04/08/1999	17.3	8.0	None	50	9.9	674	260	2.1
20/08/1999	No Sample - Dried Up		----	----	----	----	----	----
01/09/1999	No Sample - Dried Up		----	----	----	----	----	----
29/09/1999	16	8.3	None	85	2.0	490	220	2.4
28/10/1999	9.5	7.7	None	45	1.8	656	150	2.4
19/11/1999	7.7	7.6	None	60	3.2	562	180	3.1

Analytical Data of Drumcarronmore Swallow Hole 2000 - 2001

Date	Temp (°C)	pH (pH units)	Odour	Colour (hazen)	Turbidity (N.T.U)	Conductivity (uS/cm)	Iron (ug/L Fe)	Nitrate (mg/l NO3)	Ammonia (mgl NH3-N)	Phosphate (mg/l P)	Nitrite (mg/l NO2-N)
22/02/2000	N/R	8.2	N/D	30	2.2	430	62	0.9	<0.03	.....	.....
29/03/2000	N/R	7.7	N/D	50	4.5	595	472	1.1	0.12	0.058	.....
19/04/2000	N/R	8.0	N/D	35	3.0	621	650	0.7	0.07	0.013	.....
31/05/2000	N/R	8.1	sl.musty	50	6.0	609	303	0.9	0.07	0.035	.....
19/06/2000	N/R	8.1	N/D	40	3.0	629	246	0.9	<0.03	<0.01	.....
12/07/2000	N/R	7.9	N/D	65	6.0	607	176	0.9	0.05	0.016	.....
28/08/2000	N/R	8.2	musty	60	14.0	677	145	0.6	.....	.....	.....
26/09/2000	N/R	7.5	N/D	85	2.5	503	197	0.8	.....	.....	.....
31/10/2000	N/R	8.2	N/D	60	2.6	453	113	0.5	<0.03	.....	.....
28/11/2000	N/R	8.1	N/D	50	2.1	486	83	0.6	<0.03	.....	0.007
18/12/2000	N/R	8.0	N/D	70	2.4	449	193	0.9	0.03	.....	0.011

Date	Temp (°C)	pH (pH units)	Odour	Colour (hazen)	Turbidity (N.T.U)	Conductivity (uS/cm)	Iron (ug/L Fe)	Nitrate (mg/l NO3)	Ammonia (mgl NH3-N)	Phosphate (mg/l P)	Nitrite (mg/l NO2-N)
17/01/2001	8.0	7.6	N/D	40	4.0	606	508	1.2	0.143	0.008	.....
13/02/2001	10.1	8.5	N/D	50	2.5	464	89	0.2	0.0064	0.003	.....
27/06/2001	N/S	N/S	N/S	N/S	N/S	N/S	N/S	N/S	N/S	N/S	N/S
19/07/2001	17.0	7.8	N/D	100	6.2	377	1076	0.5	0.1	.....	0.002
28/08/2001	19.4	7.6	slight	70	3.9	593	323	0.4	0.02	.....	0.008
28/09/2001	16.3	7.4	slight	125	20.0	443	1.4	0.4	0.008	.....	0.004
09/10/2001	N/S	N/S	N/S	N/S	N/S	N/S	N/S	N/S	N/S	N/S	N/S
31/10/2001	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R
27/11/2001	8.9	7.6	N/D	60	2.5	365	329	0.7	<0.03	0.005	.....
11/12/2001	7.7	7.6	N/D	60	4.0	470	220	7.5	0.04	0.033	.....

NR: Not Recorded N/S: No Sample N/D: Not Detected

Analytical Data of Drumcarronmore Swallow Hole 2002

Date	Temp (°C)	pH (pH units)	Odour	Colour (hazen)	Turbidity (N.T.U)	Conductivity (uS/cm)	Iron (ug/L Fe)	Nitrate (mg/l NO_3)	Ammonia (mgl NH_3-N)	Nitrite (mg/l NO_2-N)
01/02/2002	N/S	N/S	N/S	N/S	N/S	N/S	N/S	N/S	N/S	N/S
06/03/2002	8.5	7.3	Sl.earthy	50	4.1	421	68	0.3	<0.03	0.002
21/03/2002	N/S	N/S	N/S	N/S	N/S	N/S	N/S	N/S	N/S	N/S
07/05/2002	15.9	7.9	Sl.earthy	50	3.2	450	162	0.4	0.03	0.003
23/05/2002	N/S	N/S	N/S	N/S	N/S	N/S	N/S	N/S	N/S	N/S
05/06/2002	15	7.5	N/D	70	2.1	443	402	0.5	0.05	0.003
19/06/2002	N/S	N/S	N/S	N/S	N/S	N/S	N/S	N/S	N/S	N/S
08/07/2002	16.7	6.7	N/D	250+	17	442	1629	1.1	0.09	<0.001
16/07/2002	N/S	N/S	N/S	N/S	N/S	N/S	N/S	N/S	N/S	N/S
14/08/2002	16.1	7.8	N/D	50	2.4	409	66	<0.10	N/R	<0.001
03/09/2002	15	7.6	N/D	100	12	563	1125	<0.10	0.01	<0.001
18/09/2002	N/S	N/S	N/S	N/S	N/S	N/S	N/S	N/S	N/S	N/S
23/09/2002	N/S	N/S	N/S	N/S	N/S	N/S	N/S	N/S	N/S	N/S
10/10/2002	N/S	N/S	N/S	N/S	N/S	N/S	N/S	N/S	N/S	N/S
05/11/2002	N/S	N/S	N/S	N/S	N/S	N/S	N/S	N/S	N/S	N/S
04/12/2002	N/S	N/S	N/S	N/S	N/S	N/S	N/S	N/S	N/S	N/S
16/12/2002	7.3	7.9	N/D	20	2.2	456	58	0.4	0.04	<0.001

N/S: No Sample N/D: Not Detected N/R: Not Recorded

Analytical Data of Drumcarronmore Swallow Hole 2003 - 2004

Date	Temp (°C)	pH (pH units)	Odour	Colour (hazen)	Turbidity (N.T.U)	Conductivity (uS/cm)	Iron (ug/L Fe)	Nitrate (mg/l NO_3)	Ammonia (mgl NH_3-N)	Nitrite (mg/l NO_2-N)
24/02/2003	—	7.69	N/D	5	12	639	514	3.54	0.02	<0.001
25/03/2003	17.4	7.8	Earthy	40	4	527	391	<0.1	0.02	0.011
08/04/2003	N/S	N/S	N/S	N/S	N/S	N/S	N/S	N/S	N/S	N/S
14/05/2003	16.6	7.7	SLIGHT	70	9.2	443	1353	0.6	0.04	0.003
17/06/2003	17.6	7.5	SLIGHT	60	4.4	569	376	0.2	0.02	0.009
17/07/2003	17.2	7.4	N/D	70	13	358	N/R	2.87	0.06	0.03
27/08/2003	20.3	8.7	N/D	150	33	284	148	0.09	0.07	0.007
01/10/2003	18.1	9.2	N/D	150	28	256	2070	2.12	0.03	0.027
29/10/2003	8.2	7.6	N/D	70	30	342	231	1.83	0.16	0.021
24/11/2003	8.4	7.07	N/D	5	1.1	654	34	18.74	0.05	<0.003
17/12/2003	7.5	7.68	N/D	30	1.2	588	210	0.98	0.03	0.024

Date	Temp (°C)	pH (pH units)	Odour	Colour (hazen)	Turbidity (N.T.U)	Conductivity (uS/cm)	Iron (ug/L Fe)	Nitrate (mg/l NO_3)	Ammonia (mgl NH_3-N)	Nitrite (mg/l NO_2-N)
21/01/2004	7.8	7.64	N/D	5	0.9	620	29	14.23	0.03	0.013
24/02/2004	6.1	7.39	N/D	40	3.5	577	501	<0.10	0.36	<0.001
24/03/2004	10.4	7.35	N/D	5	1.0	599	15	0.3	N/R	0.001
27/04/2004	14.7	7.7	N/D	40	2.3	332	426	<0.44	0.02	<0.001
03/06/2004	17.7	8.00	N/D	20	4.5	571	319	0.73	0.09	0.018
16/06/2004	20.1	8.06	N/D	40	6.5	573	582	0.21	0.08	0.008
08/07/2004	15.9	7.96	N/D	20	1.2	533	105	1.05	0.003	0.006
05/08/2004	15.5	7.65	N/D	30	2.00	587	175	0.41	0.04	0.021
29/09/2004	15.9	7.94	N/D	30	0.73	478	80	<0.10	0.07	0.021
28/10/2004	11.4	8.04	N/D	30	1.10	451	58	1.1	0.03	0.01
30/11/2004	9.6	7.63	N/D	30	1.50	471	69	2.08	0.02	0.0052

N/R: Not Recorded N/D: Not Detected N/S: No Sample

Appendix C

SHALLEE RIVER DATA 1998 - 2004

SHALLEE RIVER DATA - 2000

Bridge N. of Ballyknock

Date	Temp °C	pH	DO %	BOD	Colour	Cond 25°C	$NH_3(N)$	$NO_3(N)$	$NO_2(N)$	PO_4	Chloride	T Coli	F Coli
27/01/2000	3.6	7.7	95	<2.0	40	297	0.1	1.00	NM	0.02	25	3300	1100
24/02/2000	6.1	7.6	89	<2.0	70	259	0.05	0.7	NM	0.03	27	1300	500
23/03/2000	6.6	8.0	97	<2.0	70	303	0.08	0.9	NM	0.02	25	930	580
26/04/2000	7.3	8.0	95	<2.0	85	307	0.04	0.6	NM	0.04	25	5100	2500
25/05/2000	9.9	8.0	87	<2.0	100	302	<0.03	0.6	NM	0.03	25	4500	2300
29/06/2000	14.1	8.1	95	<2.0	65	363	0.02	0.6	NM	0.02	25	7400	900
26/07/2000	16.1	8.0	101	<2.0	60	351	0.3	0.3	NM	0.03	23	6200	1300
31/08/2000	15.7	8.0	89	2.0	70	346	0.05	0.8	NM	0.01	25	7800	700
28/09/2000	11.6	7.5	89	3.0	200	217	0.032	1.0	NM	0.08	19	7000	2100
26/10/2000	10.0	7.7	92	<2.0	85	258	<0.03	1.0	NM	0.02	25	1500	100
29/11/2000	8.8	7.6	98	<2.0	125	172	0.05	0.7	0.01	0.02	22	5300	1200
14/12/2000	7.1	7.6	93	<2.0	125	210	0.008	0.8	0.005	0.02	23	500	200

Kilcurrish Br

Date	Temp °C	pH	DO %	BOD	Colour	Cond 25°C	$NH_3(N)$	$NO_3(N)$	$NO_2(N)$	PO_4	Chloride	T Coli	F Coli
27/01/2000	6.2	7.6	94	<2.0	15	489	0.08	1.3	NM	0.03	26	400	100
24/02/2000	7.7	7.7	85	<2.0	50	404	0.03	0.7	NM	0.03	25	530	280
23/03/2000	8.3	7.9	90	<2.0	30	488	0.05	1.2	NM	0.02	27	140	90
26/04/2000	8.6	7.9	99	<2.0	50	461	<0.03	0.6	NM	0.01	25	400	340
25/05/2000	10.3	7.9	81	<2.0	50	484	<0.03	0.9	NM	0.02	24	460	400
29/06/2000	12.8	7.9	94	2.3	40	514	0.02	0.6	NM	0.02	22	800	590
26/07/2000	14.5	7.9	85	2.2	40	472	0.9	0.9	NM	0.02	19	810	490
31/08/2000	13.4	7.8	82	2.0	30	581	0.05	0.8	NM	-0.01	23	500	350
28/09/2000	11.6	7.5	88	2.0	150	346	0.013	1.3	NM	0.06	21	>1000	>1000
26/10/2000	10.4	7.6	91	<2.0	60	449	<0.03	1.2	NM	0.03	27	700	100
29/11/2000	9.5	7.8	100	<2.0	100	307	0.02	0.9	0.007	0.03	23	1200	600
14/12/2000	7.8	7.6	93	<2.0	85	363	0.004	0.9	0.003	0.04	25	200	100

Ballymaquiggan Br.

Date	Temp °C	pH	DO %	BOD	Colour	Cond 25°C	$NH_3(N)$	$NO_3(N)$	$NO_2(N)$	PO_4	Chloride	T Coli	F Coli
27/01/2000	5.3	7.6	81	<2.0	40	507	0.07	1.0	NM	0.02	25	300	<1000
24/02/2000	7.2	7.9	82	<2.0	30	444	0.01	0.4	NM	0.01	25	110	40
23/03/2000	8.7	7.9	85	<2.0	20	505	0.05	0.9	NM	0.03	27	50	20
26/04/2000	9.0	8.1	95	<2.0	20	479	<0.03	0.5	NM	0.01	25	160	110
25/05/2000	12.6	8.1	86	<2.0	30	461	0.03	0.4	NM	0.02	23	340	280
29/06/2000	16.8	7.9	81	2.3	25	480	0.02	0.2	NM	0.02	19	600	630
26/07/2000	17.7	7.9	73	2.0	25	504	0.7	0.7	NM	0.01	19	120	130
31/08/2000	16.0	8.0	83	2.0	30	520	0.06	0.2	NM	0.02	23	1000	420
28/09/2000	12.1	7.6	73	3.0	150	363	0.021	1.2	NM	0.07	23	>1000	>1000
26/10/2000	10.3	7.8	80	<2.0	50	485	<0.03	1.1	NM	0.03	255	200	100
29/11/2000	9.1	8.0	97	<2.0	70	395	0.02	0.8	NM	0.02	25	1100	600
14/12/2000	7.2	7.8	86	<2.0	70	419	0.006	0.8	0.004	0.04	25	100	<100

NM: Not Measured

Units as mg/l unless otherwise stated. pH as pH units Cond: as us/cm³ T Coli and F Coli as nos/100mls

SHALLEE RIVER DATA - 2001

Bridge N. of Ballyknock

Date	Temp °C	pH	DO %	BOD	Colour	Cond 25°C	$NH_3(N)$	$NO_3(N)$	$NO_2(N)$	PO_4	Chloride	T Coli	F Coli
30/01/2001	6.9	7.8	91	<2	80	242	0.8	0.006	-0.03	-0.01	23.5	N/M	N/M
22/02/2001	8.8	8.1	99	<2	125	283	0.8	0.008	-0.03	0.04	59	N/M	N/M
28/03/2001	6.2	7.8	93	3	70	321	0.7	0.017	-0.03	0.01	39.7	560	120
25/04/2001	9.1	7.7	105	<2	175	238	1	0.003	0.08	N/M	N/M	N/M	N/M
31/05/2001	11.6	8.4	99	<2	85	388	0.2	0.006	-0.03	-0.01	26	230	150
28/06/2001	18.3	7.7	80	<2	125	378	0.9	0.009	0.09	0.02	69	20	10
01/08/2001	16	8.3	101	<2	85	332	0.2	0.005	-0.03	N/M	38	150	175
19/09/2001	9.7	8.3	94	N/M	40	442	1.2	0.007	-0.03	N/M	N/M	1000	100
12/10/2001	14.4	7.9	99	<2	70	294	1.1	-0.001	0.04	0.09	51	440	85
01/11/2001	9.7	8	97	<2	100	292	1.6	0.005	-0.03	0.08	37	920	80
22/11/2001	10	7.8	100	<2	70	292	1.2	-0.01	-0.03	0.03	30	910	250
12/12/2001	4.4	7.7	139	<2	60	274	1	0.003	-0.01	-0.01	36	690	30

Kilcurrish Br

Date	Temp °C	pH	DO %	BOD	Colour	Cond 25°C	$NH_3(N)$	$NO_3(N)$	$NO_2(N)$	PO_4	Chloride	T Coli	F Coli
30/01/2001	7.5	7.8	93	<2	50	373	0.9	0.004	-0.03	-0.01	24.9	N/M	N/M
22/02/2001	8.8	8.2	99	<2	100	454	0.8	0.006	-0.03	0.03	57	N/M	N/M
28/03/2001	8.4	8.1	98	<2	40	404	0.8	0.017	-0.03	0.04	24.2	693	0
25/04/2001	10.5	7.7	120	<2	100	358	1.5	0.008	0.04	N/M	N/M	N/M	N/M
31/05/2001	11.8	8	91	<2	70	559	1.1	0.002	-0.03	0.13	31	70	74
28/06/2001	16.4	7.7	81	<2	50	619	0.6	-0.001	0.09	0.05	22.6	50	3
01/08/2001	15	7.9	88	<2	50	499	0.3	-0.001	-0.03	N/M	37	240	216
19/09/2001	10.1	8.8	93	<2	40	630	0.8	0.014	-0.03	N/M	N/M	500	93
12/10/2001	14.2	7.9	100	<2	40	428	0.7	-0.001	0.06	0.04	56	364	288
01/11/2001	10.1	8.3	90	<2	85	418	1.7	0.011	-0.03	0.03	29	600	110
22/11/2001	10.1	7.5	100	<2	60	469	1.4	-0.001	-0.03	0.03	31	210	80
12/12/2001	4.4	7.7	121	<2	30	486	1	0.013	-0.01	0.04	27	600	30

Ballymaguiggan Br.

Date	Temp °C	pH	DO %	BOD	Colour	Cond 25°C	$NH_3(N)$	$NO_3(N)$	$NO_2(N)$	PO_4	Chloride	T Coli	F Coli
30/01/2001	6.6	8	82	<2	40	438	0.8	0.002	-0.03	0.03	23.5	N/M	N/M
22/02/2001	8.4	8.3	98	<2	125	425	0.7	0.005	-0.03	0.01	43	N/M	N/M
28/03/2001	8.5	7.8	98	3	30	747	0.7	0.017	-0.03	0.02	25.5	140	120
25/04/2001	9.1	7.8	101	<2	70	509	1	0.002	0.04	N/M	N/M	N/M	N/M
31/05/2001	16.6	7.9	105	<2	125	100	0.6	0.008	0.12	-0.01	24.7	0	3
28/06/2001	15.3	8.1	88	<2	50	378	0.6	-0.001	0.09	0.07	56	12	0
01/08/2001	19	8.1	92	<2	30	365	0.2	-0.001	-0.03	N/M	32	0	4
19/09/2001	12.1	8.2	61	<2	40	446	0.7	0.017	-0.03	N/M	N/M	130	101
12/10/2001	14.1	8	100	<2	30	379	0.4	-0.001	0.04	0.05	40	50	0
01/11/2001	9.9	8	91	3	70	558	0.7	0.003	2.26	0.15	33	60	0
22/11/2001	10.9	8	112	9.3	40	604	1	0.023	0.72	0.06	29	0	0
12/12/2001	8.4	7.9	114	<2	30	643	0.1	0.03	-0.01	0.04	27	20	90

NM: Not Measured

Units as mg/l unless otherwise stated. pH as pH units Cond: as us/cm^3 T Coli and F Coli as nos/100mls

SHALLEE RIVER DATA - 2002

Bridge N. of Ballyknock

Date	Temp °C	pH	DO %	BOD	Colour	Cond 25°C	NH_3(N)	NO_3(N)	NO_2(N)	PO_4	Chloride	T Coli	F Coli
03/01/2002	6.5	8.1	99	<2	85	912	<0.03	1.4	0.013	0.13	24.5	NR	NR
28/02/2002	4.9	7.9	105.6	NFR	125	243	0.17	0.4	0.003	0.04	21.5	3	0
04/04/2002	12.0	8.1	115	2	70	298	0.09	0.5	0.016	0.02	23	4	0
08/05/2002	11.5	8.4	104.0	NFR	60	303	0.03	0.6	0.002	0.03	20.7	5	0
05/06/2002	12.0	8.2	99.4	<2	70	290	0.04	0.6	0.003	0.05	21.5	0	2
09/07/2002	12.2	8.1	96.6	3	70	284	0.07	0.1	0.006	NFR	19.5	TNTC	100
07/08/2002	15.7	8.1	104.2	4	175	352	0.05	0.9	0.022	0.08	22	TNTC	0
04/09/2002	15.6	8.2	104.2	<2	150	323	0.1	0.4	<0.001	0.01	22.5	1230	330
01/10/2002	15.5	8.1	107.7	4	50	345	0.19	0.5	<0.001	<0.01	23.5	37	0
05/11/2002	10.2	7.9	71	4	70	266	0.59	0.5	<0.001	<0.01	28.5	108	29
04/12/2002	12.5	7.8	112	NFR	40	287	0.03	0.2	<0.001	0.02	49.5	12400	1300

Kilcurrish Br

Date	Temp °C	pH	DO %	BOD	Colour	Cond 25°C	NH_3(N)	NO_3(N)	NO_2(N)	PO_4	Chloride	T Coli	F Coli
03/01/2002	7.1	7.8	112	<2	100	472	<0.03	1.5	0.012	<0.01	24.5	NR	NR
28/02/2002	6.1	7.9	97.1	NFR	50	411	0.04	0.5	0.004	<0.01	23.5	19	0
04/04/2002	11.8	7.9	110.2	<2	40	401	0.06	0.7	0.019	<0.01	24	19	0
08/05/2002	12.7	7.8	97.1	NFR	20	463	0.03	0.5	0.004	0.08	23.2	23	0
05/06/2002	13.4	7.9	93.4	<2	20	490	0.04	0.6	0.004	0.01	22.5	99	25
09/07/2002	14	7.9	92.7	2	70	478	0.06	0.1	0.004	NFR	20	34	0
07/08/2002	16.7	7.7	104	<2	30	537	0.05	0.3	<0.001	<0.01	24	52	69
04/09/2002	15	7.7	110	<2	15	515	0.11	0.1	0.003	<0.01	21.0	120	80
01/10/2002	15.9	7.6	101.2	3	20	547	0.15	0.3	0.001	<0.01	19	58	TNTC
05/11/2002	10.2	7.5	69	6	40	470	0.61	0.5	0.002	<0.01	27.5	93	32
04/12/2002	12.7	7.7	96.8	NFR	20	483	0.03	0.8	<0.001	0.02	36.5	4000	600

Ballymaquiggan Br.

Date	Temp °C	pH	DO %	BOD	Colour	Cond 25°C	NH_3(N)	NO_3(N)	NO_2(N)	PO_4	Chloride	T Coli	F Coli
03/01/2002	6.6	7.9	86.6	<2	85	511	<0.03	1.6	0.013	0.02	25.5	NR	NR
28/02/2002	6.3	8	103.4	NFR	50	408	0.04	0.5	0.004	0.04	23	13	0
04/04/2002	11.6	8	111	2	40	351	0.06	0.9	0.028	<0.01	24.5	11	0
08/05/2002	13	7.9	101.2	NFR	30	473	0.03	0.6	0.005	<0.01	24.2	11	0
05/06/2002	13.8	8.0	97.3	<2	20	500	0.03	0.7	0.004	0.03	22.5	0	96
09/07/2002	14.1	7.8	97.2	2	40	493	0.07	0.1	0.005	NFR	19.5	9	0
07/08/2002	17.2	7.7	118	4	30	529	0.08	0.2	<0.001	<0.01	22	12	39
04/09/2002	15.1	7.8	96	<2	5	523	0.11	0.1	0.002	<0.01	21.0	88	43
01/10/2002	15.9	7.5	61.4	3	30	553	0.16	0.3	0.008	<0.01	21	73	TNTC
05/11/2002	10.2	7.6	71.2	3	30	493	0.63	0.9	<0.001	<0.01	36.0	17	0
04/12/2002	12.5	7.8	96.6	NFR	10	500	0.03	0.9	<0.001	0.05	32.5	700	2100

NR: Not Recorded NFR: Not for Recording TNTC: Too Numerous to Count

Units as mg/l unless otherwise stated. pH as pH units Cond: as us/cm^3 T Coli and F Coli as nos/100mls

SHALLEE RIVER DATA - 2003

Bridge N. of Ballyknock

Date	Temp °C	pH	DO %	BOD	Colour	Cond 25°C	$NH_3(N)$	$NO_3(N)$	$NO_2(N)$	PO_4	Chloride	T Coli	F Coli
29/01/2003	7	8.0	118	<2	30	290	0.03	0.6	<0.001	0.02	30.5	TNTC	17
25/02/2003	NT	8.16	108	<2	50	438	0.02	0.6	0.011	0.01	30.5	260	260
27/03/2003	12	8.21	97.3	<2	60	314	0.04	0.2	<0.001	<0.01	29.5	194	106
24/04/2003	9.8	8.2	99.3	3	60	345	0.05	0.3	<0.001	<0.01	30.5	960	117
22/05/2003	12.5	7.8	102.7	4	175	201	0.06	<0.1	<0.001	0.05	24	TNTC	TNTC
19/06/2003	16.4	8.36	104.2	<2	40	613	<0.03	0.1	<0.001	<0.01	25.5	730	101
17/07/2003	14	8.06	102.5	5	200	234	0.03	0.2	<0.001	0.08	22	TNTC	15
14/08/2003	18	8.25	88.4	<2	85	340	0.04	0.3	<0.001	0.02	24	480	0
11/09/2003	16.1	8.32	78	3	60	416	0.04	0.3	<0.001	<0.01	62	150	1
09/10/2003	12.9	8.05	99.2	<2	60	367	0.06	<0.1	0.001	<0.01	35	920	500
06/11/2003	8.7	7.41	101.8	3	100	275	0.04	0.4	0.001	0.02	30	770	660
03/12/2003	7	7.56	104.4	2	30	272	0.05	0.66	<0.001	<0.01	33	130	70

Kilcurrish Br

Date	Temp °C	pH	DO %	BOD	Colour	Cond 25°C	$NH_3(N)$	$NO_3(N)$	$NO_2(N)$	PO_4	Chloride	T Coli	F Coli
29/01/2003	6.8	7.9	121	<2	15	478	0.03	0.7	<0.001	0.01	33	96	0
25/02/2003	NT	8.03	111	<2	20	547	0.03	0.8	0.01	0.04	30.5	25	4
27/03/2003	10.6	7.87	92.6	<2	30	552	0.08	0.6	<0.001	<0.01	31.5	60	40
24/04/2003	11.3	7.99	98.9	<2	50	537	0.04	0.2	0.03	<0.01	26.5	133	45
22/05/2003	11	7.7	92.6	2	100	346	0.06	0.5	<0.001	<0.01	23	140	2
19/06/2003	17.3	7.87	95.9	<2	20	535	<0.03	0.3	<0.001	<0.01	26	120	71
17/07/2003	14	7.94	85	3	85	416	0.04	0.7	<0.001	0.07	27	TNTC	1
14/08/2003	17	7.82	91.5	<2	30	564	0.05	0.2	0.003	<0.01	27	150	140
11/09/2003	16	7.87	69	2	30	584	0.04	0.3	0.014	<0.01	28	200	2
09/10/2003	12.6	7.74	78.3	<2	30	589	0.03	0.4	0.001	<0.01	29	100	90
06/11/2003	9.7	7.45	97.7	4	85	364	0.04	<0.1	0.002	0.06	30	1400	1220
03/12/2003	8.3	7.56	102.9	<2	15	461	0.05	1.16	<0.001	<0.01	33	120	90

Ballymaguiggan Br.

Date	Temp °C	pH	DO %	BOD	Colour	Cond 25°C	$NH_3(N)$	$NO_3(N)$	$NO_2(N)$	PO_4	Chloride	T Coli	F Coli
29/01/2003	7	7.9	103	<2	10	494	0.04	0.8	<0.001	<0.01	33	31	0
25/02/2003	NT	8.06	114	<2	10	560	0.03	1	0.011	<0.01	30	30	2
27/03/2003	11.5	7.86	98.1	<2	30	564	0.08	0.6	0.007	<0.01	31	37	40
24/04/2003	11.3	7.93	86.6	2	30	539	<0.03	0.4	0.057	<0.01	26	520	90
22/05/2003	11.7	7.73	88.6	2	70	405	0.06	0.5	<0.001	<0.01	24	64	40
19/06/2003	17.5	7.89	98.4	<2	30	550	<0.03	0.2	<0.001	<0.01	26.5	105	70
17/07/2003	15.2	7.88	85.8	<2	50	521	0.05	0.5	<0.001	0.01	27	TNTC	3
14/08/2003	17.3	7.69	83.5	<2	20	562	0.07	0.2	0.011	0.03	26	110	0
11/09/2003	16	7.63	74	<2	30	573	0.03	0.3	0.023	<0.01	32	140	330
09/10/2003	13	7.74	40.8	3	30	610	0.03	0.4	0.013	0.05	28	56	61
06/11/2003	10	7.61	81.3	3	40	346	0.04	0.7	0.01	0.02	28	730	660
03/12/2003	7.5	7.59	90.5	<2	20	473	0.06	0.99	0.001	<0.01	35	80	50

NT: Not Tested NFR: Not for Recording TNTC: Too Numerous to Count

Units as mg/l unless otherwise stated. pH as pH units Cond: as us/cm^3 T Coli and F Coli as nos/100mls

SHALLEE RIVER Data - 2004

Bridge N. of Ballyknock

Date	Temp °C	pH	DO %	BOD	Colour	Cond 25°C	$NH_3(N)$	$NO_3(N)$	$NO_2(N)$	PO_4	Chloride	T Coli	F Coli
28/01/2004	3.6	7.2	109	2	30	276	0.02	0.7	0.001	0.01	29	390	310
25/02/2004	3.6	7.9	109	2	30	314	0.07	0.6	0.001	0.02	33	248	110
25/03/2004	7.4	7.7	114	2	20	260	0.05	0.3	0.001	0.01	28	570	NM
21/04/2004	8	7.3	95	3	125	220	0.14	0.3	0.001	0.07	28	1986	1986
19/05/2004	14.3	7.6	94	4	30	333	0.07	0.4	0.001	0.01	25	>2419	1733
16/06/2004	15.1	7.7	92	2	30	389	0.01	0.3	0.001	0.01	25	14000	0
22/07/2004	13.1	7.8	89	2	40	329	0.05	0.2	0.001	0.03	24	2400	100
24/08/2004	14.8	7.6	83	3	125	333	0.03	0.1	0.001	0.04	25	1040	2240
22/09/2004	13.3	7.3	89	2	85	246	0.02	0.1	0.002	0.26	30	453	NM
20/10/2004	6.1	7	71	4	70	277	0.08	0.2	0.001	0.02	25	250	100
17/11/2004	14.4	7.8	89	2	100	245	0.07	0.4	0.016	0.01	26	4000	120
15/12/2004	10.3	6.98	89	AR	150	242	0.06	0.1	0.018	0.05	NM	290000	NM

Kilcurrish Br

Date	Temp °C	pH	DO %	BOD	Colour	Cond 25°C	$NH_3(N)$	$NO_3(N)$	$NO_2(N)$	PO_4	Chloride	T Coli	F Coli
28/01/2004	5.4	7.7	111	2	10	460	0.01	0.9	0.001	0.01	32	200	210
25/02/2004	5.4	7.9	111	2	15	488	0.07	1.1	0.001	0.03	29	52	2
25/03/2004	8.5	7.6	113	2	15	428	0.04	1.1	0.001	0.05	27	140	NM
21/04/2004	8.7	7.5	93	2	70	358	0.07	0.5	0.004	0.03	24	2419	2419
19/05/2004	14.1	7.4	93	2	20	536	0.05	1.1	0.001	0.01	26	659	436
16/06/2004	14.1	7.3	64	3	15	610	0.03	1.2	0.006	0.01	27	340	0
20/07/2004	13	7.7	79	2	30	503	0.05	0.7	0.001	0.02	27	900	110
24/08/2004	14.1	7.6	78	3	175	364	0.03	0.1	0.001	0.05	26	3800	20
22/09/2004	12.7	7.4	89	2	30	465	0.02	0.1	0.001	0.02	25	782	Nm
20/10/2004	7.3	7.6	67	2	70	365	0.07	0.4	0.002	0.03	25	220	40
17/11/2004	14.5	7.7	90	2	70	418	0.05	0.6	0.026	0.01	25	330	180
15/12/2004	10.1	7.29	87.5	AR	125	335	0.06	0.1	0.04	0.07	NM	334000	NM

Ballymaguiggan Br.

Date	Temp °C	pH	DO %	BOD	Colour	Cond 25°C	$NH_3(N)$	$NO_3(N)$	$NO_2(N)$	PO_4	Chloride	T Coli	F Coli
28/01/2004	4.6	7.8	103	2	15	492	0.01	0.9	0.003	0.01	27	90000	60
25/02/2004	4.6	7.9	103	2	15	532	0.07	1.3	0.013	0.01	29	70	0
25/03/2004	8.4	7.8	106	2	20	447	0.04	0.8	0.003	0.02	27	19	NM
21/04/2004	8.5	7.8	89	2	30	426	0.05	0.6	0.004	0.01	28	46	NM
19/05/2004	15.3	7.6	81	2	15	525	0.06	0.7	0.001	0.01	29	1203	58
16/06/2004	18.9	7.5	76	2	30	519	0.04	0.1	0.007	0.02	26	489	87
20/07/2004	16.4	7.7	65	2	30	499	0.05	0.4	0.01	0.02	28	200	240
24/08/2004	14.4	7.5	62	3	125	388	0.03	0.1	0.001	0.05	23	800	40
22/09/2004	13.3	7.6	83	2	20	467	0.02	1.3	0.001	0.001	27	4000	NM
20/10/2004	8.2	7.5	70	2	50	475	0.05	0.2	0.002	0.02	27	>2000	160
17/11/2004	14.3	7.8	89	2	70	476	0.05	0.6	0.014	0.01	26	170	0
15/12/2004	9.7	7.52	89	AR	50	468	0.06	0.1	0.079	0.043	NM	180	NM

NM: Not Measured

Units as mg/l unless otherwise stated. pH as pH units Cond: as us/cm[3] T Coli and F Coli as nos/100mls

Appendix D

RAINFALL DATA RECORDED AT DRUMCLIFF WATER TREATMENT PLANT
1998 - 2004

Rainfall Data Recorded at Drumcliff WTP in mm - 1998

Month	Jan-98	Feb-98	Mar-98	Apr-98	May-98	Jun-98	Jul-98	Aug-98	Sep-98	Oct-98	Nov-98	Dec-98
Day 1	6	0	12	0	—	8	0	1	23	2	10	0
2	25	0	5.5	8	0	6	0	0.5	0	0	15	0
3	22	0	18	19	0	9	0	22	0	0	9	0
4	13	2	6	7	0	0	0	2	10	11	0	3
5	10	1	12	3	3	0	0	0	0	0.5	5	0
6	9	0.5	23	0	6	6	2	0	5	0	5	0
7	8.5	15	15	0	8	3	0	0	8	0	1	0
8	18	1	8	5	1	4	0	—	9	0	13	0
9	15	0	0	10	2	12	5	—	32	0	—	8
10	0.5	5	1	—	0	3	0	0	6	10	14	11
11	—	4.5	0	1	3	2	5	0	3	—	1	1
12	0	—	0	0	0	0	20	1	6	4	35	11
13	0.2	—	0	0	0	7	2	—	2	4	1	3
14	3	0	0	0	0	3	0.05	—	0	15	15	16
15	11	0	0	1	0	0	—	—	5	2	—	10
16	8	9	0	0	0	0	0	—	3	10	2	1
17	2	0	—	1	0	16	2	—	3	—	19	0
18	15	0	—	0	0	35	4	0	3	—	1	13
19	10	—	0	9	0	1	15	0	0	5	—	4
20	0	5	0	0.5	0	0	4	17	0	2	5	3
21	10	—	0	3	0	1		10	0	40	1	2
22	0	9	0	15	0	2	5	0.5	0	12	18	1
23	18	0	0	11	0	8	22	—	—	9	2	9
24	0	0	3.5	5	0	7	1	25	0	25	8	10
25	0	0	10.5	—	0	4	0	1	4	—	3	6
26	0	0	15	—	0	12	0	1	23	—	4	13
27	0	3	1	—	3	11	0	0	1	35	3	8
28	0	6	1	7	1	1	12	0	1	7	9	12
29	0		4	4	2	1	6	0	1	10	3	4
30	0		13	1	8	3	5	0	1	13	1	30
31	0		0		0		1	13		8		6

Rainfall Data Recorded at Drumcliff WTP in mm - 1999

Month	Jan-99	Feb-99	Mar-99	Apr-99	May-99	Jun-99	Jul-99	Aug-99	Sep-99	Oct-99	Nov-99	Dec-99
Day 1	9	0	25	1	0	0	16	0	0.5	4	20	5
2	15	—	17	1	1	0	5	9	0	38	6	1
3	26	—	13	1	0	0	5	1	0	—	4	12
4	8	—	2	3	0	6	3	5	1	0	0	4
5	10	0	1	6	0	4	0.5	7	1	0	34	0
6	1	0	0	8	1	3	0	0	7	0	0	8
7	5	3	0	2	2	0	0.5	12	15	2	2	14
8	14	13	0	1	—	0.5	0.5	2	14	8	3	14
9	0	0	0	0	3	0	0	1	25	3	0	18
10	0	0	1	3	8	0	0	0	0	3	0	10
11	0	0	0	2	—	0	0	0	18	1	0	17
12	10	5	2	17	15	0	0	0	1	0	0	9
13	8	1	3	1	11	0		2	10	0	0	11
14	6	2	2	5	8	0	8	0	12	0	0	6
15	18	0	1	—	0	0.5	3	0	2	1	0	0
16	25	1	3	4	0	0	1	11	7	2	2	2
17	12	1.5	0	3	0	1	2	9	4	—	1	29
18	10	1.5	0	3	0	0	30	2	14	0	11	10
19	5	15	0	0	0	1	7	1.5	7	0	0	13
20	3.5	0	0	9	0	16	12	0	0	0	0	0
21	2.5	8	2	6	4	1	3	0	31	7	0	16
22	0	5	0.5	3	1	11	1	0	1	3	4	35
23	6	2.5	0	4	2	1	0	8	9	—	—	7
24	3	8	3	—	8	0	0	6	11	1	18	27
25	12	0.1	0	10	1	0	0	—	0	2	1	43
26	—	3	6	1	0	0	0	8	1	0	18	11
27	—	8	1	0	0.5	12	0	0	13	0	5	5
28	—	17	4	0	21	11	0	—	5	—	35	4
29	20		13	0	4	0.5	0	4	12	3	2	1
30	1		1	0	0	1	0	0	1	—	3	19
31	0		0		0		0	0		—		2

Rainfall Data Recorded at Drumcliff WTP in mm - 2000

Month	Jan-00	Feb-00	Mar-00	Apr-00	May-00	Jun-00	Jul-00	Aug-00	Sep-00	Oct-00	Nov-00	Dec-00
Day 1	0	9	0	---	0	10	---	---	29	0.5	25	6
2	3	2	5	---	0	15	---	14	3	23	15	12
3	4	2	15	---	0	1	25	0	0	3	5	8
4	9	0	0	---	0	0	3	---	0	4	3	8
5	4	4	---	---	0	4	25	1	7	9	0	18
6	2	---	0	0	0	0	0	0	8	1	30	2
7	0	17	7	0	0	0	0	2	8	0	2	2
8	7	6	5	0	0	15	3	1	4	6	2	7
9	12	8	2	0	0	0	13	2	6	17	0	5
10	1	15	1	0	0	0	2	2	13	7	1	10
11	7	2	0	5	0	0	1	0	1	22	15	13
12	28	14	0	4	0	5	0	3	1	4	12	20
13	6	4	0	1	0	2	0	1	0	2	5	8
14	0	13	0	1	5	12	0	5	6	2	2	0
15	0	6	0	0	2	1	5	3	11	3	1	3
16	0	28	0	4	8	0	0	1	0	7	8	3
17	1	6	3	9	10	1	0	8	3	4	6	1
18	1	8	0	1	6	0	0	3	17	9.5	2	7
19	0.05	6	0	0	2	0	0	0	2	9.5	12	7
20	0	0	0	6	4	0	0	0	6	7	3.5	10.5
21	1	7	0	3	2	7	0	1	8	0	3.5	10.5
22	0	6	0	2	0	19	0	2	1	17	10	0
23	0	4	0	5	10	1	0	---	---	5	3	0
24	0	1	3	8	2	0	0	---	---	5	3	0
25	1	7	6	1	5	0	0	---	10	13	11	0
26	0	0	6	1	2	0	0	2	8	30	11	0
27	1	29	1	6	11	0	1	8	11		5	0
28	7	8	---	1	7	0	15	1	28	0	9	0
29	10	15	---	0	---	0	8	0	5	23	6	---
30	32		---	0	---	0	2	0	0		4	---
31	4		---		---		8	9		23		11

Rainfall Data Recorded at Drumcliff WTP in mm - 2001

Month	Jan-01	Feb-01	Mar-01	Apr-01	May-01	Jun-01	Jul-01	Aug-01	Sep-01	Oct-01	Nov-01	Dec-01
Day 1	0	1	0	0	0	1	4	0	4	10	8	8
2	10	0	0	2	0	1	0	1	3	---	---	5
3	3	0	0	1	0	0	1	5	1	15	---	6
4	4	8	0	5	0	0	15	8	---	---	5	34
5	4	10	0	---	0	0	0	0	---	---	2	15
6	1	15	0	25	0	0	---	6	---	30	---	5
7	3	7	10	7	0	0	0	3	---	4	---	10
8	0	0	1	7	0	0	0	---	---	2	36	0
9	0	0	6	12	0	0	0	---	5	5	4	0
10	0	8	7	2	0	0	5	18	0	---	---	0
11	0	2	16	0	0	0	---	3	1	5	---	0
12	0	0	5	7	0	0	20	6	6	---	6	0
13	0	0	12	0	0	0	5	3	6	---	1	0
14	0	1	0	3	0	0	8	2	6	---	3	0
15	0	0	0	4	5	18	10	19	0	10	---	0
16	0	0	12	1	10	0	1	4	0	8	1	0
17	0	0	1	0	0	5	---	---	0	6	---	0
18	0	0	2	2	8	5	5	11	0	10	---	0
19	1	0	0	0	3	8	---	---	0	---	0	0
20	0	2	0	0	0	11	10	5	0	8	0	1
21	10	3	0	0	0	0	1	18	0	0	3	1
22	4	1	6	12	0	0	3	1	0	---	3	---
23	7	0	0	0	0	0	0	0	0	9	1	---
24	13	0	3	15	0	2	3	---	0	9	3	---
25	4	0	0	7	0	0	0	---		1	---	1
26	9	3	1	2	3	0	0	---	2	---	8	---
27	8	3	6	0	8	6	0	---	8	19	18	---
28	2	0	2	11	8	2	0	---	6	---	5	---
29	0		0	4	1	18	0	---	20	0	20	13
30	8		1	5	2	2	0	0	4	0	20	12
31	2		8		2		0	---		---		---

Rainfall Data Recorded at Drumcliff WTP in mm - 2002

Month	Jan-02	Feb-02	Mar-02	Apr-02	May-02	Jun-02	Jul-02	Aug-02	Sep-02	Oct-02	Nov-02	Dec-02
Day 1	—	23	4	3	7	0	18	6	0	5	0	40
2	—	18	0	—	2	0	6	4	0	5	13	12
3	4	25	0	6	0	6	6	4	0	5	14	4
4	1	9	1	—	0	5	2	1	0	0	12	8
5	—	15	2	—	0	4	12	4	2	0	3	6
6	—	13	10	4	0	0	1	3	1	0	7	0
7	16	8	2	0	0	2	0	8	4	0	9	0
8	0	6	2	0	0	10	9	13	—	12	22	0
9	2	12	20	0	0	8	2	12	18	4	7	0
10	3	15	16	0	0	25	6	1	0	6	14	0
11	—	25	5	0	12	5	4	8	12	5	7	0
12	—	5	0	3	0	3	0	1	0	5	9	1
13	4	0	0	0	12	3	0	12	0	2	5	0
14	3	0	0	0	18	10	0	4	0	0	4	0
15	10	0	0	0	4	12	0	3	0	0	3	0
16	1	0	2	0	0	5	1	0	0	0	1	0
17	10	2	1	12	2	11	0	0	0	0	1	0
18	4	3	3	0	2	—	0	0	0	0	1	0
19	26	8	—	5	5	5	0	0	0	0	1	0
20	8	33	2	2	10	3	0	0	0	10	5	6
21	4	2	3	3	1	12	0	0	0	28	8	2
22	7	8	1	4	12	5	2	0	0	27	2	10
23	20	10	0	1	15	8	4	0	0	1	—	6
24	10	13	1	—	25	0	0	0	0	0	—	10
25	8	23	0	—	11	0	2	0	0	13	5	5
26	—	13	0	—	15	0	0	0	0	19	3	—
27	20	8	0	18	12	1	0	0	0	13	12	6
28	10	10	0	—	10	0	7	0	0	4	5	1
29	12		0	25	6	0	5	6	0	35	—	22
30	9		0	12	8	5	5	11	0	2	—	2
31	15		12		1		—	2		0		—

Rainfall Data Recorded at Drumcliff WTP in mm - 2003

Month	Jan-03	Feb-03	Mar-03	Apr-03	May-03	Jun-03	Jul-03	Aug-03	Sep-03	Oct-03	Nov-03	Dec-03
Day 1	18	0	20	9	6	0	7	1	0	0	1	2
2	2	17	0	2	3	0	4	0	0	0	15	0
3	2	15	1	0	3	0	0	2	0	1	11	0
4	0	4	10	0	9	30	0	0	0	0	1	0
5	0	—	6	0	0	0	0	1	5	0	0	0
6	0	—	4	0	3	0	0	0	15	15	7	1
7	0	4	6	0	3	0	4	0	1	2	1	0
8	0	4	23	0	4	0	2	0	5	5	0	0
9	0	2	8	0	5	20	0	0	1	1	0	1
10	0	9	4	—	4	44	2	0	5	3	6	0
11	0	4	4	—	5	1	0	0	2	1	10	5
12	0	0	0	—	10	1	0	0	5	0	22	14
13	2	0	0	—	9	0	0	1	0	0	8	6
14	0	0	0	20	0	0	0	0	0	0	33	3
15	12	0	0	3	3	0	0	0	0	0	11	0
16	4	0	0	—	8	0	6	0	0	0	0	0
17	17	1	0	—	0	2	24	0	0	0	6	—
18	8	0	0	—	0	3	4	2	1	0	6	—
19	4	0	0	—	21	4	3	0	4	0	12	—
20	15	0	0	—	7	—	2	0	0	0	2	13
21	1	0	0	—	9	0	10	1	5	0	3	8
22	0	0	0	—	9	0	0	3	7	0	0	1
23	0	0	0	—	3	0	5	0	0	0	2	6
24	0	0	0	4	0	0	2	0	0	0	2	1
25	10	0	0	10	0	0	10	0	0	0	12	—
26	0	6	0	4	3	—	0	0	1	2	6	—
27	2	0	0	3	0	—	1	0	0	0	2	—
28	8	10	0	6	8	—	6	0	0	2	20	—
29	4	—	5		5	—	5	0	3	12	6	48
30	1	—	0	10	0	41	8	0	2	15	—	5
31	0	—	0	6	0	—	10	0	—	13	—	0

Rainfall Data Recorded at Drumcliff WTP in mm - 2004

Month	Jan-04	Feb-04	Mar-04	Apr-04	May-04	Jun-04	Jul-04	Aug-04	Sep-04	Oct-04	Nov-04	Dec-04
Day 1	—	18	—	2	0	1	11	0	—	2	0	0
2	15	13	—	1	0	7	7	2	9	18	0	—
3	10	—	—	10	0	0	13	0	0	5	0	1
4	1	—	6	4	15	0	4	1	0	28	3	—
5	1	20	3	6	4	0	3	0	0	12	1	—
6	4	1	—	2	2	0	0	9	0	15	2	2
7	2	8	—	1	0	0	9	0	0	4	2	3
8	13	4	—	0	0	0	0	8	—	0	0	—
9	—	0	—	5	0	1	0	1	—	0	1	—
10	15	0	—	0	0	—	5	0	—	0	0	3
11	8	0	6	0	0	1	0	13	6	0	3	—
12	7	3	10	0	0	—	0	11	11	0	3	—
13	10	—	8	0	0	0	0	9	36	7	0	—
14	11	0	12	0	0	—	3	0	20	5	1	2
15	26	0	4	17	—	0	4	0.5	1	1	2	11
16	16	0	3	0	—	—	4	1	2	0	2	9
17	1	1	7	—	—	0	6	2	13	0	5	17
18	0	0	28	16	0	2	4	1	16	3	16	4
19	0	1	9	4	0	4	1	2	6	10	13	26
20	2	—	10	5	0	4	4	22	—	—	13	4
21	—	—	10	—	0	—	3	2	25	—	7	2
22	—	—	2	1	—	7	1	2	6	17	3	18
23	4	—	0	0	—	35	0	15	8	—	—	6
24	2	—	—	0	0	3	0	5	1	35	2	9
25	0	4	0	0	—	2	0	3	2	8	2	15
26	—	2	0	0	—	15	—	0	1	1	13	—
27	—	0	1	0	—	6	0	8	2	4	—	—
28	—	1	0	0	12	0	0	—	0	15	—	16
29	—	—	0	0	1	4	5	7	2	13	—	4
30	—		1	0	1	9	6	1	4	—	2	2
31	—		0		—		0	0		1		—