Report on the Killynenagh Lough Catchment
(Bunnoe Group Water Scheme)

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February 2010

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1. Introduction

Source protection is the protection of raw water quality through measures that limit or eliminate the risk of water contamination. It is an increasingly important strategy for the protection and maintenance of drinking water sources, in particular, as the first barrier in a multi-barrier approach to drinking water quality.

In Ireland, a limited number of studies have investigated the potential of source protection to improve water quality. The National Source Protection Pilot Project (NSPPP) at Churchill and Oram group water scheme, Co. Monaghan (2005-2009), was established by the National Rural Water Monitoring Committee and is overseen by the National Centre for Freshwater Studies (NCFS) at Dundalk Institute of Technology. The objectives of the Pilot Project are to assess water quality, identify sources of contamination and implement remediation measures to protect and enhance water quality in Milltown Lake. The project represents a model of best practice for the implementation of source protection in Ireland and was designed for replication to other group water schemes around the country.

It is in the interest of privately-sourced group water schemes to carry out risk assessments to determine the potential for nutrient enrichment and biological contamination (e.g. *Enterococcus* spp., *Escherichia coli*, *Cryptosporidium* spp.) of their water supplies, and to meet application conditions for a Water Services Licence under the Water Services Act (2007).

The assessment of the Bunnoe GWS catchment has three components. The first is a preliminary characterisation of the catchment whereby the underlying geology, hydrogeology, soils and habitats are described and their influence on water quality is discussed. Secondly, potential water quality risks in the catchment are identified, including possible point and diffuse sources of pollution that might threaten water quality in waterbodies[1]. Thirdly, a series of recommended practical measures are proposed that can be implemented by the GWS to safeguard the long-term quality of water within the catchment.

2. Background

Bunnoe Group Water Scheme was originally founded in 1970. In the period between 2000-2003 monitoring of water quality at Killynenagh Lough was conducted by T.J. O'Connor and Associates, Cavan County Council and the National Water Monitoring Committee to establish baseline conditions for the lake. The DBO contract for operation of the treatment plant was

[1] Point sources are distinct points (e.g. pipeline, drain) where pollution enters a waterbody at a specific location. Diffuse pollution typically arises when fertiliser, pesticides and slurry run off land into waterbodies via rainfall, soil infiltration and surface run-off.

awarded to Veolia Water Ltd. in December 2005. The treatment process at the plant consists of coagulation, flocculation, dissolved air filtration and chlorine treatment. The average daily water volume abstracted is approximately 275 m^3 (2009).

3. Methodology

As part of an information-gathering exercise to collate all existing historical information and water quality data for Bunnoe GWS, the NCFS consulted with Bunnoe GWS committee through committee member, Mary O'Reilly. Visual inspections and walkover assessments of the treatment plant and its immediate surroundings were conducted on 14th October 2009 to identify characteristics of the catchment and potential environmental issues relating to water quality. Historical water sampling data for the scheme was provided by:

- T.J. O'Connor and Associates
- Cavan County Council
- National Water Monitoring Committee
- Veolia Water Ltd.
- City Analysts

The Geological Survey of Ireland provided assistance with the interpretation of geological and hydrogeological maps.

4. Physical site description

The physical characteristics of an area encompass its geology, hydrogeology, soils, slope of land and habitats. These characteristics influence the vulnerability of waterbodies in the area to pollution by nutrients, pathogens (disease-causing organisms) and/or pesticides. The following sections describe the physical attributes of the Bunnoe GWS catchment and highlight features of the landscape that are vulnerable to pollution.

4.1 Source water supply

Killynenagh Lough is approximately 10 ha in size, 81 m above sea level and lies on the border between counties Cavan and Monaghan (grid reference H533 162) (Figure 1). The lake is located in the North-Western International River Basin District (Hydrometric Area HA36, IE_NW_36_409). According to the designation process undertaken as part of the implementation of the Water Framework Directive, the status of the lake is "Moderate" and "not at risk". Killynenagh Lough is a relatively small, low-lying lake, surrounded by gently to steeply sloping agricultural land (Plate 1). There are no inflowing streams or drains into the lake, and run-off from the surrounding land is possibly the main input. Although surface water flows into Killynenagh Lough via run-off from surrounding land, it is primarily a spring-fed lake and, therefore, protection of the groundwater in the catchment is of major importance. The lake catchment is estimated to be 1 km^2 (100 hectares).

Plate 1 View of Killynenagh Lough from the west

Delineation of a catchment/source protection zone is critical in order to ensure that raw water is adequately protected (only an estimation of the catchment size could be attempted in this report). The actual extent of the groundwater source and associated protection zones as well as the direction of flow can only be determined by a detailed hydrogeological study.

The GWS should endeavour to determine the extent of the groundwater contribution to the lake. This could be achieved through liaison with Cavan County Council who have some mapping information (as discussed with Colm O'Callaghan, Environment section) and the source protection unit of the Geological Survey of Ireland (Taly Hunter-Williams).

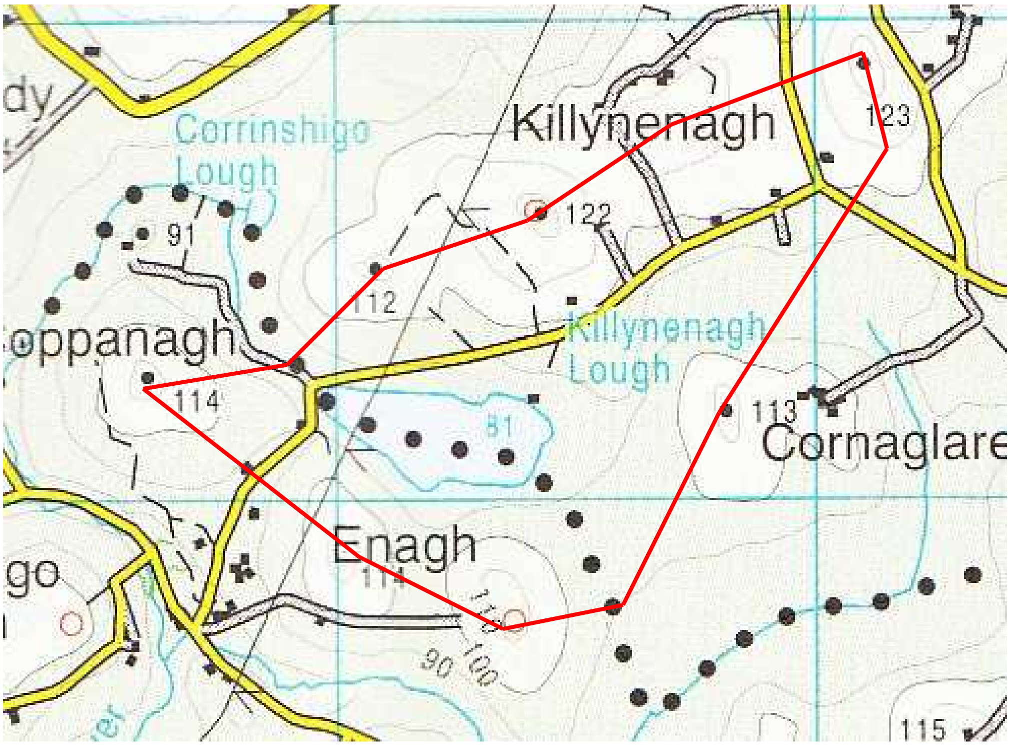


Figure 1 Geographical extent of the Killynenagh Lough catchment

Catchment boundary

4.2 Bedrock Geology

Bedrock geology describes the rock formations underlying the Earth's surface. Over time, the weathering of bedrock by water, wind and ice contributes to the formation and composition of overlying subsoils and soils. The vulnerability of overlying aquifers to pollution is influenced by bedrock type and the nature and thickness of overlying subsoils. For example, limestone tends to be highly fissured and at risk of dissolution by water, which increases its susceptibility to pollution. The catchment is underlain with Ordovician Metasediments which consist of layered sandstones, siltstones and shales (Figure 2). These tend to be non-calcareous so are not as vulnerable to pollutants seeping through as other bedrock types. These rocks are also more resistant to weathering which provides better protection to any groundwater.

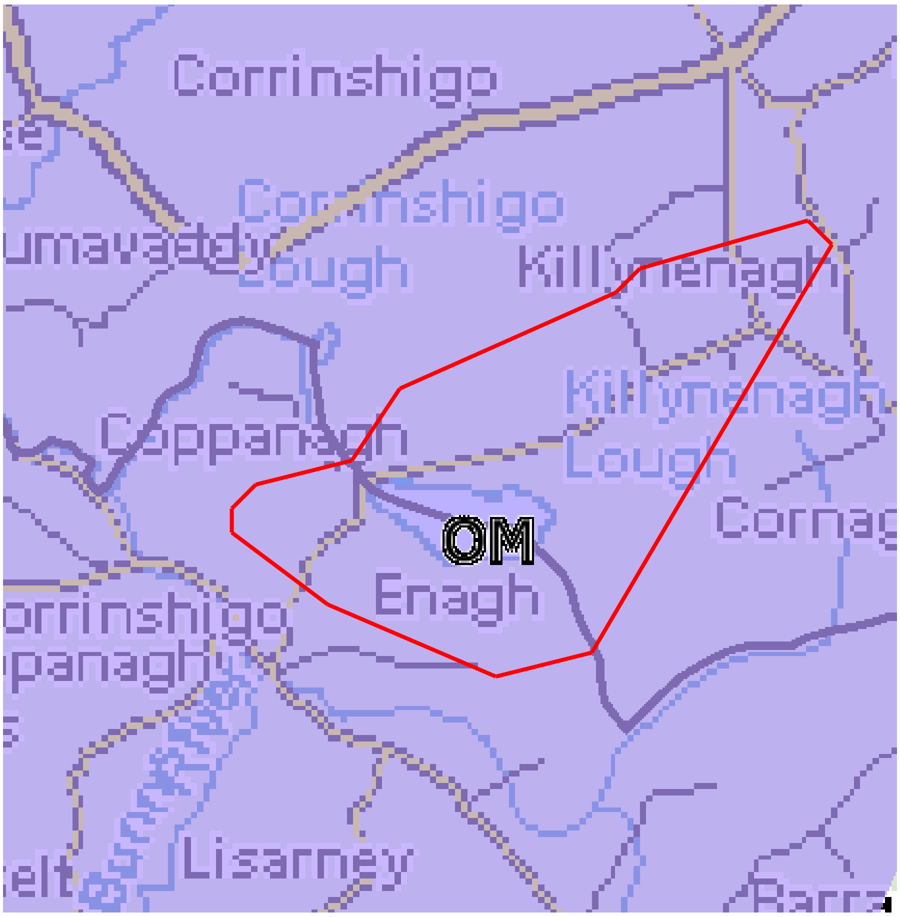


Figure 2 Bedrock geology in the Killynenagh Lough catchment

Ordovician Metasediments (OM)

Catchment boundary

4.3 Groundwater

Groundwater is water occurring below the water table (i.e. saturated gaps in rock (also called aquifers)) and is typically abstracted from wells and springs. It is at risk of contamination from excessive nutrients and pathogens that may infiltrate via fissures and pores in overlying soils and rocks. Contamination of groundwater takes much longer (months or years) to resolve than that of surface water because it moves more slowly.

The lake is underlain by a poor bedrock aquifer that is moderately productive only in local zones (Figure 3). Therefore, the quantity of water in this aquifer is more limited than in, for example, a limestone aquifer. This aquifer has few and poorly-connected fractures, fissures and joints, and with reduced permeability and/or limited zones of higher permeability. In general, permeability, storage capacity, recharge capacity, and length of flow paths are likely to be relatively low. This suggests that surface water does not easily move to groundwater and that groundwater movement within the aquifer is slow, thus providing a level of protection to groundwater from surface contaminants.

The bedrock aquifer is part of a single larger groundwater body, the Cavan groundwater body (GWB) (IE_NW_G_061) (see Appendix 1 for further information on the groundwater body).

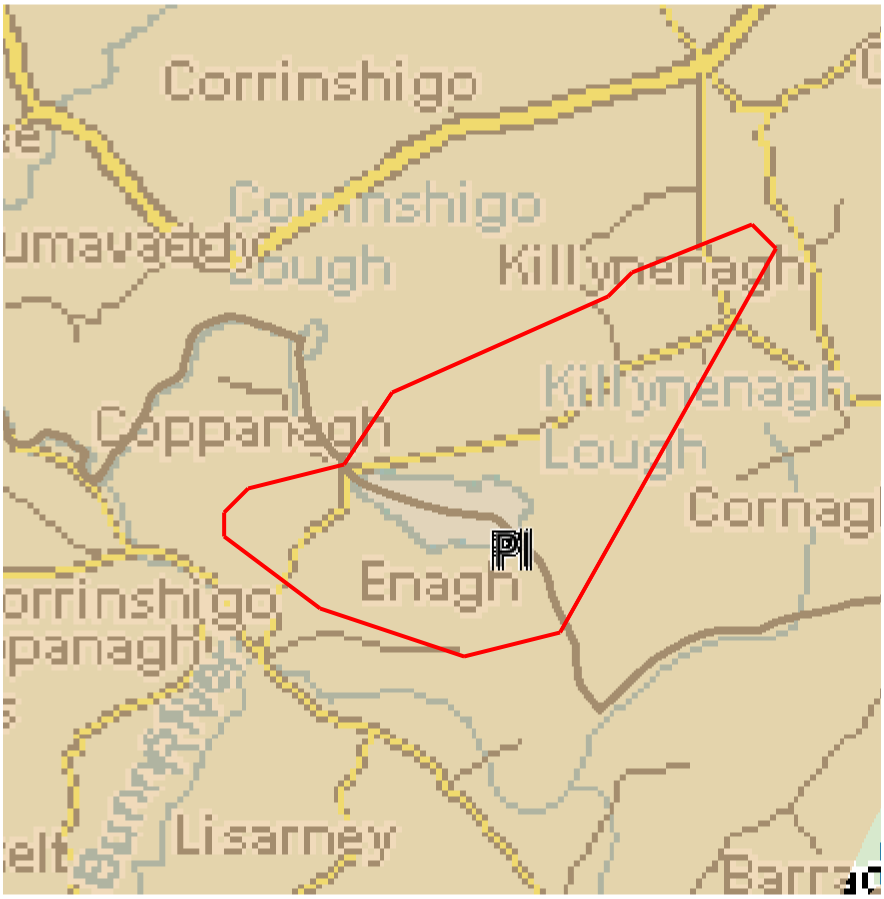


Figure 3 Bedrock aquifer in the Killynenagh Lough catchment

Poor aquifer – bedrock which is moderately productive only in local zones (Pl)

Catchment boundary

Groundwater vulnerability in the catchment ranges from low in the north and east and high to low in the south and west (based on the findings of an interim study by the GSI) (Figure 4). Based on the characteristics of the groundwater body and the local aquifer, groundwater in the catchment should not be particularly vulnerable to contamination, although there may be localised areas of vulnerability.

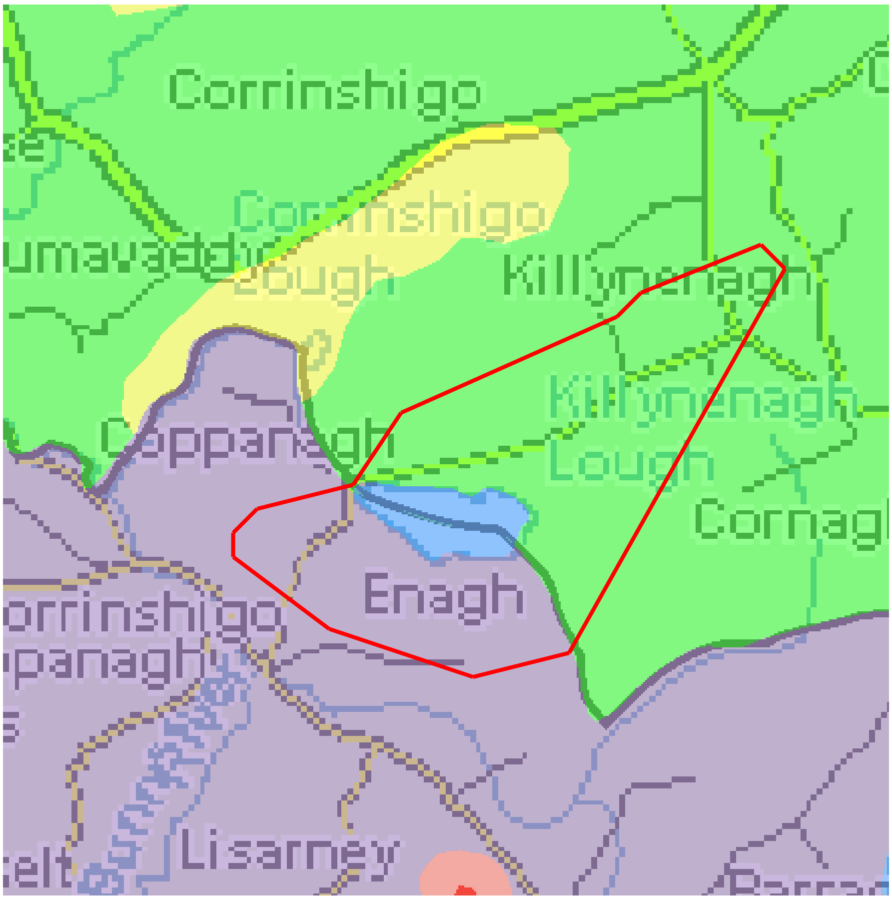


Figure 4 Groundwater vulnerability in the Killynenagh Lough catchment

High to low; based on an interim study

Low

Catchment boundary

Due to the interconnected nature of groundwater and surface water, contamination at one location can have impacts at another. However, the extent of these impacts depends on a number of factors, such as soil permeability, groundwater flow direction and the time-to-travel (the time it takes water to travel from one point to another). In the Cavan GWB, water moves slowly and groundwater flow paths are short. These GWB characteristics suggest that groundwater contamination, if it occurs, will tend to have localized impacts and not affect areas that are further away. Groundwater flow is likely to follow local topography, flowing from high to low ground.

4.4 Subsoils and Soils

The overlying soil type, structure and depth are other key factors in determining the vulnerability of groundwater to contamination. The rate at which contaminants (e.g. pathogens) move from the soil surface to groundwater depends on the physical structure and chemical composition of soils and subsoils, and the depth of these to the rock interface. Soil type also determines the capacity of soil to retain or weaken pathogens, thereby reducing their impact on underlying waterbodies. The risk of pathogen contamination is generally highest in the top 3 m of soil.

Subsoils lie underneath topsoil and above bedrock. The permeability and depth of subsoils determines its infiltration capacity and the vulnerability of groundwater to pollutants transported from the soil surface. Thus subsoils present the most effective barrier to groundwater contamination. An area of cutover peat lies to the northeast of the catchment. Peat has low permeability to water. The catchment is dominated by sandstone and shale till (Figure 5). Shales and tills are considered to generally have low permeability. All of the above indicate good protection for groundwater. On the other hand, they suggest greater risk of contaminants being carried to a waterbody as run-off.

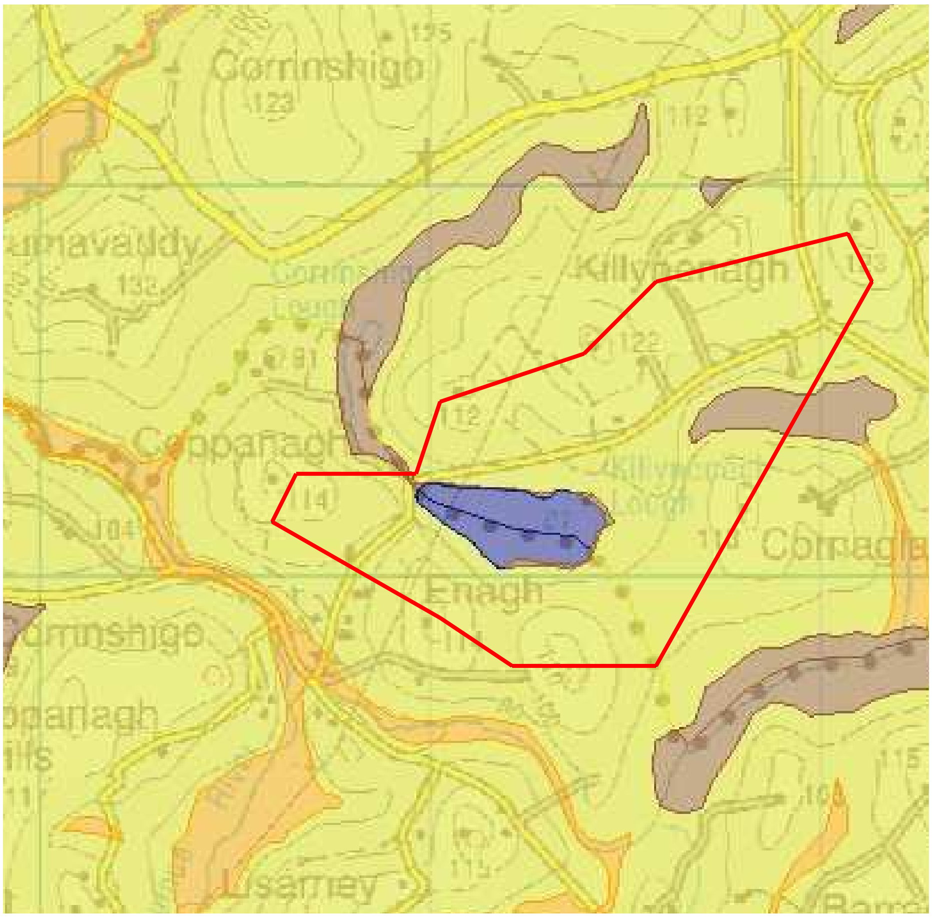


Figure 5 Subsoils in the Killynenagh Lough catchment

Sandstone and shale till

Cutover peat

Catchment boundary

Soil type describes the topsoil of an area. The permeability and depth of the soil determines its infiltration capacity and thus the volume and rate at which potential pollutants might move from the soil to subsoil and possibly to groundwater. Well-draining acid brown earths and brown podzolics overlie subsoil at the northern edge of the lake and in pockets to the northeast and northwest of the catchment. An area of cutover peat lies to the north west of the catchment. The remainder of the catchment is dominated by surface and groundwater gleys which are poorly draining (Figure 6).

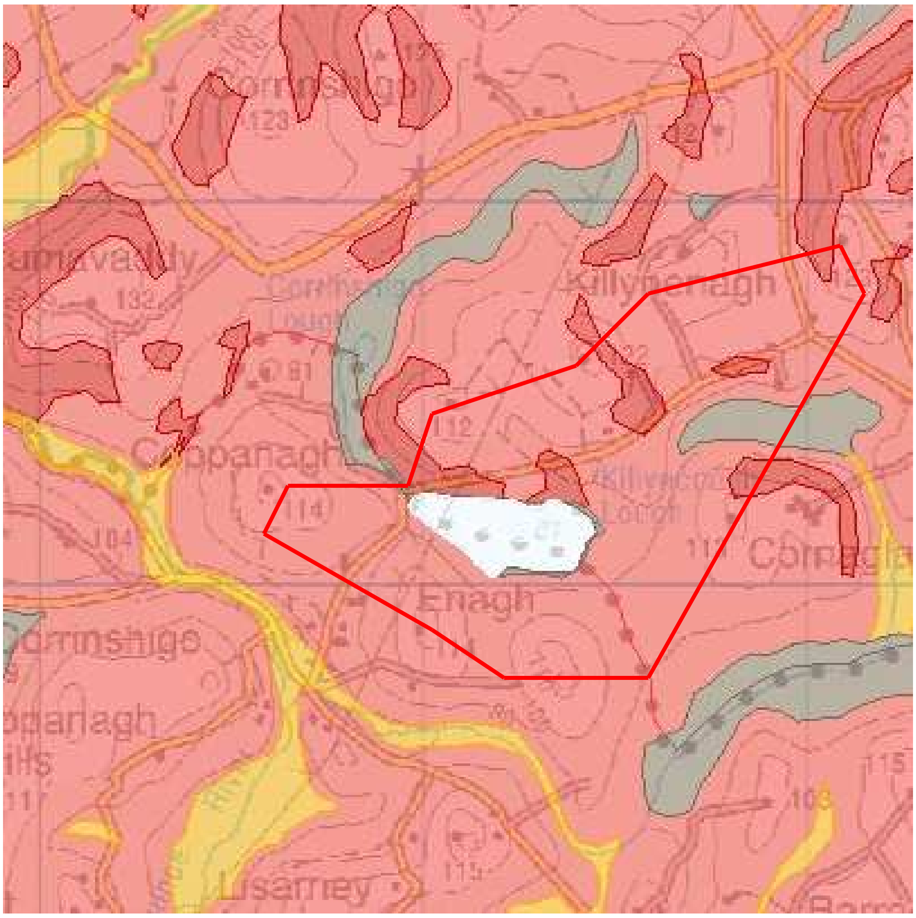


Figure 6 Soils in the Killynenagh Lough catchment

Surface and Groundwater gleys

Cutover Peat

Acid Brown Earths/Brown Podzolics

Catchment boundary

The combination of subsoils and soils in the catchment probably provide adequate protection for groundwater due to their thickness and low permeability. A detailed hydrogeological survey would confirm this. However, low permeability soils suggest that ground can become readily saturated with water and prone to run-off. **Therefore, the main potential source of contaminants in the lake is likely to be surface run-off from surrounding land.**

4.5 Soil nutrient status

Soil nutrient status provides a measure of soil fertility levels and indicates the presence of excessive or deficient nutrient levels. This determines the rate, volume and nature of nutrient additions to the surface and groundwater sources.

Assessment of the nutrient status of soils within the lake catchment would involve a field survey which was not within the scope of this report but should be prioritised by the GWS on a phased basis as part of a source protection plan and target areas of vulnerability.

4.6 Slope

The slope of lands leading to a waterbody is an important determinant of the rate at which water and pollutants move into the waterbody by overland and subsurface flows. Slope also influences the quantity of nutrients and pathogens entering the waterbody and, hence, its water quality. Steep slopes are vulnerable to surface run-off.

Killynenagh Lough occurs in a basin, surrounded by sloping land. Hills on the southern side of the lake have a steep to moderate slope towards the lake (Plate 2). Slopes to the north of the lake are also moderately sloping, divided by a road. The combination of steep to moderate slopes and poorly draining soils suggests that any activity (e.g. slurry spreading, fertiliser spreading) that results in nutrient or pathogen release will contribute to nutrient enrichment or biological contamination of the lake, unless appropriate safeguards are in place (e.g. adequate buffer zones).

The degree of slope within the catchment needs to be considered further as part of a source protection plan.

Plate 2 View of slopes on the south and north sides of the lake (view from the north)

4.7 Habitats

The range of habitat types in an area may affect the rate and movement patterns of nutrients and pathogens into a waterbody. For instance, the presence of vegetation around a lake can act as a buffer strip by intercepting or preventing the entry of nutrients and pathogens into the lake. The flora and fauna adjacent to, or within, a waterbody, act as biological indicators of water quality. For example, the presence of freshwater trout and salmon, or mayfly larvae may be used to indicate water of high quality.

According to the National Parks and Wildlife Service (NPWS), there are no protected areas (Natural Heritage Areas (NHAs), Special Protection Areas (SPAs) or Special Areas of Conservation (SACs)) adjacent to the Killynenagh Lough catchment.

The catchment is predominantly agricultural, consisting of pastureland. A buffer strip of reed mace surrounds the lake on all sides and is widest at its western and eastern sides (Plates 3 and 4). Some Willow and Alder also grow in this buffer strip. The presence of a buffer strip provides protection to the lake as a natural filter and should be maintained and extended.

Plate 3 Buffer zone at eastern edge of lake

Plate 4 Buffer zone at western edge of lake

4.8 Drainage

Land drainage can lead to increased sedimentation due to disturbance of banks and beds and increased nutrient loads. Drainage of land will increase the rate of flow of water and can impact on habitat and water quality by increasing the movement of sediments into a waterbody.

An assessment needs to be carried out on drainage so that intercepting piping or a ditch can be positioned to divert run-off away from the lake (e.g. into a wetland or buffered area), if necessary

5. Activities within the catchment

5.1 Agriculture

Landuse in the catchment is agricultural, consisting of non-intensive cattle-grazing. There are no dairy farms in the catchment. Fertiliser spreading takes place in the catchment and slurry spreading occurs on sloping fields at the south of the lake. Cattle graze in fields surrounding the lake but cannot directly access the lake due to the presence of the buffer zone. A stock-proof fence has also been erected at the northern edge of the lake to prevent cattle access.

There is a risk of pathogenic contamination of water due to the presence of animals and spreading of animal manures, in spite of the presence of the buffer zone around the lake. Faecal coliforms, including *E. coli*, have been detected in raw water samples, indicating faecal contamination in the lake. There is also a risk of *Cryptosporidium* contamination. Spreading of slurry and fertiliser can result in leaching and run-off of nutrients such as nitrogen and phosphorus into the lake.

The GWS should work with local farmers to ensure that the Code of Good Agricultural Practice is adhered to (see Appendix 3). Any slurry pits/waste storage facilities in the catchment should be assessed to determine if they are in good working condition or present a threat to water quality. The GWS might approach landowners to discuss the possibility of controlling grazing in lands immediately adjacent to the lake, or leasing/purchasing land that would act as a buffer strip.

5.2 Domestic properties

There are a number of households in the lake catchment, each having its own wastewater treatment system. Damaged or leaking systems, and those with inadequate percolation areas, will become sources of phosphates and pathogens for source water. Cavan County Council adopted the Water Pollution (Wastewater Treatment Systems for Single Houses) Bye-Laws, 2004, to control the design, maintenance and operation of wastewater treatment systems, such as septic tanks. These Bye-Laws require the owners of such systems to have an approved and fully functioning system, and to maintain it to certain standards.

In cooperation with householders, the GWS should ask the County Council to assess the potential risk posed by wastewater treatment systems in the catchment. This

should determine if they are adequately maintained and/or adhere to the conditions of the Bye-Laws.

6. Water quality data

The baseline quality of raw water in the lake was established in 2000-2003 prior to the award of the DBO contract. T.J. O'Connor and Associates (Consulting Engineers), Cavan County Council and the National Water Monitoring Committee conducted sampling during this time. Since 2006, Veolia Water Ltd. has carried out weekly sampling of raw water from the lake and City Analysts has conducted periodic sampling of the lake since July 2007. All sampling results are presented in Appendix 2.

The following pages provide a summary and interpretation of water quality data collated for the GWS. The possible sources and significance of water quality parameter values are discussed. The parameter values are compared to the maximum values (+ 20%) recorded during the baseline survey of 2000-2003. They are also compared to mandatory limits in the Drinking Water Regulations (2007) [European Communities (Drinking Water) Regulations 2007 (S.I. No. 106/2007)].

6.1 Iron

Iron (Fe) is present in rocks and soils in an insoluble form but can become soluble when water passes through ground formations. Large amounts of iron in water do not normally have harmful effects for users but can be aesthetically unpleasing by causing colour changes or turbidity (due to oxidation of soluble ferrous to insoluble ferric). This can lead to staining of laundry, discolouration of vegetables following cooking, and taste problems. Under the Drinking Water Regulations (2007) the recommended concentration of Fe is 0.2 mg/L. The maximum value recorded in 2000-2003 was 0.576 mg/L. The maximum value has not been exceeded to date although the drinking water limit has been exceeded on a number of occasions. It appears, however, that iron is not a problematic parameter for the GWS.

6.2 Manganese

Manganese (Mn) is found in soils and groundwater. It is generally not considered to be harmful to humans but can cause more severe staining problems than iron and adversely affect taste. Under the Drinking Water Regulations (2007) the recommended value for Mn is 0.05 mg/L. The maximum value recorded in 2000-2003 was 0.355 mg/L. There have been a few exceedances of both limits, most recently in April and June of 2009. Manganese levels cannot be manipulated at source but should be monitored to ensure that high manganese levels are not persistent.

6.3 Conductivity

Conductivity quantifies the ability of water to conduct an electrical current and is an indicator of the mineral salt content of water. The Drinking Water Regulations (2007) specify a limit of 2500 µS/cm at 20 ℃ for Class A1 waters. The maximum value recorded in 2000-2003 was 382.8 µS/cm. Conductivity in raw water in Bunnoe has not exceeded either value to date.

6.4 pH

The pH value of water is generally only of concern if it is extremely low or high, indicating extreme acidity or alkalinity, respectively, which in turn may have consequences for odour or taste, lead to corrosion in distribution systems, or affect fish survival. Water generally lies in the range of 6.5-8.0. The Drinking Water Regulations (1989) recommend a range of 6.5-9.5. The maximum value recorded in 2000-2002 was 9.4. Water in Killynenagh Lough has not fallen outside this range since monitoring began.

6.5 Colour

Natural colour reflects the presence of organic molecules originating from humic matter such as peat, leaves and branches. A coloured water supply does not pose high health risks in itself but can react with chlorine in the treatment plant to create trihalomethanes. For this reason high levels of colour should be avoided.

Colour is a parameter that varies greatly depending on quantities of precipitation (e.g. rain, snow) and run-off leading to spikes in results. Generally, both apparent colour (from an unfiltered sample) and true colour (filtered sample) are recorded. The Drinking Water Regulations (2007) do not state limits for colour. The maximum value recorded for apparent colour (unfiltered water) in 2000-2003 was 106.8 PtCo. This level has generally not been exceeded since Veolia commenced monitoring in 2006. The maximum value for true colour (22.8 PtCo) was based on only one measure of the parameter during the initial monitoring period in 2000-2003. It is not, therefore, a representative value.

Reasons for high readings or exceedances in colour are likely to be due to heavy rainfall, marking the entry of large quantities of vegetative and soil material (e.g. peat) into raw water. Decaying algal matter may also cause seasonal changes in lake water colour.

6.6 Turbidity

Turbidity in water consists of very finely divided particles. Their origin may include clay particles, silt, sewage solids and organic or biological sludges. High levels of turbidity in the raw water supply can interfere with the ability of the treatment plant to provide safe drinking water. The following units are often used to present Turbidity: JTU (Jackson Turbidity Units), FTU (Formazin Turbidity Units) and NTU (Nephalometric Turbidity Units). These three units can be interpreted to mean the same thing.

Turbidity is measured by Veolia and City Analysts. The Drinking Water Regulations (2007) specify a limit of 1 NTUs while the EPA recommends that turbidity should not exceed 0.2 NTUs. The maximum level recorded during 2000-2003 was 22.8 NTUs. Turbidity has remained well below the maximum level value to date but has exceeded regulatory limits. Turbidity is an important parameter to monitor as it can act as an indicator of potential *Cryptosporidium* contamination.

6.7 Phosphorus

Phosphorus occurs widely in nature but is also added to the environment by human activities e.g. use of phosphorus as a fertilizer in agriculture and as a constituent in cleaning products. Phosphorus and Nitrate are the main nutrients that stimulate eutrophication. This process leads to an increase in algal mass and a decrease in raw water quality. Phosphorus results for lakes are usually presented as mg/L Total Phosphorus. This makes for easy comparison with standards.

The baseline assessment in 2000-2003 established a maximum allowable limit of 0.334 mg/L P for total phosphorus and 0.044 mg/L P for orthophosphate. Orthophosphate is measured as part of the external laboratory analysis by City Analysts. While this is not directly comparable with total phosphorus it does form part of total phosphorus and is useful for interpretation. Orthophosphate is also the form of phosphorus most easily used by algae and therefore can lead to the development of algal blooms. Since 2007, orthophosphate has only been measured in the lake six times. Since absolute values have not been provided (Table 6, Appendix 2), it is not possible to know whether orthophosphate levels have increased since the baseline survey. Parameter values, such as orthophosphate, can vary greatly over time since many environmental factors affect water quality and pollution events may be missed by infrequent sampling. Orthophosphate needs to be measured on a much more regular basis to gain a better understanding of P variability.

The main sources of P within the catchment are likely to be agricultural (e.g. slurry, cattle livestock manure, chemical fertiliser) and human (waste from septic tanks). Human or animal wastes are loaded with nutrients, such as phosphorus, and if not properly applied to the land or treated, are susceptible to loss to the aquatic environment. Household detergents are also sources of phosphorus.

The Code of Good Agricultural Practice (see Appendix 3) should be complied with when organic manure and chemical fertiliser are being spread. The GWS should

encourage homeowners to reduce their use of phosphate washing powders and detergents, or replace these with phosphate-free alternatives.

6.8 Nitrogen

Nitrogen exists in many forms in the natural environment. The most important and widely measured are ammonia, nitrate and nitrite.

Ammonia (NH_3) is present in natural waters but if it is found in excess of 0.1mg/L N, it is seen as an indication of human waste or industrial contamination. Due to the potential link between high ammonia concentrations and human waste, it is an important parameter to monitor at a drinking water source. The Drinking Water Regulations (2007) specify a limit of 0.3 mg/L for ammonium. The maximum level recorded in 2000-2003 was 0.36 mg/L. Ammonia in raw water has not exceeded this level to date.

Nitrate (NO_3) is the most common form of nitrogen in rivers and lakes. It usually originates from human or animal wastes or from the application of artificial fertilizers to agricultural lands. Nitrate is an important nutrient for plant growth and excess of this nutrient can play a significant role in eutrophication. External analysis of raw water in Killnenagh Lough indicates that the 50 mg/L NO_3 limit recommended by the Drinking Water Regulations (2007) has not been exceeded. The maximum level recorded for nitrate during 2000-2003 was 0.72 mg/L. However, due to the presence of grazing animals, and slurry and fertiliser spreading within the catchment, there is a risk that nitrate levels may become problematic for the GWS in the future if not monitored and controlled.

6.9 Faecal and Total Coliforms

Faecal coliforms (e.g. *E. coli*) originate in either human or animal wastes. Total coliforms include faecal and soil-borne coliforms. Coliforms are used as an indicator of pathogenic organisms within a water body. Coliforms are currently only measured by City Analysts but are sampled periodically and not on a monthly basis.

Faecal Coliforms (E. coli)

Under the Drinking Water Regulations (2007) there should be no coliforms in drinking water. The maximum value recorded in 2000-2003 was 45.6/100 ml. This value was exceeded in March 2008 and April 2009. *E. coli* was also found in the lake in April and May 2009, indicating that faecal material (from grazing animals or slurry) is entering the lake.

Total Coliforms

The maximum level for total coliforms recorded in 2000-2003 was 91.2/100 ml; this level was exceeded in March 2008. Total coliforms can never be totally eliminated, but steps to reduce the potential for organic contamination of raw water might include reducing stock numbers on steep slopes where soil is vulnerable to erosion.

6.10 Clostridium perfringens

Clostridium perfringens is typically found in faecal matter. Their spores are longer-lived than those of coliforms and are more resistant to disinfection. The presence of *C. perfringens* in water is often used as an early warning of the potential for *Cryptosporidium* contamination. Levels of *C. perfringens* are not currently measured in Killynenagh Lough.

6.11 Cryptosporidium

Cryptosporidium spores may be present in faeces of infected animals and are highly pathogenic, leading to cryptosporidiosis in the gastrointestinal tract of humans. Humans are mainly infected by *C. parvum* which is found in the faeces of cattle and sheep. It is very resistant to treatment processes such as disinfection. T.J. O'Connor and Associates were commissioned by Cavan County Council in 2008 to conduct a *Cryptosporidium* Risk Assessment for GWS in the East Cavan bundle, including Bunnoe GWS, in accordance with EPA guidelines (Drinking Water Regulations Guidance Booklet No. 4: Risk Screening Methodology for *Cryptosporidium*). Bunnoe GWS was classified as Low Risk based on an assessment of catchment factors (e.g. animal densities, farming activities, livestock access to the source) and treatment plant factors (e.g. presence/absence of turbidity alarms and monitors). The report made a number of recommendations including:

- linking and alarming of the existing raw water turbidity meter to the telemetry
- monthly catchment inspections with a defined monitoring procedure
- official procedures for notification of stakeholders e.g. landowners, County Council Environment section, Department of Agriculture officials, etc., in the event of irregularities in the catchment
- installation of fencing to prevent access to source and feeder streams

However, based on observations during the field visit, it would appear that the *Cryptosporidium* risk to the lake is high, rather than low, due to the fact that cattle graze at the at the lake edge .

Cattle access to the lake should be immediately prevented by fencing off the perimeter of the lake. Alternatively, the GWS should consult with local landowners to determine what can be done to minimise the impact of grazing cattle on sloping lands bordering the lake.

There is also a risk associated with septic tanks in the catchment if these are not adequately maintained or are discharging into the lake.

Clostridium perfringens is typically found in faecal matter and its presence is often used as an early warning of the potential for *Cryptosporidium* contamination.

The GWS should include *Clostridium perfringens* in its monthly sampling programme as it is often used as an indicator of potential *Cryptosporidium* contamination.

7. Sampling protocols

7.1 Raw water sampling protocols

Maximum allowable limits for raw water parameters were determined following sampling by T.J. O'Connor and Associates, Cavan County Council and the National Drinking Water Monitoring Committee in 2000-2003 as part of the tender process for the DBO contract. Tables 1-4 (Appendix 2) present these limits. Deviations of + 20% in these limits are permitted under the current DBO contract but exceedances are the responsibility of the GWS. The raw water parameters measured by Veolia Water Ltd. (e.g. iron, manganese, turbidity and colour) provide valuable information but are not widely used as indicators of water quality and tend only to become important when there are aesthetic concerns about water e.g. appearance, taste.

A programme of monthly raw water sampling of relevant parameters should be conducted by the GWS over a 12 month period at the lake. Parameters should include faecal and total coliforms, *Clostridium*, pH, chlorophyll-a, conductivity, colour, dissolved oxygen, E. coli, pH, turbidity, transparency, ammonia, nitrite, nitrate, total nitrogen, orthophosphate, total phosphorus, iron, manganese and suspended solids.

Operational staff should be properly trained in sampling techniques by collaborating with an accredited laboratory.

Apart from weekly sampling of raw water by Veolia, additional sampling of the lake takes place infrequently. The absence of a continuous monitoring programme may miss important events that could impact on water quality e.g. heavy rainfall events when large amounts of P and faecal matter could potentially enter the lake. In addition, lake dynamics change with season; stratification generally occurs in summer while mixing of water occurs under cooler temperatures in winter. Such seasonality can influence water quality parameters.

Lake sampling needs to be conducted on a more frequent basis to gain a real understanding of lake chemistry and to avoid missing pollution events. It is recommended, in addition to monthly monitoring and sampling, that the GWS takes lake samples following specific events e.g. storms, forestry removal, land-spreading, in the area.

8. Recommendations

8.1 Preliminary source protection measures - recap

1. The GWS should endeavour to determine the extent of the groundwater contribution to the lake. This could be achieved through liaison with Cavan County Council which has some mapping information (as discussed with Colm O'Callaghan, Environment section) and the source protection unit of the Geological Survey of Ireland (Taly Hunter-Williams).
2. Assessment of the nutrient status of soils within the lake catchment would involve a field survey which was not within the scope of this report but should be prioritised by the GWS on a phased basis as part of a source protection plan and target areas of vulnerability.
3. The degree of slope within the catchment needs to be considered further as part of a source protection plan.
4. An assessment needs to be carried out on drainage so that intercepting piping or a ditch can be positioned to divert run-off away from the lake (e.g. into a wetland or buffered area) if necessary.
5. The GWS should work with local farmers to ensure that the Code of Good Agricultural Practice is adhered to (see Appendix 3). Any slurry pits/waste storage facilities in the catchment should be assessed to determine if they are in good working condition or present a threat to water quality. The GWS might approach landowners to discuss the possibility of controlling grazing in lands immediately adjacent to the lake, or leasing/purchasing land that would act as a buffer strip.
6. In cooperation with householders, the GWS should ask the County Council to assess the potential risk posed by wastewater treatment systems in the catchment. This should determine if they are adequately maintained and/or adhere to the conditions of the Bye-Laws.
7. The Code of Good Agricultural Practice (see Appendix 3) should be complied with when organic manure and chemical fertiliser are being spread. The GWS should encourage homeowners to reduce their use of phosphate washing powders and detergents, or replace these with phosphate-free alternatives.
8. Cattle access to the lake should be immediately prevented by fencing off the perimeter of the lake. Alternatively, the GWS should consult with local landowners to determine what can be done to minimise the impact of grazing cattle on sloping lands bordering the lake.

9. The GWS should include *Clostridium perfringens* in its monthly sampling programme as it is often used as an indicator of potential *Cryptosporidium* contamination.

10. A programme of monthly raw water sampling of relevant parameters should be conducted by the GWS over a 12 month period at the lake. Parameters should include faecal and total coliforms, *Clostridium*, pH, chlorophyll-a, conductivity, colour, dissolved oxygen, *E. coli*, pH, turbidity, transparency, ammonia, nitrite, nitrate, total nitrogen, orthophosphate, total phosphorus, iron, manganese and suspended solids.

11. Operational staff should be properly trained in sampling techniques by collaborating with an accredited laboratory.

12. Lake sampling needs to be conducted on a more frequent basis to gain a real understanding of lake chemistry and to avoid missing pollution events. It is recommended, in addition to monthly monitoring and sampling, that the GWS takes lake samples following specific events e.g. storms, forestry removal, land-spreading, in the area.

13. The GWS should erect signage around Killynenagh Lough to indicate that the lake is a drinking water source and should be respected as such. Signs should state that motor-powered vehicles (e.g. boats, jet-skis) are not permitted on the lake. Signs should also state that boats be thoroughly cleaned before entering the lake to avoid the introduction of invasive species to the lake e.g. *Lagarosiphon major* (Curly-leaved waterweed).

8.2 Agriculture

Guidelines and recommendations on environmental mitigation of agricultural practices are outlined in Appendix 3.

8.3 Cryptosporidium *Risk Assessment*

The recommendations of the Risk Assessment by Jennings O'Donovan should be implemented in conjunction with those outlined above. The report should be consulted for a full list of recommendations.

Appendices

Appendix 1: Groundwater body description

Cavan Groundwater Body: Summary of Initial Characterisation

Hydrometric Area Local Authority	Associated surface water bodies	Associated terrestrial ecosystems	Area (km2)
Hydrometric Area 36 Cavan Co. Co. Monaghan Co. Co. Longford Co. Co. Leitrim Co. Co.	***Rivers:*** Annalee, Bunnoe, Cavan, Cullies, Dromore, Finn, Knappagh, Erne, Stradone, Laragh, Magheramey. ***Streams:*** Aghnacliffe, Avaghon Lake Stream, Laheen, Legga, Madabawn, 1100 unnamed. ***Lakes:*** see list below *	Lough Oughter and associated lakes (O'Riain, 2004)	1410

Topography

This large, SW-NE aligned GWB is bounded to the south, east and west by the topographic divide (Hydrometric Area 36). The northern boundary comprises more productive aquifers. The entire GWB is characterised by drumlin topography. Inter-drumlin elevations generally range from 5 mAOD around Lough Oughter (Killashandra GWB), to c.250 mAOD in the southeast. The drumlin peaks are generally an additional 40-60 m. There are also three higher areas in western and central region of the GWB, the highest of which rises to c.300 mAOD. Surface water generally feeds from the periphery of the GWB towards Lough Oughter, which then flows northwards towards Lough Erne.

Geology and Aquifers	
	Aquifer type(s) The vast majority of the GWB (c.98%) comprises **Pl:** Poor aquifer, generally unproductive except for local zones. In the southwest, there is a small area of **Ll:** Locally important aquifer, moderately productive only in local zones, and there is also a small outlier of **Lm:** Locally important aquifer, generally moderately productive, in the centre of the GWB.
	Main aquifer lithologies Essentially split by a SW-NE line across this GWB, the northern area is dominated by Ordovician Metasediments (54.22% of GWB) and the south by Silurian Metasediments and Volcanics (41.97%). Other rocks of note are two areas of Granites & other Igneous Intrusive Rocks (1.34%) and thin bands of Ordovician Volcanics (<0.5%) in the southern area. There are also Dinantian age rocks (2.17%) in the southwest and as the central outlier. Refer to Table 1 for details.
	Key structures. Being part of the Longford-Down Inlier, the rocks in this part of the country have been significantly deformed, resulting in a large number of approximately SW-NE faults with associated perpendicular faults e.g. Carrickateane, Orlock Bridge, Kehernagilly and Laragh Faults. Dips in the rock succession are variable but overall, appear to be to the SE by up to 80°.
	Key properties Yields in this GWB are available for 65 wells and range from 4.4-1091 m^3/d, averaging 143 m3/d. Of these, 3 have 'excellent' yields – 2 of which are located on a mapped fault – and 39 have 'good' yields, approximately half of which are in faulted zones. Only 3 specific capacity values are available for the higher yields, all of which are quite low: 6, 7 and 12 m^3/d/m. These low specific capacities result in low productivity values for these wells (III; IV and IV). For the remaining poorer yielding wells, specific capacity values range from 0.1-19.9 m^3/d/m, averaging 4.3 m^3/d/m over are 23 values. Only one transmissivity value is available for this GWB: 0.23 m^2/d for a low yielding well. The national transmissivity data for these rocks are also low (<20 m^2/d in most rocks) or possibly moderate in the Silurian rocks (20-80 m^2/d). However, higher values may be achieved in faulted zones, especially in the coarser-grained rocks, which may be exemplified by the 'excellent' and 'good' yields. The available specific dry weather flows are low, ranging from 0.01-0.55 l/s/km^2 (6 stations), suggesting that

	these aquifers do not make a significant baseflow contribution to streamflow. Storativity is also expected to be low. Of the c.320 available groundwater levels, 60% are 0-3 m below ground level and just over 12% area greater than 10 m bgl, indicating that flow is predominantly shallow. Groundwater gradients have not been calculated by are expected to be relatively steep. *(Ordovician Aquifer Chapter; Silurian Aquifer Chapter*)
	Thickness Most groundwater flux will be in the uppermost part of the aquifer comprising a broken and weathered zone typically less than 3 m thick, as indicated by the predominantly shallow water levels, a zone of interconnected fissuring around 10 m thick, and a zone of isolated poorly connected fissuring typically less than 150 m. Water strikes of between 30-40 m bgl are noted 5 boreholes and an additional borehole ('good' yield) has strikes recorded at 43 and 82 m bgl. This suggests some deeper flow component, although it is likely to be very limited.
Overlying Strata	**Lithologies** The GWB is predominantly covered by till subsoil (71%), with a smaller proportion of peat (9%). Approximately 10% of the body is mapped as rock outcrop/shallow subsoil. There are no data for the western end of the GWB (c.4% of the area).
	Thickness Across the GWB, outcrop and borehole data suggest that the drumlins appear to represent a thicker deposit, frequently >10 m thick, with rock nearer the surface of the inter-drumlin areas. Generally, the southern half of the GWB has shallower subsoil.
	% area aquifer near surface *[Information will be added at a later date]*
	Vulnerability From the Monaghan GWPS, the vulnerability is predominantly classed as Extreme in the southeast of the GWB, and Low in the northeast, where deposits are less permeable and thicker. No data are available for Cavan or Leitrim however, the similar topography and outcrop distribution may suggest a similar pattern of vulnerability.
Recharge	**Main recharge mechanisms** Diffuse recharge occurs via rainfall percolating through the thinner/more permeable subsoil and via outcrops. Due to the low permeability of some of the subsoil (thicker till and peat) and the aquifers in the GWB, a high proportion of the available recharge will discharge to the streams in the GWB. In addition, the steep drumlin slopes will promote surface runoff. The high stream density is likely to be influenced by the lower permeability rocks as well as the subsoil.
	Est. recharge rates *[Information will be added at a later date]*
Discharge	**Important springs and high yielding wells** ***Sources:*** None identified. ***Springs:*** None identified. ***Excellent Wells:*** Cooltrimegish (1091 m^3/d), Sallaghan (523 m^3/d), Corrachulter (436 m^3/d). ***Good Wells:*** Drumloo (327 m^3/d), Milltown (273 m^3/d), Dromod (262 m^3/d), Tirquin (259 m^3/d), Poles (245 m^3/d), Corglass (218 m^3/d), Dernaroy (218 m^3/d, 196 m^3/d), Drumaveale (218 m^3/d), Drumgola (218 m^3/d), Garrybane (218 m^3/d), Drumauna (218 m^3/d), Ardlougher (196 m^3/d), Drollagh (190 m^3/d), Fastry (173 m^3/d), Killycannan (153 m^3/d), Killgary (153 m^3/d), Tullyvin (149 m3/d, 120 m^3/d), Annagelliff (131 m^3/d), Bruse (131 m^3/d), Brusky (131 m^3/d), Carrickboy (131 m^3/d), Cootehill (131 m^3/d), Lismagratty (131 m^3/d), Tievenanass (131 m^3/d), Tullnahinnera (131 m3/d, 118 m^3/d), Unshinagh (131 m^3/d), Corduff (126 m^3/d), Turfad (120 m^3/d), Ardvarny (112 m^3/d), Clonoose (109 m^3/d), Derrycassan (109 m^3/d), Lisnacark (109 m3/d), Moyne (109 m^3/d), Mullaghoran (109 m^3/d), Tullnanegish (109 m^3/d), Carrickallen (103 m^3/d).

	Main discharge mechanisms The main groundwater discharges are to the lakes and rivers and streams crossing the GWB, reflecting short groundwater flow paths. Small springs (of which a number are recorded) and seeps are likely to issue at the stream heads and along their course. Groundwater may also flow into the adjacent, higher permeability (Lm) GWB.
	Hydrochemical Signature ***National classification:*** Ordovician/Silurian Metasediments Non-calcareous. Ca-Mg-HCO_3 signature. However, Cavan and Monaghan also have Ca-Mg-SO_4 recorded. Alkalinity (mg/l as $CaCO_3$): range of 9-470; mean of 172 (445 'non limestone subsoils' data points) Total Hardness (mg/l): range of 5-481; mean of 222 (389 'non limestone subsoils' data points) Conductivity (μS/cm): range of 80-477; mean of 490 (477 'non limestone subsoils' data points) *(Calcareous/Non calcareous classification of bedrock in the Republic of Ireland report)*

Groundwater Flow Paths

In the absence of inter-granular permeability, groundwater flow is expected to be concentrated in fractured and weathered zones and in the vicinity of fault zones. Available groundwater levels are mainly 0-10 m below ground level (60% <3 mbgl). Flow paths are likely to be short (30-300 m) with groundwater discharging rapidly to nearby lakes, streams and small springs. There are observed deeper water strikes, indicating that there is a component of deep groundwater flow, however shallow groundwater flow is thought to dominant. Groundwater flow directions are expected to follow topography – overall in a northerly direction.

Groundwater & surface water interactions

Groundwater will discharge locally to streams and rivers crossing the aquifer and also to small springs and seeps. Owing to the poor productivity of the aquifers in this body it is unlikely that any major groundwater - surface water interactions occur. Baseflow to rivers and streams is relatively low.

Conceptual model

This large, SW-NE aligned GWB is bounded to the south, east and west by the topographic divides (Hydrometric Area 36). The northern boundary comprises more productive aquifers. The entire GWB is characterised by drumlin topography. Inter-drumlin elevations generally range from 5 mAOD to c.250 mAOD. There are also three higher areas in western and central region of the GWB, the highest of which rises to c.300 mAOD.

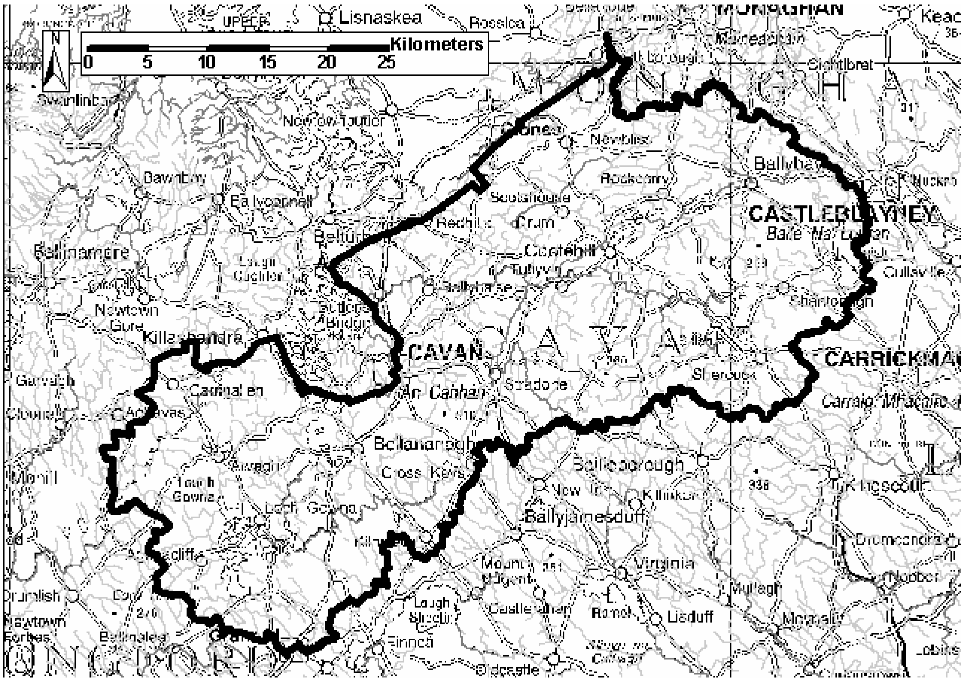
The GWB is composed primarily of low transmissivity rocks. Most of the groundwater flux is in the uppermost part of the aquifer: comprising a broken and weathered zone typically less than 3m thick; a zone of interconnected fissuring typically less than 10m; and a zone of isolated fissuring typically less than 150m.

Recharge occurs diffusely through the thin/permeable subsoil and via outcrops, although is limited by ay thicker low permeability subsoil and the low permeability bedrock itself. Therefore, most of the effective rainfall is not expected to recharge the aquifer.

Flow paths are likely to be short (30-300 m) with groundwater discharging rapidly to the lakes and streams crossing the aquifer, and to small springs and seeps. Overall, the flow direction is expected to be to the north and east, as determined by the topography.

Instrumentation

Stream gauges: 36010*, 36011*, 36012 *, 36015* (Present but not representative of flow in this GWB), 36016*, 36017*, 36018*, 36024, 36030, 36031, 36037, 36038, 36039, 36044, 36070, 36072, 36074, 36075, 36076, 36077, 36078, 36079, 36080, 36081, 36082, 36085, 36120, 36121, 36122, 36123, 36124, 36125, 36126, 36127, 36130, 36135, 36136, 36137, 36138, 36139, 36141, 36143, 36145, 36146, 36147, 36149, 36150, 36151, 36152, 36153, 36155, 36157, 36172, 36173, 36174, 36182, 36183, 36184, 36190, 36192, 36193, 36194, 36195, 36196, 36197, 36198.
*Adjusted dry water flow data available for these
EPA Water Level Monitoring boreholes: CAV141 (on boundary with Killashandra GWB), CAV161
EPA Representative Monitoring points: CAV26, LEI67, MON14, MON17, MON18, MON19, MON23, MON28, MON29, MON31, MON44, MON46, MON53, MON55.



Location and boundaries of Cavan GWB

Appendix 2: Raw water sampling results

Background raw water sampling data for source water in Killynenagh Lough were compiled T.J. O'Connor and Associates Consulting Engineers, Cavan County Council and the National Water Monitoring Committee prior to the competition for the DBO contract. Veolia Water Ltd. records raw water quality data for colour, turbidity and pH on a regular basis while City Analysts conduct monthly analysis on raw water samples.

T.J. O'Connor and Associates Consulting Engineers

Baseline parameter values for raw water in were recorded by T.J. O'Connor and Associates Consulting Engineers for the period September 2002 to July 2003. Results are presented in Table 1.

Table 1 Raw water results (TJ O'Connor and Associates)

Parameter	Units	04/09/2002	09/10/2002	05/11/2002	04/12/2002	27/01/2003	25/02/2003	12/03/2003	09/04/2003	22/05/2003	18/06/2003	17/07/2003	MAX
Alkalinity (bicarbonate)	**mg/l HCO_3**									<5			**6**
Alkalinity (total)	**mg/L $CaCO_3$**	130	194	106	65	127	120	103	112	95			**232.8**
Aluminium	**mg/L**				<0.02			0.054		<0.006.6			**0.0648**
Aluminium (dissolved)	**µg/L**									<0.006.6			**0.00792**
Ammonia	**mg/L as N**	<0.12	<0.12	0.3	0.08	0.09	0.1	0.05	0.03	0.1	0.06	0.16	**0.36**
Antimony	**µg/L**									<1.4			**1.68**
Arsenic	**µg/L**	<0.005	0.107	<0.005	0.3	0.4	2.9	0.4	0.5	0.3			**3.48**
Barium	**mg/L**	0.056	0.09	0.058	23.1	28.7	0.038	0.042	0.027				**34.44**
Boron	**µg/L**									2.8			**3.36**
Bromide	**mg/L**	<0.01	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5			**0.6**
Cadmium	**µg/L**	<0.003	<0.003	<0.003	<0.1	<0.1	<0.1	0.2		<0.4			**0.24**
Calcium	**mg/L**									58.26			**69.912**
Carbon dioxide	**mg/L**									40			**48**
Chloride	**mg/L**									14			**16.8**
Chlorophyll	**mg/m3**	15.8	<3	71	8.9	3.8	19.9	21.5	11.6	21.2	15.3	10.2	**85.2**
Chromium	**µg/L**	<0.02	0.03	<0.02	0.02	<0.001	0.002	<0.001	<0.001	<2.0			**0.036**
Clostridia	**no/ml**									3			**13.2**
Coliforms (total)	**no/ml**	2	6	0	37	0	1	0	2	35	1	17	**91.2**
Coliforms (faecal)	**no/ml**	0	3	0	7	0	1	0	2		0	2	**45.6**
Colour (apparent)	**PtCo**	28	29	45	45	41	38	31	41	25	40	37	**106.8**
Colour (true)	**PtCo**		254							19			**304.8**
Conductivity	**$\mu S/cm^{-1}$ @ 25℃**	249		223	220	197	243	238	238	240			**382.8**
Copper	**µg/L**									<2.8			**3.36**
Cryptosporidium	**no/ml**	0	0	0	0	0	0	0	0	0			**0**
Cyanide	**µg/L**									<3			**3.6**
DOC	**mg/L**									8			**9.6**

Parameter	Units	04/09/2002	09/10/2002	05/11/2002	04/12/2002	27/01/2003	25/02/2003	12/03/2003	09/04/2003	22/05/2003	18/06/2003	17/07/2003	MAX
DO	**mg/L**	9.9	9	9.1	9.3	9.4	9	11.6	9.7	9			**13.92**
E coli	**no/100ml**									34			**69.6**
Fluoride	**mg/L**									0.12			**0.144**
Hardness (bicarbonate)	**mg/L $CaCO_3$**	<5	<5	<5	<5	<5	<5	5	<5				**6**
Hardness (total)	**mg/L $CaCO_3$**	112	120	94	85	102	112	108	104	105			**144**
Iron (dissolved)	**mg/L**									<0.002			**0.0024**
Iron (total)	**mg/L**	0.2	0.17	0.1	0.249	0.417	0.48	0.186	0.013	<0.002	0.052	0.018	**0.576**
Lead	**µg/L**									<0.6			**0.072**
Magnesium	**mg/L**									3.61			**4.332**
Manganese	**mg/L**	0.253	0.248	0.079	0.09	0.043	0.071	0.101	0.029	<0.0002	0.0218	0.0003	**0.3552**
Manganese (dissolved)	**mg/L**									<0.004			**0.0048**
Mercury	**µg/L**	<0.0005	<0.0005	<0.0005	<0.01	<0.01			<0.01	<0.4			**0.48**
Nickel	**µg/L**						0.03	<0.02		<9.9			**11.88**
Nitrate	**mg/L as N**	<0.09	<0.09	0.43	0.11	0.04	0.016	0.017	<0.02	<0.04			**0.72**
Nitrite	**mg/L as N**	0.022	0.027	0.112	0.005	0.04			<0.005	0.023			**0.1344**
Pesticides (organochlorine)	**µg/L**	<0.1	<0.1							<0.1			**0.12**
Pesticides (organophosphorus)	**µg/L**									<0.1			**0.12**
pH		7.8	7.7	7.5	7.4	7.6	7.3	7.5	7.6	7.4	7.5	7.7	**9.36**
Orthophosphate	**mg/L as P**	0.016		0.018	0.037	0.019	0.011	0.011	<0.005	0			**0.0444**
Phosphate (total)	**mg/L as P**	0.24	0.039	0.039	0.061	0.046	0.039	0.037	0.278	0.024			**0.3336**
PAH	**µg/L**									<1			**1.2**
Potassium	**mg/L**									3.3			**3.96**
Pseudomonas	**no/100ml**									0			**0**
Selenium	**µg/L**									<4.6			**5.52**
Semivolatile organic compounds	**µg/L**									<1			**1.2**
Silica	**mg/L as Si**				4.2					1.2			**5.04**

Parameter	Units	04/09/2002	09/10/2002	05/11/2002	04/12/2002	27/01/2003	25/02/2003	12/03/2003	09/04/2003	22/05/2003	18/06/2003	17/07/2003	MAX
Sodium	**mg/L**									7.4			**8.88**
Solids (total dissolved)	**mg/L**	112	112	164	152	144	138	154	148	148			**196.8**
Sulphate	**mg/L as SO_4**				<5					<5			**6**
Temperature		17.9	14.1	8.1	6.9	7.6	6.5	7.7	11.2	12			**21.48**
TOC	**mg/L**	0	7	12	5	18	8	11	20	8	9.3	11.5	**24**
Turbidity	**NTU**	5.7	<0.1	6.2	3.09	2.24	5.39	5.54	16.5	17.47	7.89	3.42	**22.8**
UV abs	**Abs**	0.206	0.222	0.266	0.319	0.264	0.2532	0.237	0.26	0.0906	0.234	0.2341	**0.3828**
Volatile Organic Compounds (VOCs)	**µg/L**									<1			**1.2**
Zinc	**mg/L**									<0.007			**0.0084**

MAX = Maximum values + 20% recorded during baseline monitoring (by TJ O'Connor, Cavan County Council and National Water Monitoring Committee) prior to establishment of treatment plant

Cavan County Council

Cavan County Council conducted water sampling and analysis of source water in January and December 2000. Results from this sampling period are presented in Table 2.

Table 2 Raw water results (Cavan County Council)

Parameter	Units	10/01/2000 Herbert Hall	12/12/2000 Fays House	MAX
Colour	**PtCo**	36	36	**106.8**
Turbidity	**FTU**	10	0	**22.8**
Taste			ND	**ND**
Odour		ND	ND	**ND**
Temperature		10	9	**21.48**
pH		7.55	7.04	**9.36**
Conductivity	**$\mu S/cm^{-1}$**	207	211	**382.8**
Nitrate	**mg/L N**	0.125	0.2393	**0.72**
Nitrite	**mg/l N**	0.005	0.006	**0.134**
Ammonia	**mg/L N**	0.006	<0.01	**0.36**
Iron	**mg/L**	0.477	0.11	**0.576**
Mn	**mg/L**	0.045	0.048	**0.355**
Chloroform	**µg/L**	<1.0	<1.0	**1.2**
Bromodichloromethane	**µg/L**	ND	<1.0	**1.2**
Dibromochloromethane	**µg/L**	ND	ND	**ND**
Bromoform	**µg/L**	ND	ND	**ND**
Total coliforms	**no/100ml**	1	18	**91.2**
Faecal coliforms	**no/100ml**	1	16	**45.6**

MAX = Maximum values + 20% recorded during baseline monitoring (by T.J. O'Connor, Cavan County Council and National Water Monitoring Committee) prior to establishment of treatment plant

National Water Monitoring Committee

The National Water Monitoring Committee conducted raw water sampling over a year from 2000-2001. Results of analyses are presented in Table 3.

Table 3 Raw water results (National Water Monitoring Committee)

Parameter	Units	Nov-00	Dec-00	Jan-01	Feb-01	May-01	Jun-01	Jul-01	Aug-01	Sep-01	Oct-01	Nov-01	Max
Colour	**Ha**	59	89	58	59	66	28	39	44	25	27	34	**106.8**
Turbidity	**NTU**	9	19	2	7	17	4	5	7	3	4	5	**22.8**
Conductivity	**µS/cm^{-1}**	227	240	256	246	319	244	242	233	229	185	245	**382.8**
pH		7.7	7.3	7.4	7.1	7.4	7.3	7.5	7.4	7.8	7.5	7.6	**9.36**
Ammonia	**mg/L N**	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.1	<0.1	0.12	<0.1	**1.68**
Nitrate	**mg/L N**	0.5	0.6	<0.5	<0.5	<0.45	<0.45	<0.45	<0.5	<0.5	<0.5	<0.5	**0.72**
Nitrite	**mg/L N**	0.007	0.011	0.019	<0.006	<0.012	<0.012	0.015	<0.010	0.023	<0.01	0	**0.134**
Al	**mg/L**	<0.0007	<0.0007	<0.0007	<0.0007	<0.0007	<0.0007	<0.0007	<0.0007	<0.0007	0.044	<0.0007	**0.0648**
Iron	**µg/L**	59	60	<0.09	13	456	<0.09	5	<0.09	79	20	<0.09	**0.576**
Mn	**µg/L**	64	<0.03	<0.03	3	296	<0.03	0	0	73	1	<0.03	**0.3552**
Total coliforms	**no per 100 ml**	4	0	3	1	0	0	16	0	25	69	1	**91.2**
Faecal coliforms	**no per 100 ml**	0	0	3	1	0	0	0	0	0	38	0	**45.6**

MAX = Maximum values +20% recorded during baseline monitoring (by T.J. O'Connor, Cavan County Council and National Water Monitoring Committee) prior to establishment of treatment plant

National Drinking Water Monitoring Programme

The National Drinking Water Monitoring Programme carried out water sampling on Killynenagh Lough on 15th November 2002. Results are presented in Table 4.

Table 4 Raw water results (National Drinking Water Monitoring Programme)

Parameter	Units	15/11/2002	MAX
Total coliforms	**no per 100 ml**	76	**91.2**
Clostridia perfringens	**no per 100 ml**	11	**13.2**
E coli	**no per 100 ml**	58	**69.6**
Colour	**PtCo**	57	**106.8**
Turbidity	**NTU**	2.02	**22.8**
pH		7.2	**9.36**
Conductivity	**$\mu S/cm^{-1}$**	205	**382.8**
Al	**mg/L**	<0.02	**0.0648**
Iron	**mg/L**	0.2	**0.576**
Mn	**mg/L**	0.04	**0.355**
Nitrite	**mg/L N**	0.0048632	**0.72**
Nitrate	**mg/L N**	0.1106095	**0.134**
Ammonia	**mg/L N**	0.0232558	**0.36**

Veolia Ltd.

Veolia carry out internal laboratory analysis on raw water samples. Results of monitoring from 2006 to present are presented in Table 5.

Table 5 Raw water results (Veolia Water Ltd.)

Parameter	Total Flow	Flow		Apparent Colour	True Colour	Turbidity	Total Iron	Total Manganese	Total Ammonia	pH	Total Alkalinity ($CaCO_3$)
Unit	m^3	m^3/day	m^3/hr	PtCo	PtCo	NTU	mg/L	mg/L	mg/L		mg/L
Limits†					20		0.2	0.05		5.5-8.5	No ref.
Limits§				106.8	22.8	22.8	0.576	0.355	0.36	9.36	232.8
04/01/2006	16131.6	N/A	22.13	42	26	6.42	0.141	0.066		7.87	104.4
10/01/2006	18547.9	402.72	23.82	76	28	3.50	0.081	0.052		7.66	122.8
17/01/2006	20873.3	332.20	23.06	197	20	3.00	0.066	0.102		7.59	121.6
24/01/2006	23045.1	310.26	23.21	72	19	3.17	0.071	0.021		7.60	128.0
07/02/2006	26851.8	277.09	22.88	35	12	3.20	0.076	0.038		7.71	126.0
14/02/2006	28891.9	291.44	22.91	94	29	3.60	0.105	0.133		7.65	125.0
22/02/2006	31617.5	340.70	22.80	60	12	3.10	0.780	0.100		7.97	124.0
28/02/2006	33516	316.42	22.70	99	28	3.84	0.124	0.111		7.45	122.0
06/03/2006	35351	305.83	25.16	59	23	2.80	0.104	0.401		7.80	123.0
13/03/2006	37967	373.71	24.90	42	26	2.60	0.006	0.227		8.30	93.0
20/03/2006	40171	314.86	25.10	70	18	3.01	0.077	0.109		8.04	100.0
27/03/2006	42294	303.29	25.00	56	28	3.04	0.066	0.079		8.11	103.0
03/04/2006	44125	261.57	23.89	101	16	3.86	0.072	0.083		8.02	103.6
10/04/2006	46019	270.57	24.10	106	23	2.51	0.078	0.558		7.66	119.0
19/04/2006	48330	256.78	23.90	62	30	3.19	0.078	0.200		8.13	102.0
24/04/2006	49706	275.20	23.90	61	18	2.63	0.088	0.275		7.70	104.0
02/05/2006	52112.7	300.84	24.12	65	18	3.89	0.100	0.418		7.63	120.0
08/05/2006	54639.2	421.08	23.89	52	15	3.81	0.258	0.258		7.82	108.8
15/05/2006	56378	248.40	23.70	71	8	3.42	0.109	0.196		7.80	129.0
22/05/2006	58814	348.00	23.82	66	21	5.34	0.042	0.351		7.70	118.0
07/06/2006	63995	315.22	23.20	45	21	4.00	0.019	0.083		7.56	112.2
13/06/2006	65723	288.00	23.40	41	20	4.28	0.100	0.105		7.61	111.2
19/06/2006	67644	320.17	23.60	51	19	3.42	0.006	0.098		7.72	112.8
26/06/2006	69739	299.29	23.20	34	3	6.40	0.041	0.158		n/r	85.6
04/07/2006	72459	302.00	23.27	53	24	3.75	0.154	0.127		7.24	121.6
11/07/2006	74385	275.14	23.10	107	30	4.12	0.224	0.459		7.60	122.0
18/07/2006	76394	287.00	23.38	40	5	2.29	0.084	0.088		7.65	119.2
24/07/2006	78589	365.83	23.06	32	20	2.75	0.091	0.067		7.44	118.4
01/08/2006	81278	302.00	23.27	49	23	3.50	0.254	0.619		7.54	119.6
10/08/2006	83607	275.14	23.10	52	33	4.32	0.193	0.533		7.66	119.6
14/08/2006	84693	287.00	23.38	83	24	5.07	0.200	0.146		7.59	144.8
22/08/2006	86867	365.83	23.06	64	31	3.27	0.066	0.229		7.70	122.8
29/08/2006	88486			53	29	3.39	0.119	0.323		7.66	116.0
06/09/2006	90406	240.00	23.70	48	32	3.17	0.104	0.290		7.79	119.2
12/09/2006	91843	205.00	22.90	53	16	2.52	0.087	0.283		7.38	110.8
19/09/2006	93770	275.00	22.70	19	15	3.54	0.034	0.120		7.68	108.8
27/09/2006	96105	292.00	23.50	88	32	3.92	0.056	0.445		7.52	117.6
05/10/2006	98328	277.88	23.90	74	27	2.82	0.098	0.057		7.52	110.0
12/10/2006	100453	303.57	23.40	62	8	5.36	0.085	0.176		7.65	117.2
18/10/2006	102441	331.33	23.00	68	20	3.53	0.089	0.196		7.98	107.6
23/10/2006	104127	337.20	23.50	87	25	5.00	0.085	0.192		7.37	107.4
01/11/2006	106911	309.33	23.53	80	16	5.20	0.070	0.143		7.32	94.2
07/11/2006	108819	318.00	23.68	65	27	2.80	0.084	0.130		7.36	109.2
13/11/2006	110442	270.50	22.50	77	14	4.30	0.101	0.082		7.34	109.2
20/11/2006	112611	309.86	23.21	61	13	2.70	0.101	0.790		7.59	106.2
04/12/2006	116977	318.43	22.77	31	17	3.00	0.122	0.164		7.60	110.8
12/12/2006	119640	332.88	22.63	218	30	2.60	0.158	0.069		7.79	161.6
18/12/2006	122091	408.50	23.45	128	41	2.30	0.130	0.074		7.69	118.3
02/01/2007	126369	285.20	23.36	71	50	1.90	0.181	0.081		7.71	87.8
10/01/2007	128482	264.13	23.49	87	46	2.10	0.009	0.046		7.17	98.2
15/01/2007	129825	268.60	23.70	61	41	5.01	0.098	0.235		7.06	101.2
22/01/2007	131806	283.00	23.40	85	47	2.34	0.101	0.046		7.75	86.4
05/02/2007	135984	296.17	22.80	58	41	1.90	0.107	0.066		7.81	98.4
12/02/2007	138282	328.29	23.20	64	45	5.40	0.120	0.058		7.85	124.0
20/02/2007	140691	301.13	23.00	56	50	2.50	0.100	0.075		7.83	107.0
26/02/2007	142455	294.00	22.75	52	48	6.00	0.136	0.050		7.60	126.4
05/03/2007	144778	331.86	23.00	66	50	4.73	0.122	0.041		7.71	174.4
12/03/2007	146962	312.00	23.00	61	56	4.34	0.178	0.095		7.87	103.4
20/03/2007	149706	343.00	23.00	59	43	3.87	0.148	0.045		8.02	58.6
26/03/2007	151431	287.50	22.00	72	57	2.98	0.143	0.103		7.84	102.0

Parameter	Total Flow	Flow		Apparent Colour	True Colour	Turbidity	Total Iron	Total Manganese	Total Ammonia	pH	Total Alkalinity ($CaCO_3$)
Unit	m^3	m^3/day	m^3/hr	PtCo	PtCo	NTU	mg/L	mg/L	mg/L		mg/L
03/04/2007	153998	320.88	23.00	47	39	2.90	0.073	0.154		7.53	96.0
10/04/2007	156323	332.14	23.00	46	30	1.91	0.117	0.051		7.63	98.0
18/04/2007	158906	322.88	23.80	25	10	2.50	0.079	0.074		7.40	99.0
24/04/2007	160960	342.33	23.20	54	36	3.25	0.079	0.175		7.51	114.0
01/05/2007	163286	332.29	22.55	40	32	3.18	0.082	0.206		7.13	106.8
09/05/2007	165965	334.88	23.00	84	45	3.50	0.121	0.258		7.61	97.3
14/05/2007	167460	299.00	22.69	30	28	3.70	0.044	0.073		7.45	105.6
21/05/2007	169278	259.71	21.60	41	31	3.30	0.051	0.064		7.50	104.0
06/06/2007	174204	318.88	22.50	74	32	4.22	0.162	0.159		7.53	108.0
13/06/2007	176498	327.71	23.00	65	41	3.50	0.213	0.195		7.51	102.0
21/06/2007	178476	247.25	24.80	79	49	n/r	0.230	0.535		7.63	100.8
25/06/2007	179539	265.75	23.60	65	43	2.60	0.070	0.102		7.42	117.0
24/07/2007				103	30	2.95	0.195	0.270		7.6	91.6
30/07/2007				67	26	3.79	0.215	0.250		7.3	89.6
07/08/2007	190842	326.38	24.20	63	34	4.07	0.082	0.312	0.00	7.6	94
15/08/2007	193189	293.38	24.90	118	21	4.12	0.416	0.508	0.00	7.2	102.4
20/08/2007	194620	286.20	24.69	143	12	3.84	0.175	0.688	10.30***	7.4	99.2
27/08/2007	196803	311.86	24.80	35	28	3.25	0.117	0.115	0.10	0.0	105
03/09/2007	198971	309.71	24.51	17	14	3.70	0.118	0.106	0.00	0.0	110
11/09/2007	201413	305.25	24.60	70	5	3.20	0.226	0.278	0.00	7.6	111
19/09/2007	203892	309.88	24.00	75	7	2.30	0.062	0.151	n/r	7.4	111
24/09/2007	205423	306.20	24.60	44	17	3.50	0.059	0.214	n/r	7.6	100
02/10/2007	207380	244.63	24.30	32	29	2.03	0.059	0.123	n/r	7.7	116
09/10/2007	209270	270.00	24.90	70	5	2.41	0.226	0.278	0.10	7.6	111
16/10/2007	211477	315.29	25.00	79	67	2.62	0.121	0.271	0.05	7.7	104
23/10/2007	213672	313.57	25.00	38	17	3.45	0.212	0.455	0.08	7.6	112
06/11/2007	217376	262.86	24.90	40	29	2.73	0.204	0.443	0.11	7.8	106.8
12/11/2007	219135	293.17	24.50	29	10	2.08	0.145	0.224	0.09	8.1	107
21/11/2007	222182	338.56	25.00	58	36	2.61	0.182	0.478	0.12	7.7	107.6
03/12/2007	225449	269.29	24.90	30	14	5.42	0.171	0.286	0.00	n/a	107
10/12/2007	227227	254.00	24.80	26	12	3.57	0.100	0.212	0.00	7.2	114
20/12/2007	229906	267.90	25.00	30	15	1.93	0.160	0.300	n/r	7.8	110
07/01/2008	234651	263.61	24.70	39	17	4.11	0.058	0.113	0.01	n/a	103.6
15/01/2008	236536	235.63	24.96	51	28	2.49	0.129	0.067	0.07	7.7	105
21/01/2008	237969	238.83	24.00	80	33	3.22	0.176	0.082	0.01	7.8	91
30/01/2008	239814	205.00	25.00	97	31	3.25	0.106	0.106	n/r	7.6	90
04/02/2008	240745	186.20	24.80	35	27	2.25	0.160	0.068	0.05	7.4	101
11/02/2008	242091	192.29	23.80	70	40	2.96	0.142	0.080	n/r	8.0	172.8
18/02/2008	243845	250.57	25.00	74	41	2.48	0.127	0.074	n/r	7.9	121.6
26/02/2008	245695	231.25	25.00	21	8	4.20	0.126	0.117	0.04	7.8	95.6
04/03/2008	247177	211.71	25.00	71	34	3.49	0.131	0.089	n/r	8.2	101
10/03/2008	248244	177.83	25.00	112	30	2.30	0.074	0.086		7.9	92
18/03/2008	249660	177.00	23.90	60	27	2.62	0.099	0.114	0.10	7.9	92.8
26/03/2008	251278	202.25	24.06	74	36	2.30	0.079	0.147		8.0	94.4
08/04/2008	253617	178.75	21.30	54	30	3.77	0.126	0.072		7.8	76
14/04/2008	254762	190.83	22.60	46	23	3.44	0.060	0.148		7.6	93.6
21/04/2008	256288	218.00	25.60	33	17	2.85	0.055	0.068	0.12	7.1	100.8
28/04/2008	258050	251.71	26.00	47	29	1.30	0.052	0.075		7.5	98.8
06/05/2008	259635	198.13	26.00	50	30	3.00	0.055	0.012		7.6	99
13/05/2008	261473	262.57	26.30	50	38	6.23	0.036	0.166		7.3	106.8
20/05/2008	263476	286.14	26.00	96	65	5.17	0.117	0.307	0.00	7.4	106.4
26/05/2008	265031	259.17	26.80	78	42	4.91	0.105	0.153	0.02	7.9	107
03/06/2008	267710	334.88	26.00	28	19	5.73	0.078	0.099		7.8	105
10/06/2008	269001	184.43	26.00	34	13	2.74	0.072	0.075		7.7	106
16/06/2008	270632	271.83	26.00	26	18	3.24	0.039	0.042		7.7	110
24/06/2008	272474	230.25	26.46	31	19	3.69	0.039	0.046	0.01	7.8	106
01/07/2008	274090	230.86	25.40	44	14	4.17	0.120	0.244	0.02	7.7	105.6
08/07/2008	275972	268.86	26.00	41	9	4.47	0.145	0.371	0.00	7.9	108.8
15/07/2008	277636	237.71	25.00	38	15	3.29	0.079	0.246	0.04	7.9	107
22/07/2008	279200	223.43	25.20	39	17	3.32	0.079	0.246	0.06	7.9	106.5
06/08/2008	282751	226.22	25.00	120	24	4.16	0.168	0.631		7.3	109.2
12/08/2008	283946	199.17	25.80	53	28	4.44	0.111	0.322	0.02	7.5	120
19/08/2008	285311	195.00	25.60	109	36	5.20	0.141	0.344	0.03	7.7	118
26/08/2008	286897	226.57	25.20	77	34	3.74	0.113	0.236		7.7	119
01/09/2008	288252	225.83	25.00	85	30	3.00		0.084	0.020		101.0
09/09/2008	290131	234.88	21.80	131	54	4.80		0.412	0.030	7.55	98.0

Parameter	Total Flow	Flow		Apparent Colour	True Colour	Turbidity	Total Iron	Total Manganese	Total Ammonia	pH	Total Alkalinity ($CaCO_3$)
Unit	m^3	m^3/day	m^3/hr	PtCo	PtCo	NTU	mg/L	mg/L	mg/L		mg/L
15/09/2008	291242	185.17	25.00	108	46	3.25		0.135		7.75	99.6
23/09/2008	292785	192.88	24.90	121	50	5.29		0.398		7.49	98.0
07/10/2008	295655	193.13	25.00	97	44	4.70	0.221	0.431		7.8	89.6
14/10/2008	297066	201.57	25.20	106	68	5.17	0.175	0.277		7.6	n/r
21/10/2008	298494	204.00	25.30	104	60	3.60	0.151	0.151	0.06	7.8	101.6
29/10/2008	300131	204.63	25.70	82	56	3.05	0.143	0.144		7.8	101
04/11/2008	301322	198.50	24.20	75	44	3.63	0.176	0.184	0.00	7.8	96
11/11/2008	302646	189.14	25.20	41	33	3.48	0.166	0.089	0.00	n/r	103
19/11/2008	304372	215.75	24.70	64	38	3.37	0.182	0.148	0.01	7.8	100
25/11/2008	305519	191.17	25.40	56	31	3.34	0.192	0.118	0.00	7.8	102.4
03/12/2008	307255	217.00	25.10	55	30	3.12	0.177	0.130		7.8	103.2
09/12/2008	308783	254.67	23.70	59	42	2.58	0.181	0.161		7.7	102.4
17/12/2008	311075	286.50	25.70	47	33	3.07	0.226	0.257		7.6	104.2
30/12/2008	314974	299.92	25.70	45	31	2.17	0.223	0.221		7.5	108
05/01/2009	316552	263.00	25.20	46	32	3.26	0.200	0.252		7.7	104
12/01/2009	318747	313.57	25.30	40	26	2.86	0.200	0.247	0.00	7.5	89.6
19/01/2009	320515	252.57	23.97	45	31	3.20	0.190	0.239		7.9	100.8
27/01/2009	322462	243.38	25.40	46	20	3.16	0.100	0.159		8.1	103.2
02/02/2009	323781	219.83	24.10	45	30	4.10	0.126	0.126		7.7	93.2
10/02/2009	325819	254.75	24.70	54	32	2.67	0.129	0.104	0.01	7.8	100.4
16/02/2009	327443	270.67	24.90	58	30	3.05	0.102	0.112		7.7	108
23/02/2009	329259	259.43	24.80	55	27	2.65	0.055	0.130		7.7	97.6
02/03/2009	331023	252.00	25.50	48	22	3.47	0.050	0.178	0.00	7.9	94.8
09/03/2009	332667	234.86	24.90	52	18	3.67	0.085	0.145	0.00	7.9	102
18/03/2009	334908	249.00	25.00	43	18	3.44	0.132	0.170	0.00	7.9	98
24/03/2009	336417	251.50	24.40	50	19	3.81	0.130	0.154	0.00	8.0	104
07/04/2009	340209	281.13	25.00	54	29	4.82	0.126	0.211	0.00	8.1	97.6
14/04/2009	342071	266.00	24.70	71	34	4.88	0.114	0.268	0.00	7.8	101
21/04/2009	343866	256.43	25.00	64	22	4.74	0.129	0.364	0.00	7.9	104.8
29/04/2009	345746	235.00	26.00	66	28	3.71	0.140	0.360	0.00	7.7	96.8
06/05/2009	346939	170.43	23.60	77	35	3.97	0.159	0.409	0.01	7.8	109
12/05/2009	348555	269.33	24.30	60	38	4.15	0.113	0.230		7.7	109.6
19/05/2009	350030	210.71	23.20	68	45	5.39	0.125	0.029		8.0	102
26/05/2009	351597	223.86	24.60	68	40	8.07	0.124	0.206	0.03	7.8	103.6
03/06/2009	353721	265.50	25.80	68	37	4.25	0.344	0.183		7.2	101
09/06/2009	355513	298.67	25.90	54	26	4.43	0.106	0.309		7.6	112.6
16/06/2009	357714	314.43	25.20	18	12	2.98	0.010	0.116		7.5	90.3
22/06/2009	359354	273.33	26.00	73	41	3.73	0.104	0.525		7.4	108
07/07/2009	364216	328.57	26.10	75	19	3.75	0.219	0.284		7.7	105.2
14/07/2009	365879	237.57	24.90	48	19	3.54	0.177	0.244		7.4	106.2
20/07/2009	367286	234.50	26.00	68	26	3.47	0.076	0.194		7.4	116.4
28/07/2009	369143	232.13	25.80	53	17	3.95	0.160	0.336		7.6	110
05/08/2009	370833	211.25	26.00	74	18	4.07	0.113	0.323		7.5	108
10/08/2009	372057	244.80	25.70	66	24	3.35	0.012	0.155	0.07	7.5	101
18/08/2009	373831	221.75	26.00	55	19	3.50	0.188	0.282		7.4	111.4
25/08/2009	375211	197.14	25.60	66	25	4.60	0.108	0.160		7.5	109
08/09/2009	378067	207	25.7	50	18	3.91	0.14	0.186		7.60	105.00
15/09/2009	379451	198	26.6	56	21	2.98	0.30	0.383		7.30	109.60
22/09/2009	380776	189	26.5	44	18	3.83	0.07	0.372	0.05	7.40	99.20
29/09/2009	382652	268	26.6	61	27	4.25	0.10	0.428		7.49	103.00

†Drinking Water limits (according to the European Communities (Drinking Water) Regulations 2007 (S.I. No. 106/2007)

§Maximum values + 20% recorded during baseline monitoring (by T.J. O'Connor and Associates, Cavan County Council and National Water Monitoring Committee) prior to establishment of treatment plant

Values highlighted in red are exceedances in the maximum values recorded in 2000-2003

Apparent colour is the colour of an unfiltered sample containing suspended and dissolved solids

True colour is the colour of a filtered sample with the suspended solids removed

***This result appears to be an error

External laboratory analysis

Analysis of raw water samples has been carried out periodically since July 2007 by City Analysts. Results are presented in Table 6.

Table 6 Raw water results (City Analysts)

Parameter	Units	13/07/2007	23/11/2007	07/03/2008	10/10/2008	09/04/2009	07/05/2009	MAX	DW limits
Nitrate	**mg/L N**	<2	<2	<0.063	<2	<2	<2	**0.72**	**50**
Orthophosphate	**mg/L P**	<0.163	<0.163	0.003	<0.49	<0.163	<0.163	**0.0444**	
Ammonia	**mg/L N**	<0.102	0.171	0.134	<0.102	0.264	0.102	**0.36**	
Conductivity	**µS/cm**	248	268	232	272	211	216	**382.8**	**2500**
Turbidity	**NTU**	2.18	3	3.5	2.4	4.3	5.1	**22.8**	
pH	**pH units**	7.55	7.65	7.81	6.9	7.89	7.73	**9.36**	**6.5-8.0**
Colour (Apparent)	**Hazen**	66	22	39	19	49	62	**106.8**	
Colour (True)	**Hazen**	5	7	79	44	9	27	**22.8**	
Total Coliforms	**MPN/100 mL**	62	57.6	166	<1	59	6.3	**91.2**	**0**
Faecal coliforms	**cfu/100mL**	0	3	65	0	16	0	**45.6**	**0**
E coli	**MPN/100mL**					9.8	3.1	**69.6**	**0**
TOC	**mg/L**	7.9	7.62		6.74	6.08	6.63	**24**	
DOC	**mg/L**	7.87	7.55	5.47	6.7	6.05	5.35	**9.6**	
Total Manganese	**mg/L**	0.008	0.195			n/a	0.327	**0.355**	**50**
Dissolved Manganese	**mg/L**	0.008	<0.001			n/a	<0.5	**0.0048**	

DW limits = Limits listed in European Communities (Drinking Water) Regulations, 2007 [S.I. No. 106/2007]

MAX = Maximum values recorded during baseline monitoring (by T.J. O'Connor, Cavan County Council and National Water Monitoring Committee) prior to establishment of treatment plant. Exceedances of the maximum values are highlighted in red

Apparent colour is the colour of an unfiltered sample containing suspended and dissolved solids

True colour is the colour of a filtered sample with the suspended solids removed

Appendix 3: Environmental guidelines for Agriculture

The following section is based on the National Action Programme that was put into law under the European Communities (Good Agricultural Practice for Protection of Waters) Regulations 2006 which has since been amended by the European Communities (Good Agricultural Practice for Protection of Waters) Regulations 2006. Important sections relating to fertiliser and manure storage and application are presented. The information presented below forms only part of the National Action Programme and should only be interpreted in relation to this source protection study. Many of the measures outlined below help to protect drinking water sources as well as achieving compliance with the Nitrates Directive.

Introduction

The Nitrates Directive (91/676/EEC) – *Council Directive of 12 December 1991 concerning the protection of waters against pollution caused by nitrates from agricultural sources* – has the objective of reducing water pollution caused or induced by nitrates from agricultural sources and preventing further such pollution, with the primary emphasis being on the management of livestock manures and other fertilisers.

Zones

For the purposes of this programme the national territory has been sub-divided into three zones (groups of counties) by reference mainly to soil type, rainfall and length of growing season.

Storage Capacity

Storage capacity on holdings in all zones shall be sufficient for the full housing period and should provide an adequate level of storage for difficult years. Livestock holdings shall have the following minimum storage capacity for bovine livestock manure:

Zones and Minimum Periods of Storage Capacity for Livestock Manure		
Zone A	**Zone B**	**Zone C**
16 weeks	**18 weeks**	**20* or 22 weeks weeks**
Carlow	Clare	Cavan
Cork	Galway	Donegal*
Dublin	Kerry	Leitrim*
Kildare	Limerick	Monaghan
Kilkenny	Longford	
Laois	Louth	
Offaly	Mayo	
Tipperary	Meath	
Waterford	Roscommon	
Wexford	Sligo	
Wicklow	Westmeath	

Periods when land application of fertilisers is prohibited

The periods during which the application to land of certain types of fertiliser will be prohibited (both dates inclusive) are as follows:

Zones	**Chemical Fertiliser**	**Organic Fertiliser**	
		All Organic Fertilisers excluding Farmyard Manure	**Farmyard Manure**
	Grassland and Other Land	**All Land**	
A	15 Sept. to 12 Jan.	15 Oct. to 12 Jan.	1 Nov. to 12 Jan.
B	15 Sept. to 15 Jan.	15 Oct. to 15 Jan.	1 Nov. to 15 Jan.
C	15 Sept. to 31Jan.	15 Oct. to 31 Jan.	1 Nov. to 31 Jan.

Distances from a water body and other issues

1. Chemical fertiliser shall not be applied to land within 1.5 m of a surface water body.

2. Organic fertilisers or soiled water shall not be applied to land within:

- 200 m of the abstraction point of any surface watercourse, borehole, spring or well used for the abstraction water for human consumption in a water schemes supplying more than 100 m^3 per day or serving more than 500 persons
- 100 m of the abstraction point of any surface watercourse, borehole, spring or well used for the abstraction water for human consumption in a water schemes supplying more than 10 m^3 per day or serving more than 50 persons
- 25 m of a borehole, spring or well used as a drinking water source
- 20 m of a lake shoreline
- 15 m of exposed cavernous (karstified) limestone or karst limestone features such as swallow holes and collapse features
- 5 m of a surface watercourse, other than those mentioned above

3. Farmyard manure shall not be stockpiled on land within:

- 250 m of any surface water body or borehole, spring or well used for the abstraction of water for human consumption in a scheme supplying more than 10m^3 per day or serving more than 50 persons
- 50 m of a borehole, spring or well used for the abstraction of water for human consumption other than a borehole, spring or well

- 50 m of exposed cavernous (karstified) limestone features such as swallow holes and collapse features
- 20 m of a lake shoreline
- 10 m of a surface watercourse

Requirements as to the manner of application of fertilisers, soiled water etc.

1. Fertiliser shall be applied to land in as accurate and uniform a manner as is practically possible.
2. Fertiliser shall not be applied to land where
3. Fertilisers shall not be applied to land when:

- the land is waterlogged
- the land is flooded or likely to flood
- the land is frozen or snow-covered
- heavy rain is forecast within 48 hours
- the ground slopes steeply and where, taking into account factors such as proximity to bodies of waters, soil condition, ground cover and rainfall there is significant risk of causing water pollution.

4. Soiled water shall not be applied to land at any one time in quantities which exceed in any period of 42 days:
   - a total quantity of 50,000 litres per hectare
   - a total quantity of 25,000 litres per hectare in areas identified by the Geological Survey of Ireland as “Extreme Vulnerability Areas on Karst Limestone Aquifers, unless the land has a consistent minimum thickness of 1 m of soil and subsoil combined.

Rural Environmental Protection Scheme (REPS)

The Rural Environmental Protection Scheme (REPS) rewards farmers for farming in an environmentally friendly manner. There are a number of measures in the REPS scheme that can be valuable tools in the protection of water resources. Standard Measure 1 (REPS 4) relating to Nutrient Managing Planning sets out buffer zones relating to spreading and storage of nutrients on the farm. Standard Measure 3 (REPS 4) relating to the protection and maintenance of watercourses, waterbodies and wells also contains valuable information relating to the protection of the water resource on the farm.

While farmers operating outside of the REPS scheme are not obliged to follow any of the measures outlined in the scheme the implementation of these or similar measures could be beneficial to water quality in the area.

Below are some of the relevant sections from REPS 4. These details should be interpreted in conjunction with a full copy of the REPS handbook and a REPS planner where appropriate.

Standard Measure 1

Buffer Zones Applicable when Farm Yard Manure (FYM) is stored in a Field (Farmers Handbook for REPS 4)

- The extraction point of any water supply source providing $10m^3$ or more of water per day, or serving 50 or more people (250 m)
- The extraction point for any other water supply for human consumption (50 m)
- Exposed cavernous or karstified limestone features (such as swallow holes or collapse features) (50 m)
- Any surface watercourse where the slope to the watercourse exceeds 10% (10 m)
- Any other watercourse (10 m)
- Any open drain (10 m)

Buffer Zones for spreading Organic Fertilisers (Farmers Handbook for REPS 4)

- The extraction point of any water supply source providing $100m^3$ or more of water per day, or serving 500 or more people (200 m)
- The extraction point of any water supply source providing $10m^3$ or more of water per day, or serving 50 or more people (100 m)
- The extraction point for any other water supply for human consumption and all wells (25 m)
- Lake Shores (20 m)

- Exposed cavernous or karstified limestone features (such as swallow holes or collapse features) (15m)
- Any surface watercourse where the slope to the watercourse exceeds 10% (10 m)
- Any other watercourse (5 m)
- Any open drain (5 m)

Precautions for chemical fertilisers

- Never apply fertilizer within 1.5 m of any watercourse or waterbody.

Other information

- Do not store or open baled silage within 20 m of watercourses and water bodies or within 50 m of wells.

Standard Measure 3

- Do not allow cattle to get within 1.5 m of watercourses. Fences must be at least 1.5m from the top of the bank of the watercourse.
- Where it is not feasible to provide a piped water supply for animals, access to drinking points can be provided. These points must be fenced so that the animals cannot move upstream or downstream or stand in the water.
- Herbicides, pesticides or chemical fertilisers must not be applied within 1.5 m of watercourses or waterbodies.
- Under Measure 3 there are also measures which facilitate the widening of watercourse margins and the establishment of planted buffer strips.