Preliminary Report on Source Protection

Billis Lavey Group Water Scheme

County Cavan

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Executive Summary

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, emphasising prevention rather than cure in relation to raw water quality. The National Source Protection Pilot Project (2005-2009) overseen by the National Centre for Freshwater Studies (now the Centre for Freshwater and Environmental Studies) at Dundalk Institute of Technology represents a model for best practice for the implementation of source protection in Ireland and was designed for replication by group water schemes around the country.

This report provides a physical site description of the Billis Lavey Group Water Scheme (GWS) catchment and explains the relevance to water quality (Section 4), discusses the potential impact of land use on raw water quality (Section 5), evaluates available relevant water quality data (Section 6) and provides recommendations to best manage concerns relating to source protection (Section 7).

Billis Lavey GWS abstract their raw water from the eastern lake of the Nadregeel Loughs, located approximately 17 km south-east of Cavan Town, County Cavan. The two lakes that comprise the Nadregeel Loughs are connected via a man-made channel that links their northern shores. The lakes have a combined surface area of approximately 84.6 ha and a catchment area of approximately 14.6 km^2. A total of five streams flow in to the two lakes, with a single outflow stream exiting the eastern lake from its eastern shore. A proportion of the town of Ballyjamesduff is located within the south-west corner of the catchment area.

The bedrock underlying the catchment is made up of five geological formations which are typically comprised of sedimentary and volcanic rocks. The aquifer present in the catchment is a poor aquifer that is generally unproductive except for local zones. Subsoils within the catchment are dominated by till derived from sandstone and shales, whilst the soils are typically poorly-draining and non-calcareous. Much of the central area of the catchment is classified as being of moderate groundwater vulnerability with areas of the three highest vulnerability classifications (high, extreme and E: rock at or near the surface or karst) also present in the north and south of the catchment where elevation is higher. The poor-draining soils in association with the groundwater vulnerability classifications and the relatively high dwelling density (with many dwellings likely serviced by domestic wastewater treatment systems) have contributed to the Very High and High Risk of nutrients and bacteria contaminating surface waters within the catchment through either surface water or groundwater pathways.

The agricultural activities undertaken within the catchment area are also likely to contribute contaminants to both surface waters and groundwaters within the catchment via diffuse pathways, particularly if the pasture lands are frequently enriched with slurry, manure or artificial fertiliser.

Raw water True Colour values exceeded the Surface Water Regulations (1989) parametric value for Class A1 waters on 92 % of sampling occasions. These True Colour values, in association with relatively high Total Organic Carbon levels observed in the raw water have contributed to the occasionally high Trihalomethane (THM) concentrations, although the Drinking Water Regulations (2007 and 2014) were not exceeded on any occasion. However, THM sampling frequency may not be sufficient to identify whether the THM parametric value is being exceeded.

The Surface Water Regulations (1989) parametric value for Manganese was exceeded on 91 % of occasions, with the average value recorded over the sampling period being over three times the parametric value. Manganese occurs naturally in soils and groundwaters and subsequently there are limited source protection measures available that may reduce levels to within the Surface Water Regulations (1989).

Nutrient levels within the Nadregeel Loughs, whilst not excessive, do represent a significant risk to raw water quality. The average Total Phosphorus value for the sampling period places Nadregeel Loughs within in the moderate quality class for Total Phosphorus, however, Total Phosphorus concentrations have exceeded levels which have been observed to contribute to water quality deterioration and eutrophication on 88 % of sampling occasions. In addition to these elevated Total Phosphorus levels, Total Oxidised Nitrogen values have also been frequently high, meaning that the two key nutrients for plant and algal growth, nitrogen and phosphorus, are readily available within the Nadregeel Loughs. Frequent algal blooms can have significant implications for water quality and potential health implications for consumers and although no algal data have been provided for this report, potentially harmful blue-green algal blooms have been reported in the past.

Given the relatively high density of dwellings and subsequently high numbers of on-site waste water treatment systems, there are two likely key sources of nutrients within the Erne Valley GWS catchment: diffuse pollution from agricultural practices; and point source pollution from septic tanks/wastewater treatment systems.

Although there is limited intensive agriculture within the immediate surrounds of the western lake of the Nadregeel Loughs, the agricultural activities undertaken within the catchment area and the spreading of slurry within the catchment is likely to contribute to the elevated nutrient levels observed within the lakes.

The relatively high dwelling density coupled with the Very High or High Risk of nutrients and bacterial contamination of water courses from domestic wastewater treatment systems means that the correct management of septic tanks/wastewater treatment systems is very important within the Billis Lavey GWS catchment to maintain good raw water quality.

Given the physical site and water quality assessments undertaken through this report, the following recommendations are made in order to improve source protection and maintain high quality raw water supplies:

1. Put Source Protection on the agenda

Including source protection issues on the agenda of committee meetings increases the profile and awareness of source protection issues within the Billis Lavey catchment, and brings into focus the recommendations made within this report. Developing a protocol for dealing with potential pollution incidences would be a good first step for the committee to address.

2. Consider initiating a short-term Trihalomethane monitoring programme

Although Trihalomethane (THM) concentrations have not exceeded the Drinking Water Regulations (2007 and 2014), despite sampling frequency being low, levels have been high on occasion. It is recommended that a one year monitoring programme is instigated, with sampling frequency focussed on the period between late summer and early winter when the possibility of THM formation is likely to be greatest as a result of high True Colour and organic content within the raw water supply.

3. Review the recommendations made in the Billis Lavey *Cryptosporidium* Risk Assessment Report

Billis Lavey GWS has been classified as being at Moderate Risk of *Cryptosporidium* contamination. The recommendations made within the C*ryptosporidium* Risk Assessment report should be reviewed and implemented if not already applied.

4. Engage with forestry owners and managers

Identifying future forestry management plans and actions will enable Billis Lavey GWS to assess the risk to raw water quality at its current abstraction point associated with each forestry management action and to develop its own management action plan in response to the potential scenarios outlined in the risk assessment.

5. Initiate a communications drive

The Scheme should undertake a communications initiative to remind Scheme members of their legal obligations with regards to nutrient enrichment practices, to recommend Good Agricultural Practices and to highlight the importance of waste water treatment system management. Highlighting the importance of Scheme members' actions in regards to improving raw water quality could also raise awareness for facilitating improvements in environmental status of all the water bodies within the Billis Lavey GWS catchment.

Blatant disregard of good agricultural practices and regulations regarding the spreading of slurry/manure/artificial fertiliser on land adjacent to water courses should be reported to Cavan County Council.

Consideration should be given to engaging local schools to take an interest in local water resource management issues and to encourage students to undertake projects that can ultimately help raise the profile of Billis Lavey GWS and the source protection measures required to help improve the environmental status of the catchment area whilst also providing cost-savings in the water treatment process.

6. Engagement of Cavan County Council

Given the location of the Local Authority abstraction point in the western lake of the Nadregeel Loughs, Billis Lavey GWS should engage with Cavan County Council regarding the communication of Good Agricultural Practices and domestic wastewater treatment system maintenance in order to work together to raise the profile of these issues and to attempt to increase the potential for community uptake. This is of particular importance where dwellings are located within the catchment and may be impacting on raw water quality but are not members of the Billis Lavey GWS and its distribution network.

1.0 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. Source protection should be the first barrier in a multi-barrier approach to providing safe drinking water. In its simplest form, source protection emphasises prevention rather than cure in relation to water quality. A clean water source will help in the long-term provision of safe and cheap potable water. This approach involves managing any pollution in the raw water catchment area.

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, County Monaghan (2005-2009) was established by the National Rural Water Monitoring Committee and was overseen by the National Centre for Freshwater Studies (now the Centre for Freshwater and Environmental Studies, CFES) at Dundalk Institute of Technology. The objectives of the pilot project were to assess water quality within the Milltown Lake catchment, identify sources of contamination and implement remediation measures to protect and enhance water quality in the lake. The project represents a model for best practice for the implementation of source protection in Ireland and was designed for replication by other group water schemes around the country. It is in the interest of privately-source group water schemes to carry out assessments to determine the potential for nutrient enrichment and biological contamination (e.g. *Enterococcus* species, *Escherichia coli, Cryptosporidium* species) of their water supplies, and to meet application conditions for a Water Services Licence under the Water Services Act (2007).

This report provides a physical site description of the Billis Lavey Group Water Scheme (GWS) catchment and explains how this is relevant to water quality. The potential impact of land use is discussed and available raw water quality data is evaluated. Finally, major concerns relating to source protection are highlighted and recommendations are made as how best to manage these concerns in the future.

2.0 Methods

2.1 Catchment delineation and description

The outline of the catchment was defined using the available contours on the Map Genie ArcGIS basemaps available from Ordinance Survey Ireland and provided under license by the Geological Survey of Ireland. A number of national digital Geographical Information System Layers (GIS) were available from a various sources (Table 1), and were clipped to the catchment area of Billis Lavey GWS. This allowed detailed descriptions of, for example, CORINE land cover, soils and geology, as well as illustrating the stream and water body network within the catchment.

Table 1: National GIS datasets used to describe the catchment

Dataset	Source	Description
Streams/Lakes/Rivers	EPA Ireland	Location of streams, lakes and rivers
CORINE	EPA Ireland	Image of land cover based on satellite imagery
Bedrock Geology	Geological Survey of Ireland (GSI)	Map (1:100,000 scale) of Irish bedrock geology)
Aquifer Bedrock	GSI	Information on the quality of groundwater aquifers
Aquifer Vulnerability	GSI	Information on the connectivity between contaminants and aquifers
Soils	GSI and Teagasc	Information on soil type
Subsoils	GSI and Teagasc	Information on subsoil type

2.2 Water Quality Data

Raw water quality data were provided by Veolia, the service provider for Billis Lavey GWS, through the National Federation of Group Water Schemes in the form of Monthly Status Reports. Data on the Nadregeel Loughs was also provided by Cavan County Council and the Environmental Protection Agency. Sampling timeframes vary from each source, with data available from July 1999 to May 2014.

Billis Lavey GWS abstract their raw water from the eastern lake of Nadregeel Loughs and raw water samples are taken 'from the tap' at the treatment plant prior to the treatment process.

In contrast, Cavan County Council abstracts water from the western lake of the Nadregeel Loughs, and raw water samples are typically taken from two sampling locations within the western lake. For the purpose of this report, because the data typically did not vary between the two Cavan County Council sampling locations, an average value was calculated and it is this average value that is presented for County Council data in Section 6.0.

Parameters relevant to source protection were taken from the overall data set, analysed temporally and interpreted to highlight potential water quality issues in the Billis Lavey GWS catchment and their potential causes and impacts.

3.0 Overview of the Billis Lavey GWS catchment and the Water Framework Directive

Under the Water Framework Directive, the island of Ireland is divided into eight River Basin Districts (RBDs), two of which are international with boundaries shared by the Republic of Ireland and Northern Ireland. The Billis Lavey GWS catchment lies on the boundary of three River Basin Districts: The far north of the catchment is within the North West International River Basin District (NWIRBD); the south-western area of the catchment, including the western lake of Nadregeel Lough lies within the Shannon International River Basin District; and the central and eastern area of the catchment lies within the Eastern River Basin District. Each RBD is subdivided into Water Management Units

(WMU), and the Billis Lavey GWS catchment is located within three Water Management Units (Figure 1): Blackwater North WMU, Inny WMU and Woodford WMU. An Action Plan for the Inny and Woodford WMUs are available from www.wfdireland.ie, however, there seems to be no Action Plan available for the Blackwater North WMU, within which the Billis Lavey GWS abstraction point is located. Subsequently there is limited information available on the current status of Nadregeel Lough, although the lake was classified as being moderately and strongly eutrophic (high to very high levels of nutrients) in 2005 and 2006 respectively (Clabby *et al.*, 2008).

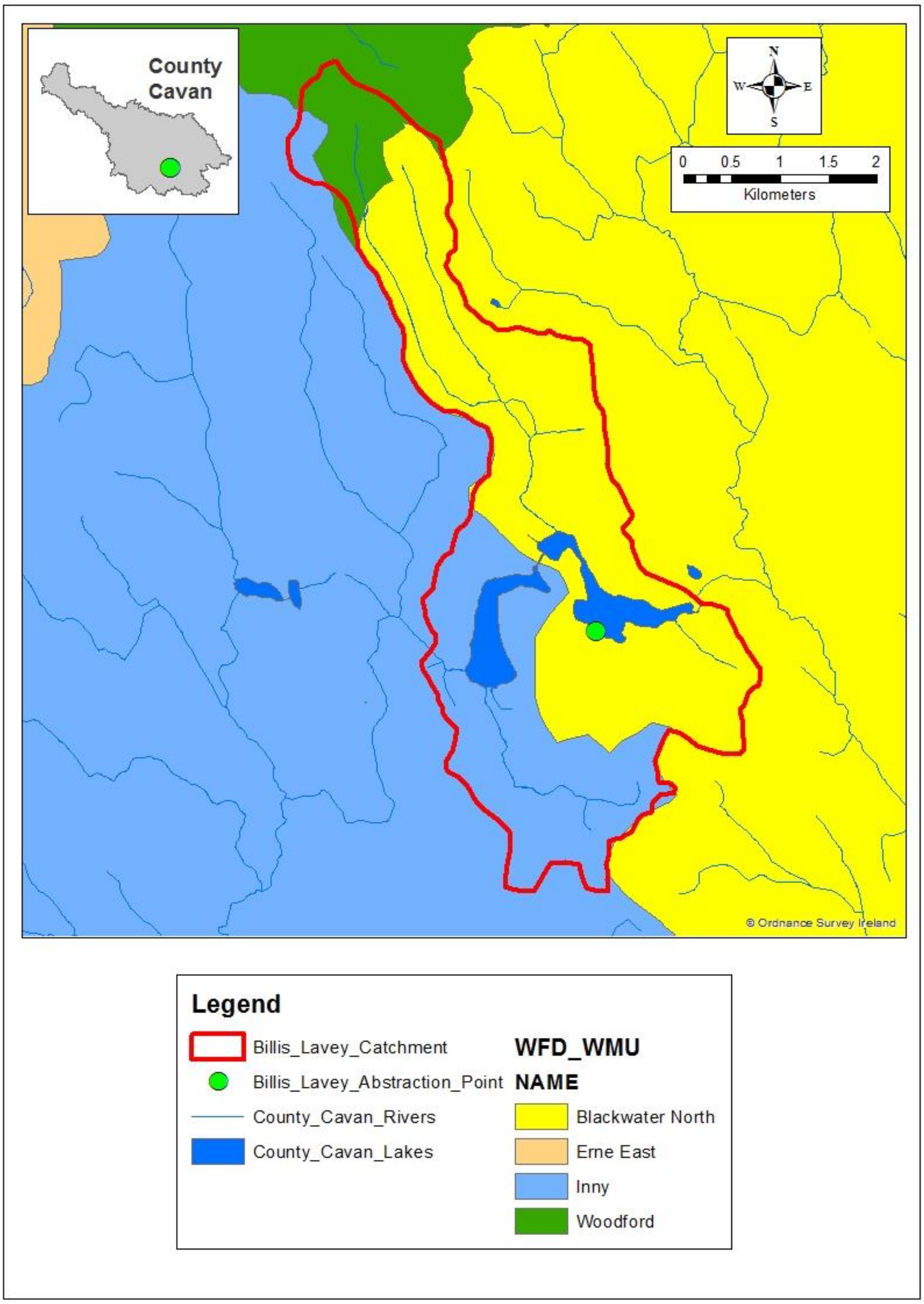

Figure 1: Water Framework Directive Water Management Units located within the Billis Lavey GWS catchment.

4.0 Physical Site Description

4.1 Catchment location and outline

Billis Lavey Group Water Scheme is located approximately 17 km south-east of Cavan Town, and approximately 8 Km north-east of Virginia in County Cavan. The scheme extracts its water from the eastern lake of the Nadregeel Loughs, a pair of lakes joined by a man-made channel that links their northern shores (Figure 2). The two lakes cover a combined area of approximately 84.6 ha.

Water flows into the western lake via three inflow streams located to the southern and western shores. Two further inflow streams flow into the eastern lake: one from the north and one from the south-east. A single outflow stream flows westwards from the eastern lake, eventually entering Lough Ramour approximately 7.5 km to the south-east of the Nadregeel Loughs. The catchment covers an area of approximately 14.6 km^2.

A proportion of the town of Ballyjamesduff is located within the Billis Lavey GWS catchment area. The town has a public sewage network, but treated effluent is discharged into a stream that is outside of the Billis Lavey GWS catchment.

4.2 Bedrock geology

The bedrock underlying the Billis Lavey GWS catchment consists of a number of geological formations (Figure 3). The Lough Avaghon Formation, made up of sandstone and microconglomerate (sedimentary rock consisting of relatively coarse sand grains within a very fine silt or clay matrix) is present in the far north of the catchment. Immediately to the south of the Lough Avaghon Formation, the Carickatee Formation is present, consisting of black shale, mafic volcanics (igneous rocks that are dominated by silicates and are often rich in magnesium and iron oxides) and tuffs (soft, porous rock usually formed by the compaction and cementation of volcanic ash and dust). The central region of the catchment, including both of the Nadregeel Loughs is underlain by the Oghill Formation which is comprised of sandstone and microconglomerate. To the south of the Nadregeel Loughs, a band of the Kehernaghkilly Formation, consisting of black shale and minor rhyolitic tuff (tuff containing pumiceous, glassy fragments and scoriae – an igneous rock containing many bubble-like cavities called vesicles), runs south-west to north-east. The far south of the catchment is underlain by the Castlerahan Formation which is comprised of dark quartz greywacke and conglomerate.

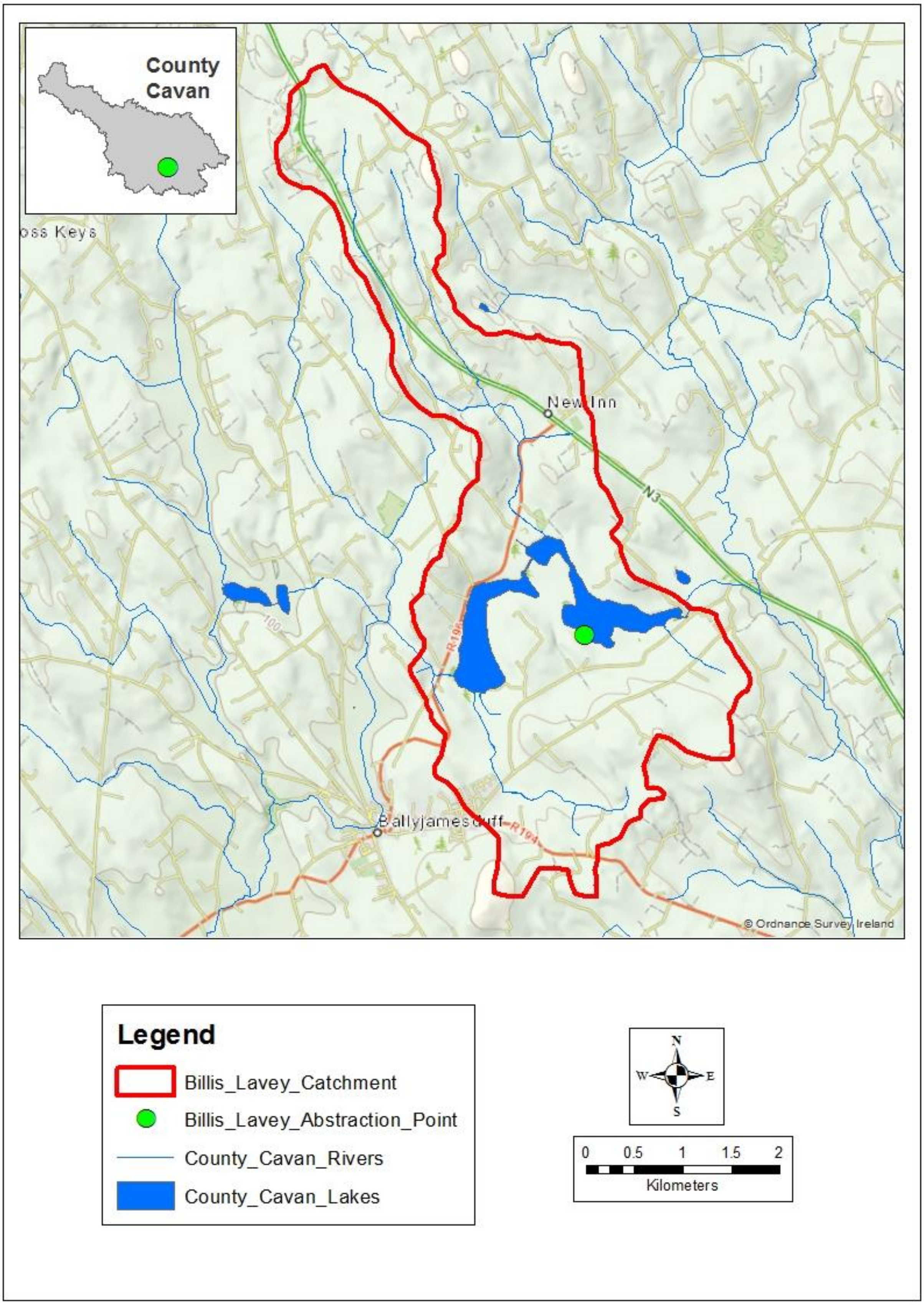

Figure 2: Surface water catchment area for the Billis Lavey GWS.

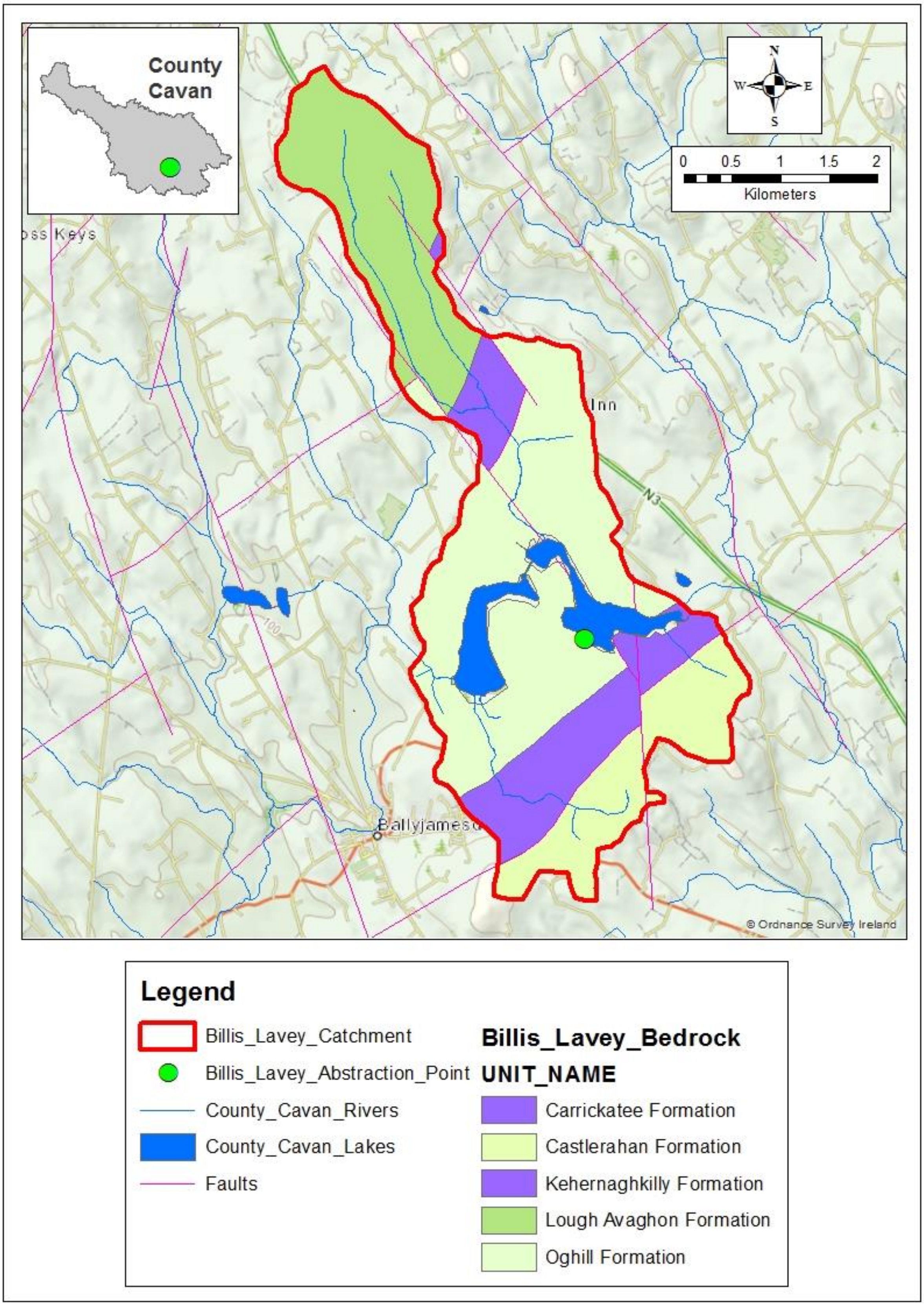

Figure 3: Bedrock geology within the Billis Lavey GWS catchment.

4.3 Bedrock aquifers

An aquifer is an underground body of permeable rock or sand/gravel that yields water in sufficient quantities for use

A single aquifer type is present throughout the entire Billis Lavey GWS catchment (Figure 4): a poor aquifer, the bedrock of which is generally unproductive except for local zones. Such aquifers are generally considered as unproductive (i.e. groundwater wells produce low yields), yet are mapped as covering approximately two-thirds of the total land area of Ireland. They are not regarded as important sources of water for public water supply, yet are believed to be important with regard to delivering water (and associated pollutants) to rivers and lakes via shallow groundwater pathways (EPA, 2010).

4.4 Groundwater vulnerability

Groundwater vulnerability refers to the likelihood of surface water contaminants reaching the groundwater store. The vulnerability of groundwater is dependent on three components: 1). the time of travel of infiltrating water (and contaminants); 2). the relative quantity of contaminants that can reach the groundwater; and 3). the contaminant attenuation capacity of the geological materials through which the water and contaminants infiltrate.

Groundwater vulnerability within the Billis Lavey GWS catchment varies between the moderate class and the highest vulnerability classification of E (rock at or near the surface or karst) (Figure 5). This highest classification is present in the southern and northern areas of the catchment where the elevation of the land is highest. Areas of extreme vulnerability are located in the southern, central and northern regions of the catchment. Areas of high vulnerability are present to the south of the Nadregeel Loughs whilst the central and northern regions of the catchment are dominated by an area of moderate vulnerability.

The vulnerability of groundwater is affected by the permeability of the overlying subsoils and soils and the interactions with surface water and groundwater.

4.5 Subsoils

Subsoils lie between the bedrock and soils and are the most important feature in influencing the groundwater vulnerability to pollution as they act as a protective filtering layer, the effectiveness of which depends on their type, permeability and thickness.

The Billis Lavey GWS catchment subsoils are dominated by till derived from Lower Palaeozoic sandstone and shales (Figure 6). Areas of cutover peat are present along some areas of the catchment water courses, in particular the area between the two lakes. Alluvium subsoils are located in in isolated patched in the south of the catchment. An area of made ground which represents the village of New Inn is present to the north-east of the catchment. Bedrock outcrops or subcrops are located in the north and south of the catchment in association with areas classed as having the highest groundwater vulnerability classification of E (rock at or near the surface or karst) (Figure 5).

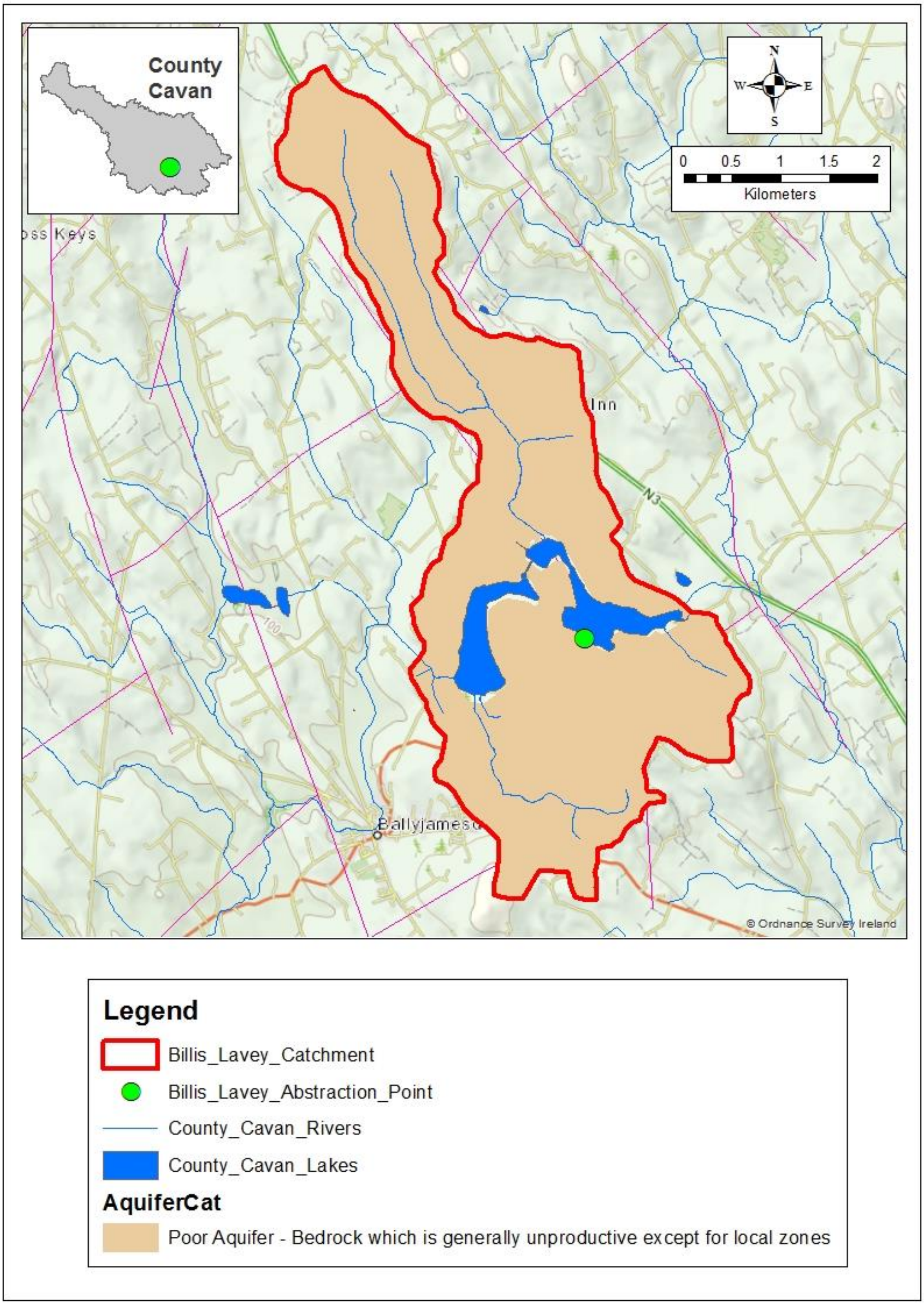

Figure 4: Aquifer types present within the Billis Lavey GWS catchment.

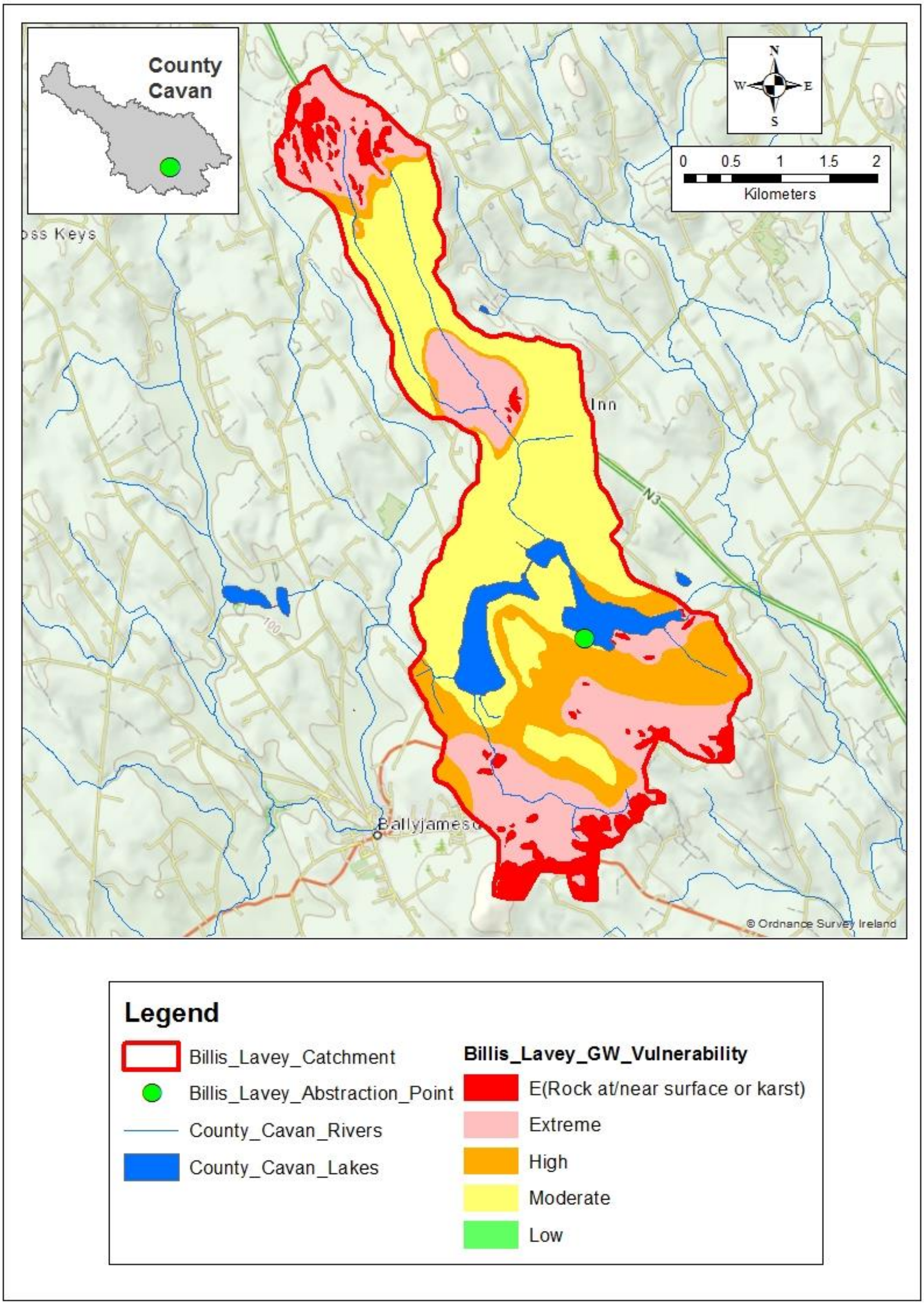

Figure 5: Groundwater vulnerability within the Billis Lavey GWS catchment.

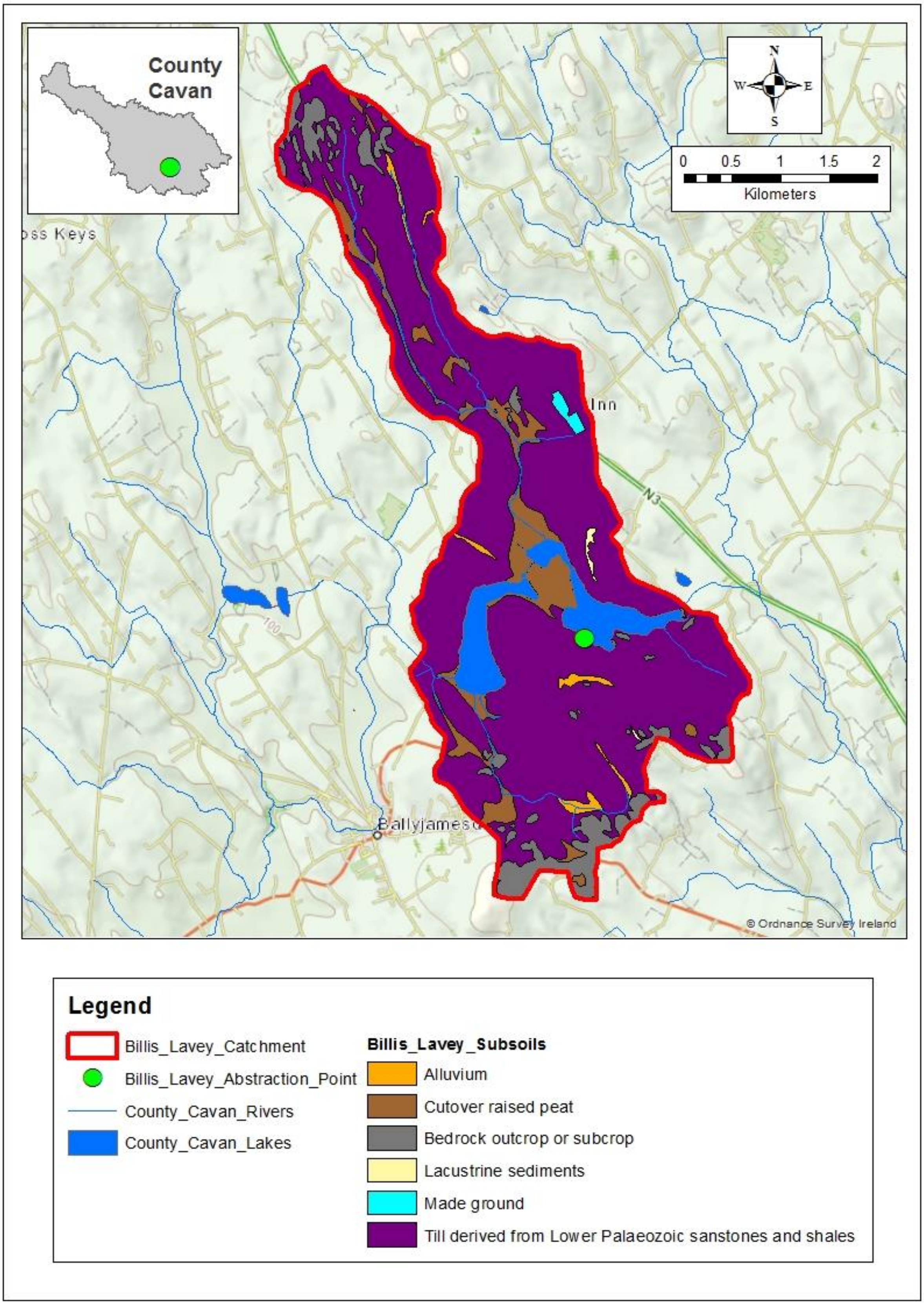

Figure 6: Subsoil deposits within the Billis Lavey GWS catchment.

4.6 Soils

Deep, poorly drained, acid mineral soils are the dominant soil type within the Billis Lavey catchment (Figure 7). Areas of cutaway/cutover peat are located in the vicinity of the water bodies within the catchment, in association with the cutover raised peat subsoils. Isolated areas of mineral alluvium soil are located to the south of the Nadregeel Loughs. Areas of shallow, acidic, well drained mineral soils and shallow, acidic rocky/peaty mineral soil are located in the northern and southern extremities of the catchment in association with the bedrock outcrop or subcrop subsoil classifications (Figure 6).

4.7 Slope and run-off

The slope of the land leading to a water body is an important determinant of the rate at which water and pollutants move into the lake by overland and groundwater flows. Slope can affect the quantity of contaminants entering a water body and thus can influence the quality of the water body. Steep slopes are vulnerable to surface water run-off, particularly if combined with poor draining soils. Soil erosion can also be a problem if vegetation cover is sparse, particularly as a result of overgrazing.

The highest elevation of approximately 210 m occurs in southern and northern areas of the catchment. Hills with an elevation of approximately 150 m surround the two lakes of the Nadregeel Loughs which are located at an elevation of approximately 100 m.

5.0 Land use within the catchment

5.1 CORINE Land Cover

CORINE land cover is a map of the European environmental landscape based on the interpretation of satellite images (remote sensing). CORINE stands for ‘Coordination of Information on the Environment’ and the project has resulted in a Europe wide cataloguing of land cover into 44 standard classes. Importantly, land cover is defined as the observed physical cover, as seen from the ground or through remote sensing, including natural or planted vegetation and human constructions (e.g. roads, buildings) which cover the land surface. Therefore water, rock and ice are also included as land cover. Land cover is therefore distinct from land use which is based upon function: the purpose for which the land is being used. CORINE land cover does not include an assessment of land use.

The majority of the Billis Lavey GWS catchment land cover is agricultural, being classified primarily as pasture, with an area of land principally occupied by agriculture with areas of natural vegetation located at the southern extremity of the catchment (Figure 8). An area of discontinuous urban fabric is present to the south-west of the catchment, representing part of the town of Ballyjamesduff. An area of transitional woodland scrub is located between the northern areas of the two lakes, in the vicinity of the man-made channel that connects the lakes.

The management of the risks associated with this land cover classification will form the basis of this source protection report.

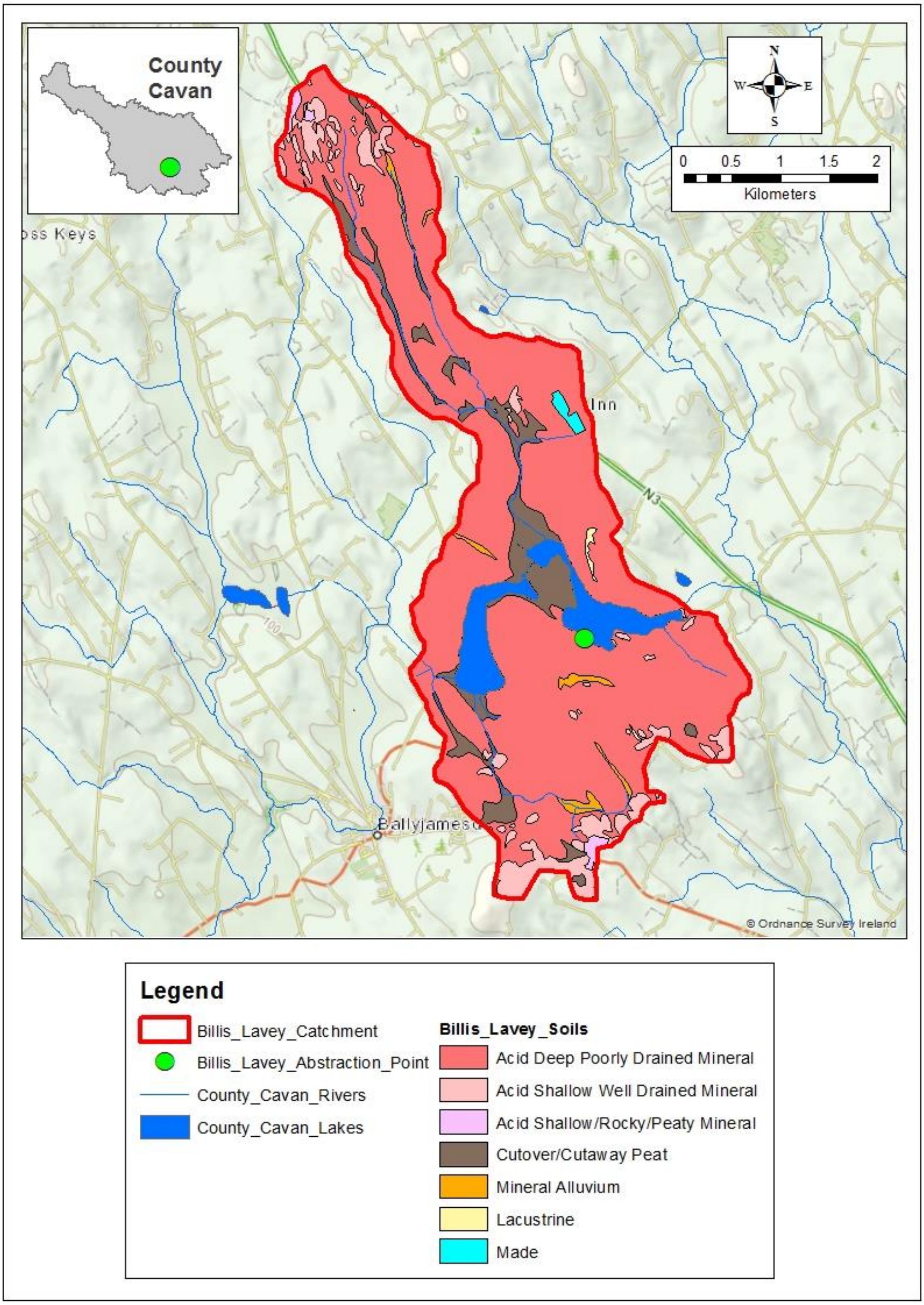

Figure 7: Soil types present within the Billis Lavey GWS.

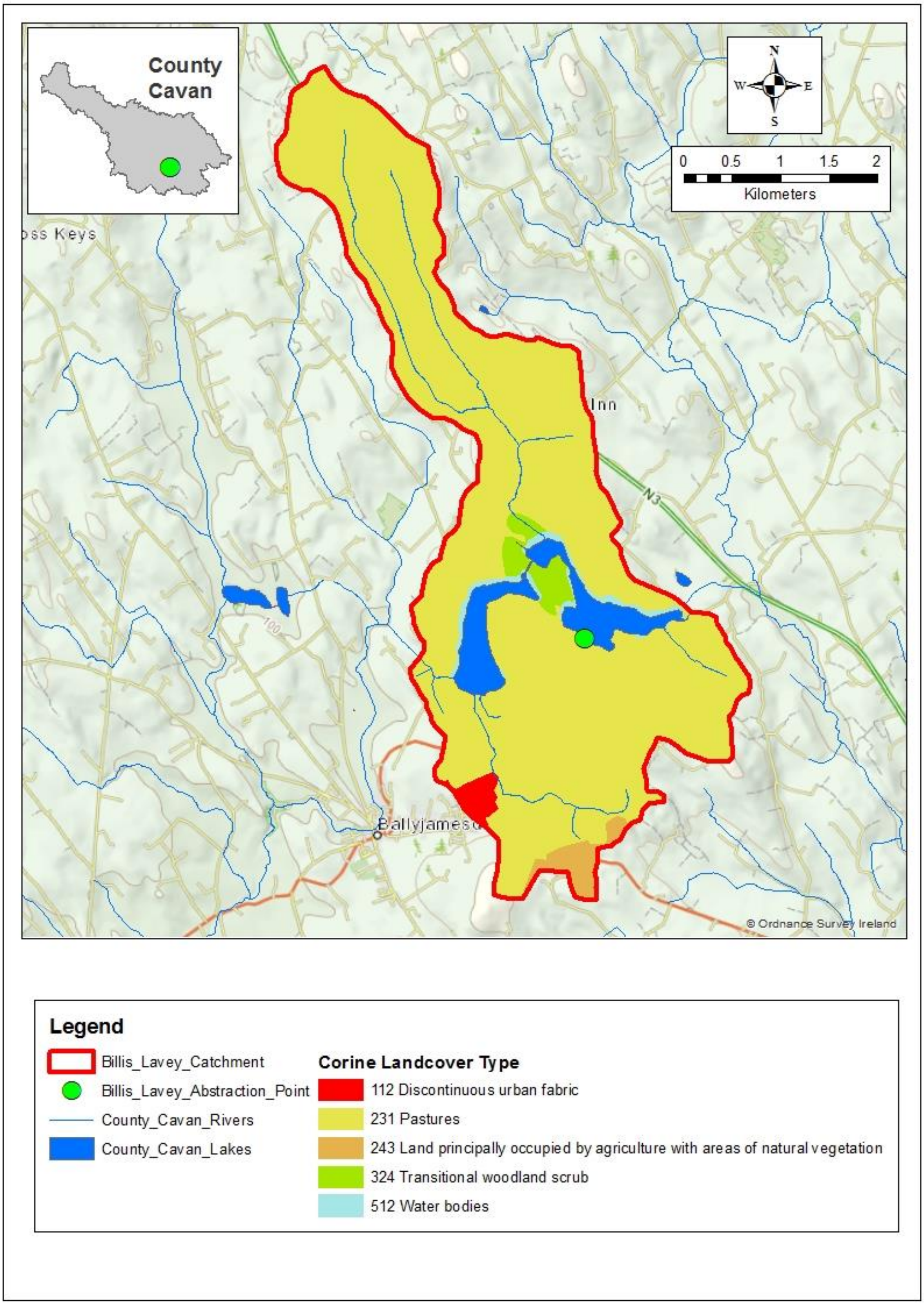

Figure 8: CORINE Land Cover classification within the Billis Lavey GWS catchment.

5.2 Forestry

Forestry plantations may present threats to the quality of water bodies during the planting and early growing phase of a forest as well as during felling. Water quality can be affected by activities such as ground preparation, fertilisation, thinning, felling and construction of forestry roads. The application of fertilisers to young standing stock to enhance growth can lead to excessive phosphorus availability with the potential to increase phosphorus (P) volumes in the run off from planted land. During felling, sediment loss, siltation and nutrient release can also occur. In addition, the exposure of unvegetated soil can lead to the run off of P in soil suspension. The construction of forestry roads causes disturbance, erosion and compaction of the soil surface, resulting in sedimentation and nutrient run-off.

Although not delineated in the CORINE Land Cover map (Figure 8), a small area of commercial coniferous forest is located on the northern shore of the eastern lake of the Nadregeel Loughs, directly opposite the Billis Lavey GWS abstraction point (Figure 9). Given the proximity of the forest to the lake shore and the slope of the land, engagement with the forestry owners and managers is recommended in order to mitigate potential risk of certain management actions impacting on the quality of the Billis Lavey raw water supply.

Figure 9: The Billis Lavey GWS abstraction point and location of commercial coniferous forest on the opposite shore.

5.3 EPA licensed facilities – Integrated Pollution Prevention Control (IPPC)

There is one IPPC licensed facility, a commercial pig farm, within the Billis Lavey GWS catchment area, located to the north-east of the village of New Inn, approximately 350 m from one of the inflow streams of the eastern lake of the Nadregeel Loughs, and approximately 2.5 km to the north of the Billis Lavey abstraction point (Figure 10). Following inspections in 2010, concerns were raised regarding potential discharges to groundwater as a result of land-spreading of organic waste. Subsequent correspondence with the EPA confirmed that issues were addressed and compliance with relevant regulations was achieved.

5.4 Rural housing and on-site wastewater treatment plants

On-site wastewater treatment systems, including septic tanks, can add nutrients, chemicals and pathogenic organisms to water bodies. These risks are particularly elevated when systems are installed in areas of high groundwater vulnerability (i.e. where there is good hydrological linkage between surface water and groundwater) and where soil drainage is poor.

Dwelling density within the Billis Lavey GWS catchment is relatively high, particularly within the south-western corner of the catchment, representing a proportion of the town of Ballyjamesduff. The houses located in the town are serviced by public sewers and the town sewage treatment plant and discharge point is located outside of the Billis Lavey GWS catchment area.

For the remainder of the dwellings in the catchment that are not connected to the Ballyjamesduff sewage system, septic tanks and on-site wastewater treatment systems are the likely sewage treatment mechanisms present.

In association with the Geological Survey of Ireland, the EPA have undertaken an assessment of domestic wastewater risk, giving a relative ranking that nutrients and bacteria from domestic wastewater treatment systems will contaminate surface waters via either surface water or groundwater pathways (EPA, 2013a and b). The majority of the Billis Lavey GWS catchment is classified as Very High Risk in a Non-Sensitive Area. The areas to the immediate west of the town of New Inn and to the north-east of the eastern lake of Nadregeel Loughs are classified as High Risk in a Non-Sensitive Area. The northern area of the eastern lake of Nadregeel Loughs, including the man-made connection between the two lakes, is classified as Low Risk in a Non-Sensitive Area. The relationship between the risk categories of the Billis Lavey GWS catchment and the rest of the local area is best viewed online via the EPA's geoportal: http://gis.epa.ie/Envision.

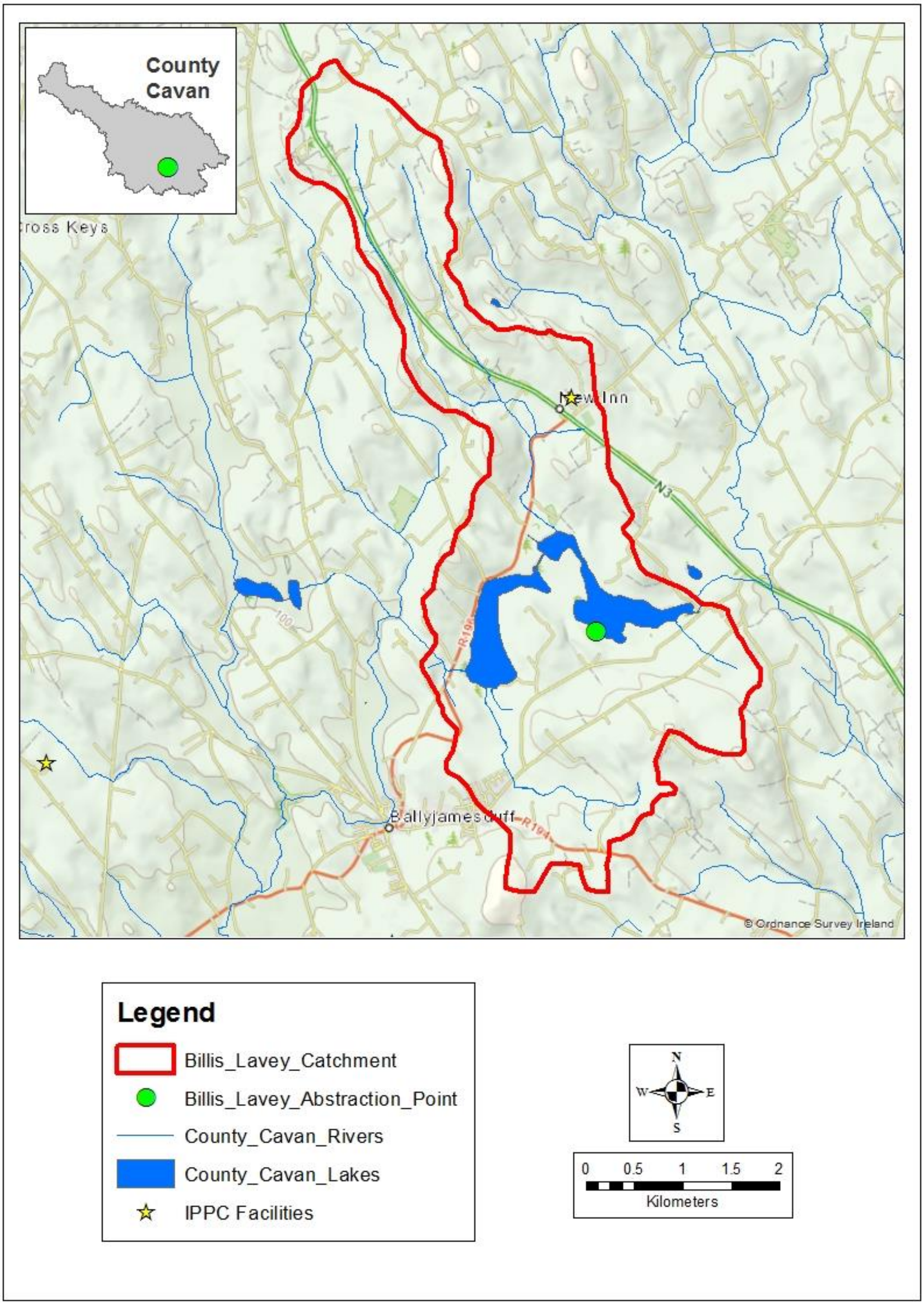

Figure 10: Location of facilities with current Integrated Pollution Prevention and Control License within the Billis Lavey GWS catchment.

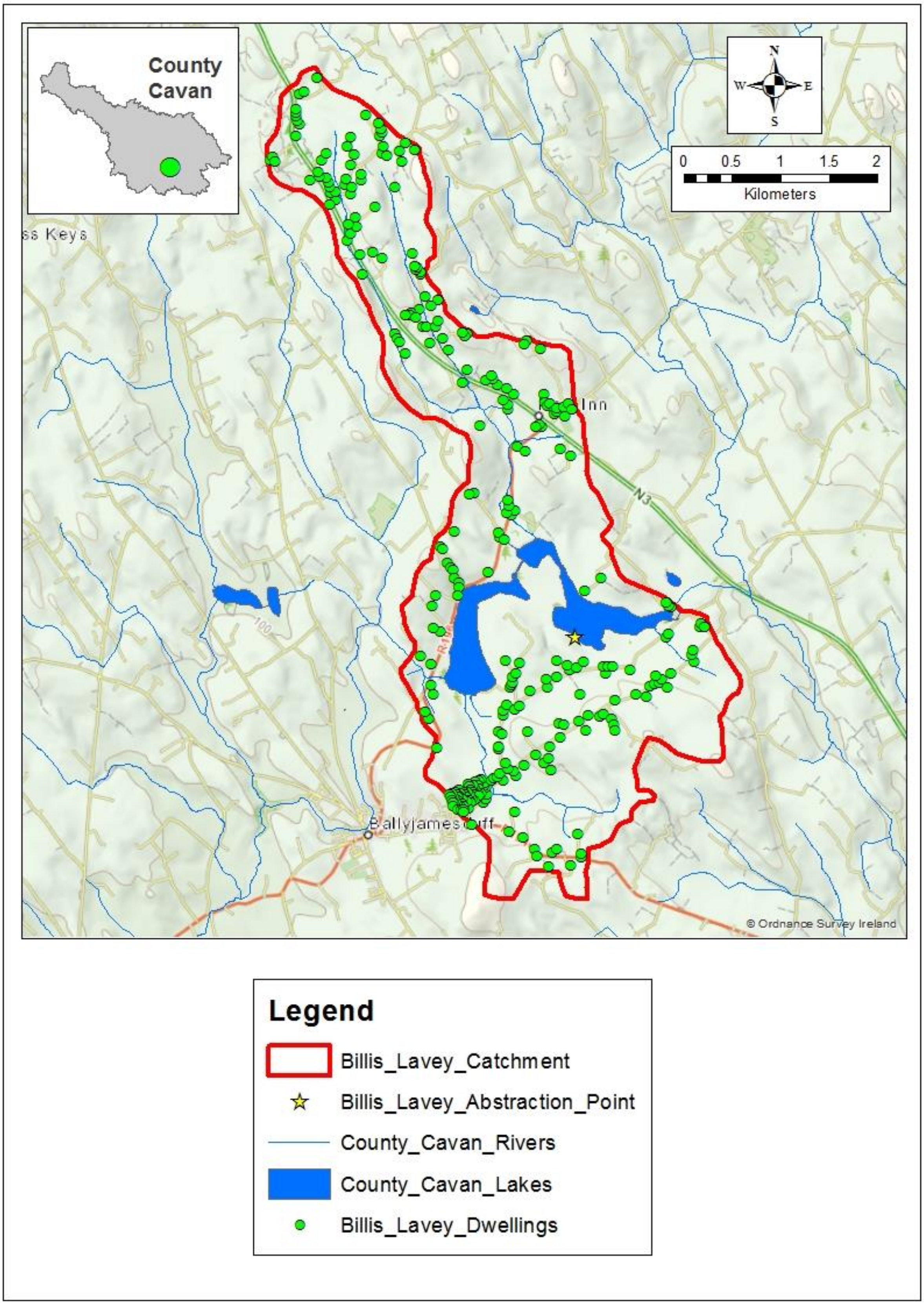

Figure 11: Dwelling density within the Billis Lavey GWS catchment.

5.5 Overall interpretation of catchment land use

Billis Lavey GWS abstract their raw water from the eastern lake of the Nadregeel Loughs, located approximately 17 km south-east of Cavan Town, County Cavan. The two lakes that comprise the Nadregeel Loughs are connected via a man-made channel located at their northern shores. The lakes have a combined surface area of approximately 84.6 ha and a catchment area of approximately 14.6 km^2. A total of five streams flow in to the two lakes, with a single outflow stream exiting the eastern lake from its eastern shore. A proportion of the town of Ballyjamesduff is located within the south-west corner of the catchment area.

The bedrock underlying the catchment is made up of five geological formations which are typically comprised of sedimentary and volcanic rocks. The aquifer present in the catchment is a poor aquifer that is generally unproductive except for local zones. Subsoils within the catchment are dominated by till derived from sandstone and shales, whilst the soils are typically poorly-draining and non-calcareous. Much of the central area of the catchment is classified as being of moderate groundwater vulnerability with areas of the three highest vulnerability classifications (high, extreme and E: rock at or near the surface or karst) also present in the north and south of the catchment where elevation is higher. The poor-draining soils in association with the groundwater vulnerability classifications and the relatively high dwelling density have contributed to the Very High and High Risk of nutrients and bacteria contaminating surface waters within the catchment through either surface water or groundwater pathways. The town of Ballyjamesduff is service by a public sewer network and the treatment plant and discharge point are located outside of the Billis Lavey GWS catchment area. Therefore the probably high number of septic tanks and other on-site wastewater treatment systems likely present within the catchment are likely to contribute to the Very High and High Risk of surface and groundwaters becoming contaminated with nutrients and/or bacteria.

The agricultural activities undertaken within the catchment area are likely to contribute contaminants to both surface waters and groundwaters within the catchment via diffuse pathways, particularly if the pasture lands are frequently enriched with slurry, manure or artificial fertiliser. The Billis Lavey GWS *Cryptosporidium* Risk Assessment (TJ O'Connors and Associates, 2008) concluded that the Billis Lavey GWS treated water supply was classified as being at moderate risk of *Cryptosporidium* contamination. This was largely due to the farming practices within the catchment. It is advised that the recommendations made by this report are reviewed and implemented if not already done so.

The location of a small commercial coniferous forest on the northern shore of the eastern lake of the Nadregeel Loughs has the potential to present a risk to the quality of the Billis Lavey GWS raw water supply under certain management scenarios. Engagement with the forestry owners and managers is advised in or to mitigate these risks. Further details regarding this recommendation are provided in Section 7.0.

An assessment of water quality parameters is provided in Section 6.0.

6.0 Raw Water Quality

Raw water quality data were provided by Veolia, the service provider for Billis Lavey GWS, in the form of Monthly Status Reports through the National Federation of Group Water Schemes (NFGWS). The NFGWS also provided raw water quality data from TJ O'Conner and Associates. Data on Nadregeel Loughs was also provided by Cavan County Council and the Environmental Protection Agency. Sampling timeframes vary from each data source, with data available from July 1999 to May 2014.

Billis Lavey GWS abstract their raw water from the eastern lake of Nadregeel Loughs and raw water samples are taken 'from the tap' at the treatment plant prior to the treatment process.

In contrast, Cavan County Council abstracts water from the western lake of the Nadregeel Loughs, and raw water samples are typically taken from two sampling locations within the western lake. For the purpose of this report, because the data typically did not vary between the two Cavan County Council sampling locations, an average value was calculated and it is this average value that is presented for County Council data below.

Parameters relevant to source protection were taken from the overall data set, analysed temporally and interpreted to highlight potential water quality issues in the Billis Lavey GWS catchment and their potential causes and impacts. On occasion, data from both the Veolia and Cavan County Council sampling has been combined in order to present more complete data sets.

6.1 Raw Water Quality

6.1.1 Colour and Trihalomethanes

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 produce trihalomethanes (THMs) which can be carcinogenic and their removal from drinking water can add significantly to the cost of treatment. The formation potential of THMs can also be correlated with the amount of Total Organic Carbon (TOC) in the raw water supply. For these reasons, high levels of colour should be avoided where possible; however colour can vary greatly as a parameter, depending on quantities of precipitation and run off, leading to spikes in results. Results of colour analyses can be presented as apparent colour (from an unfiltered sample) or true colour (from a filtered sample). Irvine *et al*. (2001) reported that colour in Irish lakes ranged between 5 mg/L mg PtCo L^{-1} to 134 mg/L mg PtCo L^{-1}. The Surface Water Regulations (1989) recommend a value of 20 mg/L mg PtCo L^{-1}/Hazen (True Colour) for A1 waters. The Drinking Water Regulations (2007 and 2014) recommend a parametric value of 100 µg/L for total trihalomethanes.

True Colour data were provided by Veolia from March 2006 to June 2013, although no data were available from May 2003 to March 2006 (Figure 12). Values ranged from a minimum of 3 mg PtCo L^{-1} in November 2007 to a maximum of 130 mg PtCo L^{-1} in January 2010, with an average value of 35 mg PtCo L^{-1} being recorded for the Veolia sampling period. Cavan County Council also monitored True Colour in the western lake of Nadregeel Loughs, with values ranging from a minimum of 6 Hazen (a unit of measurement equivalent to mg PtCo L^{-1}) in September 2010, to a maximum of 176 Hazen in October 2013, with an average value of 42 Hazen recorded for the sampling period of April

2007 to May 2014. True Colour values exceeded the Surface Water Regulations (1989) parametric value on 357 out of 387 sampling occasions (92 % of occasions).

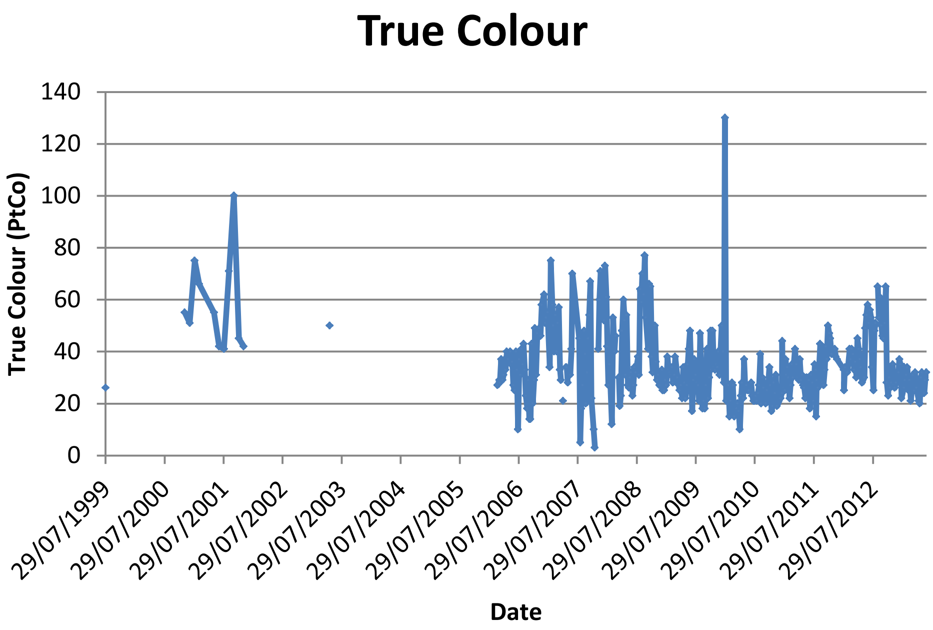

Figure 12: Raw water True Colour from July 1999 until June 2013.

Trihalomethane data were provided for five annual sampling occasions between December 2008 and October 2012 (Figure 13). Values ranged from a minimum of 39 µg/L recorded in August 2011, to a maximum of 90 µg/L recorded in October 2012, with an average value of 53 µg/L recorded for the sampling period. The Drinking Water Regulations (2007 and 2014) were not exceeded on any occasion, however, given the recent high True Colour and the lack of recent Trihalomethane data, the Trihalomethane sampling frequency may not have been sufficient to detect any occasion when the parametric value was exceeded.

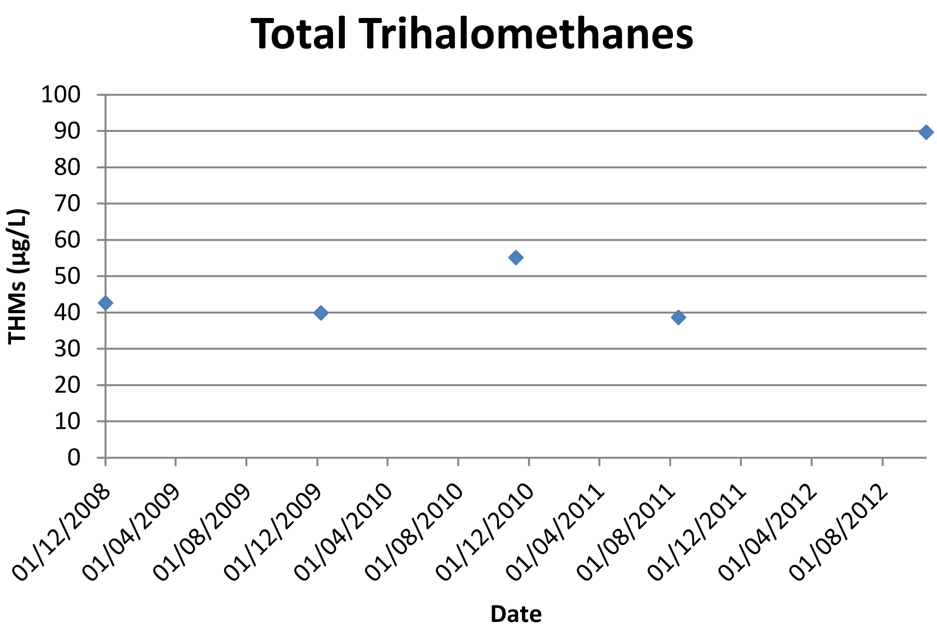

Figure 13: Total Trihalomethane concentrations within the treated water from December 2008 until October 2012.

6.1.2 Total Organic Carbon

Natural Organic Matter (NOM) is the complex of organic material that is found within natural waters which is typically derived from decayed vegetation or microbial decomposition processes. The chlorination of raw water can lead to the production of disinfection bi-products such as Trihalomethanes as a result of the reaction of chlorine compounds with the NOM content of the raw water. Total Organic Carbon (TOC) provides an estimate of the NOM present in a water source and can be used as an assessment of water quality during the treatment process for drinking water. TOC levels within raw water samples from 12 Irish water treatment works were found to range between 3.5 – 14.0 mg/L (Chua, 1996).

TOC was monitored in the raw water on 15 occasions between September 2002 and August 2012, although no data were available from July 2003 to February 2011 (Figure 14). Values ranged from a minimum of 0 mg/L in September 2002 (likely to have been below the limit of detection) to a maximum of 12 mg/L in May 2003, with an average value of 8.73 mg/L recorded for the sampling period. These values are relatively high and, depending on a number of factors such as the levels of chlorination and residence time in the GWS reservoir, are likely to contribute to the formation of THMs in the treated water.

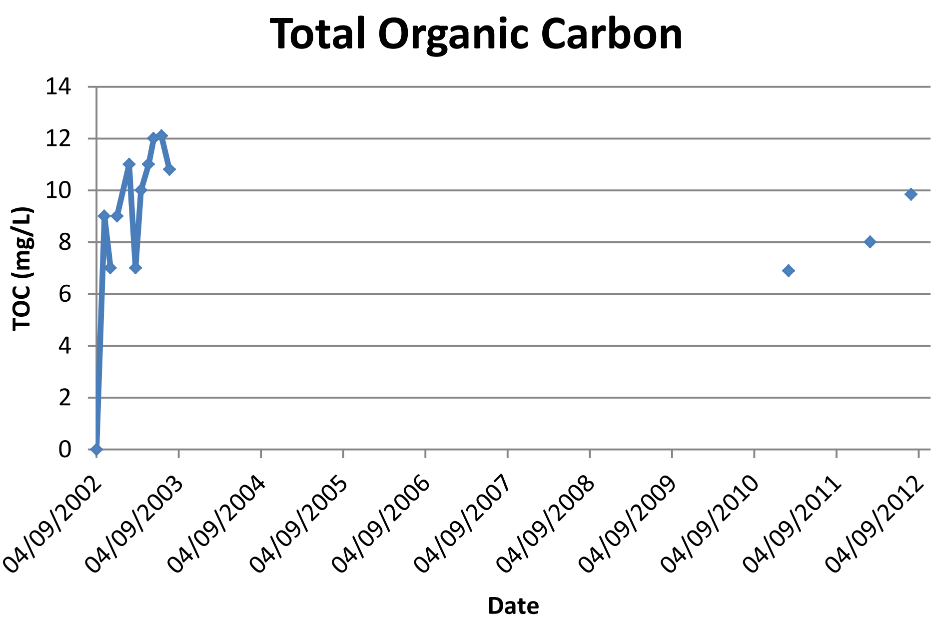

Figure 14: Raw water Total Organic Carbon from September 2002 to August 2012.

6.1.3 pH

The pH value of water is generally only of concern if it is extremely low or extremely high indicating acid or alkaline waters respectively. High or low pH values may have consequences for odour or taste, lead to corrosion in distribution systems and affect fish survival. The pH of water generally ranges from 6.5-8.0 and the Surface Water Regulations (1989) recommend a pH range of 5.5-8.5 for Class A1 waters. The Drinking Water Regulations (2007 and 2014) recommend a pH range of 6.5-9.5 for treated water.

The NFGWS provided raw water pH data from July 1999 until June 2013, although no data were available from July 2003 to March 2006 (Figure 15). Values ranged from a minimum of pH 5.18 in July 2006 to a maximum pH 8.2 in April 2007, with an overall average of pH 7.6 observed over the Veolia sampling period. pH values fell outside of the recommended range for Class A1 waters as stated in the Surface Water Regulations (1989) on one occasion in July 2006.

Cavan County Council also monitored pH in the western lake of Nadregeel Loughs from April 2007 until May 2014. Values ranged from a minimum of pH 6.7 in November 2007, to a maximum of pH 8.5 in July 2012, with an average value of pH 7.5 observed over the Cavan County Council sampling period.

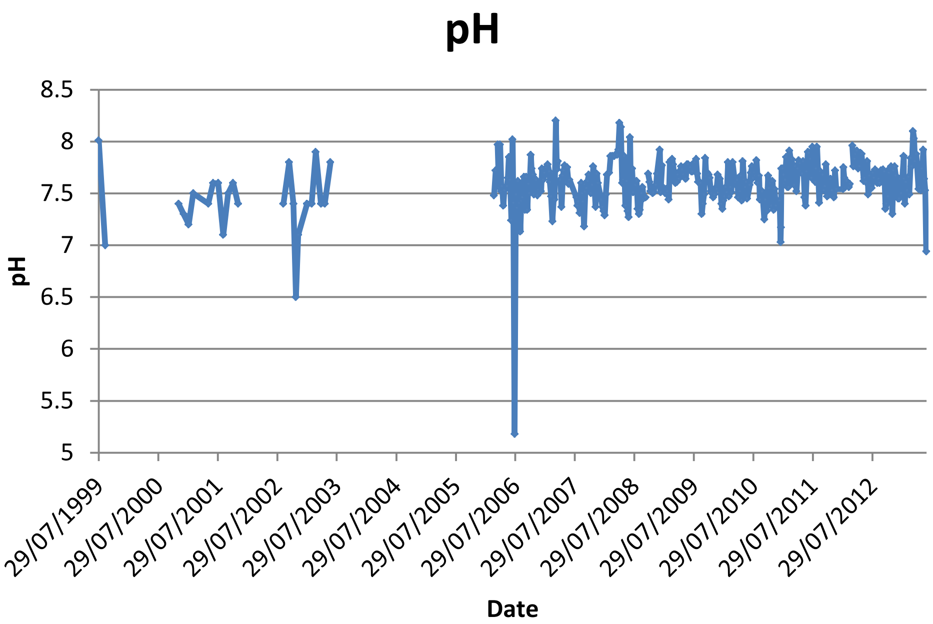

Figure 15: Raw water pH from July 1999 until June 2013.

6.1.4 Turbidity

Turbidity in water consists of very finely divided particles that are too small to be removed through filtration. Their origin may include clay particles, algae, 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. Turbidity can be represented using the following units: Jackson Turbidity Units (JTU); Formazin Turbidity Units (FTU); and Nephalometric Turbidity Units (NTU). Each of these units can be interpreted to mean the same thing.

Raw water turbidity data were provided by the NFGWS from July 1999 until December 2013, although no data were available from July 2003 to March 2006 (Figure 16). Values ranged from a minimum of 0.41 NTU in September 2007, to a maximum of 37 NTU recorded in June 2003, with an average of 4.2 NTU for the sampling period.

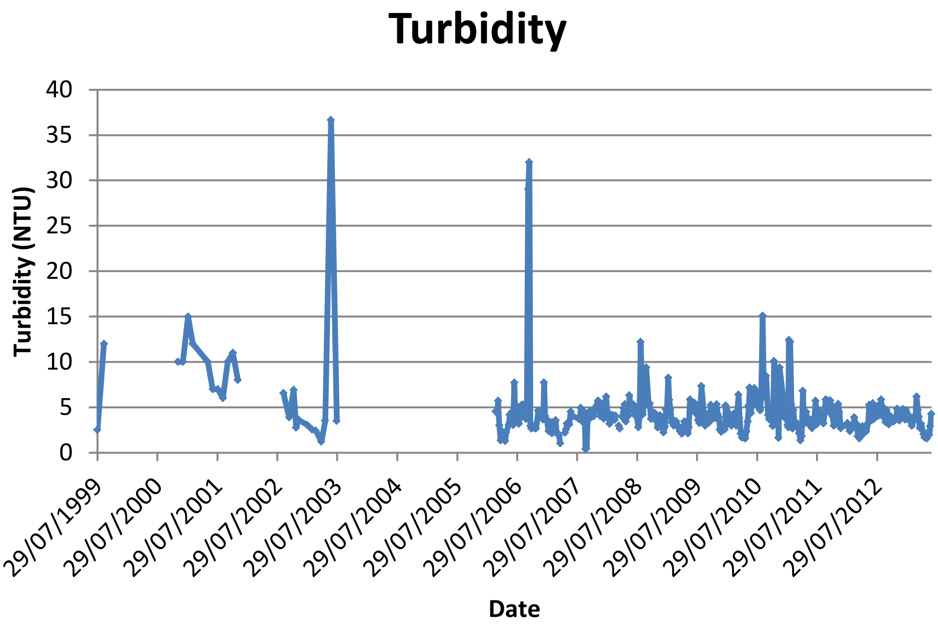

Figure 16: Raw water turbidity from December 1999 until March 2014.

6.1.5 Sulphates and Chlorides

Drinking water that contains high levels of sulphates has been reported to have the potential to cause diarrhoea. Issues with taste and odour may occur where sulphate levels exceed 250 mg/L. The Drinking Water Regulations (2007 and 2014) state a parametric value of 250 mg/L sulphate whilst the Surface Water Regulations (1989) (the quality of surface waters intended for the abstraction of drinking water) recommend a parametric value of 200 mg/L sulphate for all water categories (Class A1, A2 and A3 waters). Group Water Schemes should aim to achieve the parametric values identified for Class A1 Waters (surface waters that only require simple physical treatment and disinfection to become drinking water).

High concentrations of chlorides in freshwater systems can be indicative of pollution by sewage and industrial wastes or the intrusion of saline water. High chloride content can also have a deleterious effect on metallic pipes and structures. The Surface Water Regulations (1989) recommend a parametric value of 250 mg/L chloride for all water categories (Class A1, A2 and A3 waters). The same parametric value is stated in the Drinking Water Regulations (2014).

Sulphates were monitored in the raw water on two occasions in December 2002 and May 2003 with values of 10 mg/L and 11 mg/L recorded respectively. Values are well below the Surface Water Regulations (1989) parametric value.

Chlorides were monitored on only one occasion in May 2003 when a value of 16 mg/L was recorded, well below the Surface Water Regulations (1989) parametric value.

6.1.6 Iron

Iron (Fe) is present in rocks and soil in an insoluble form but can become soluble when water passes through ground formations containing iron. Large amounts of iron in water are not usually harmful to consumers, but can be aesthetically unpleasing as a result of causing changes in colour or turbidity. This can lead to staining of laundry, discoloration of vegetables following cooking and taste problems. The Surface Water Regulations (1989) parametric value for iron in Class A1 waters is 0.2 mg/L.

The NFGWS provided raw water iron data from July 1999 until June 2013, although no data were available from July 2003 to March 2006 (Figure 17). Values were seasonal and ranged from a minimum of 0.001 mg/L recorded in July 2001, to a maximum of 0.443 mg/L recorded in February 2003. An average value of 0.103 mg/L was recorded for the sampling period. The Surface Water Regulations (1989) parametric value of 0.2 mg/L iron in Class A1 waters was equalled or exceeded on 17 out of 351 sampling occasions (4.8 % of occasions). Due to the lack of recent monitoring data, it is not possible to draw conclusions on current iron levels within the raw water.

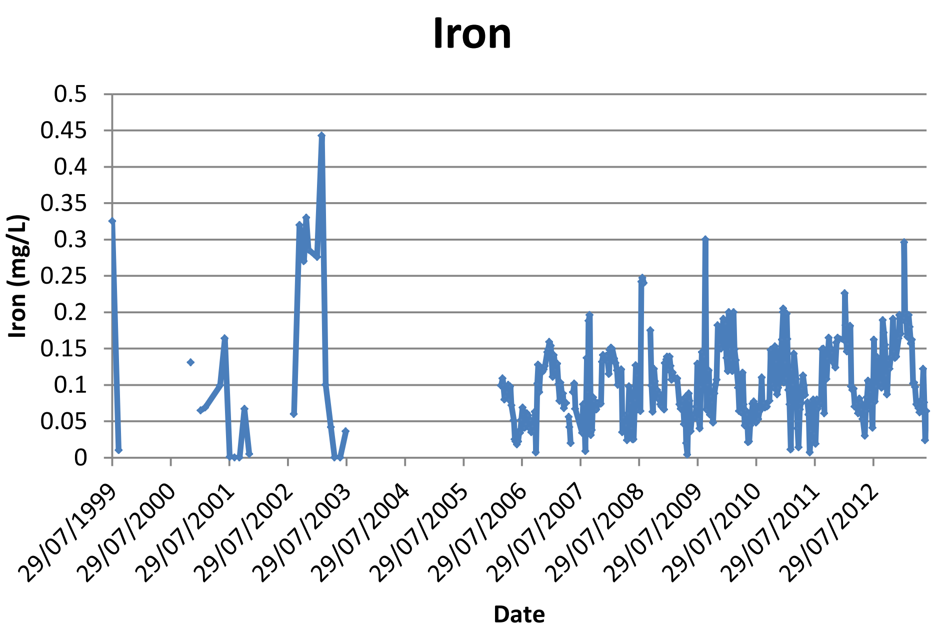

Figure 17: Raw water iron concentrations from July 1999 until June 2013.

6.1.7 Manganese

Manganese is found in soils and groundwaters and is generally not considered harmful to humans. However it can cause more severe staining problems than iron and can adversely affect taste and potentially block pipes in large volumes. The Surface Water Regulations (1989) parametric value for concentrations of manganese in Class A1 waters is 0.05 mg/L.

The NFGWS provided manganese data from July 1999 until June 2013, although no data were available from July 2003 to March 2006 (Figure 18). Values ranged from a minimum of 0 mg/L recorded in September and November 2001 to a maximum of 0.769 mg/L recorded in January 2011.

An average value of 0.158 mg/L was recorded for the sampling period. The Surface Water Regulations (1989) parametric value of 0.05 mg/L manganese in Class A1 waters was equalled or exceeded on 333 out of 366 sampling occasions (91 % of occasions).

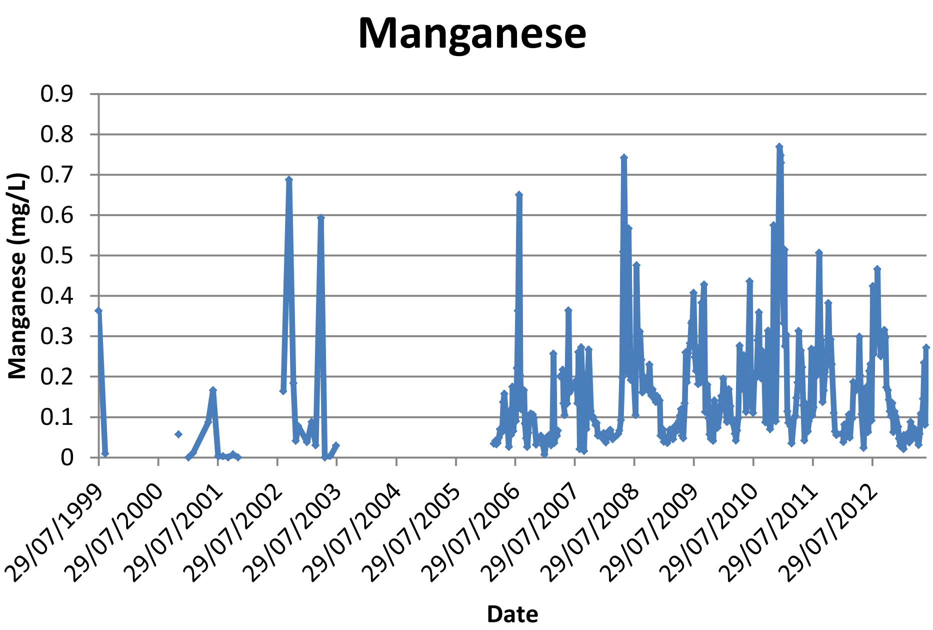

Figure 18: Raw water manganese from July 1999 until June 2013.

6.1.8 Alkalinity

Alkalinity is a measure of a water's capacity to neutralise acids, with high alkalinity providing a buffering capacity against pH change. The alkalinity of water is typically associated with bicarbonates in catchment soils. There is little known sanitary significance to alkalinity; however increased levels can be indicative of eutrophication and photosynthesis.

Figure 19 presents data provided by the NFGWS from September 2002 to March 2010 and Cavan County Council from March 2010 to May 2014. Values ranged from a minimum of 37 mg/L $CaCO_3$ recorded in May 2014 to a maximum of 115 mg/L $CaCO_3$ recorded in October 2002, with an average value of 58.3 mg/L $CaCO_3$ recorded for the sampling period.

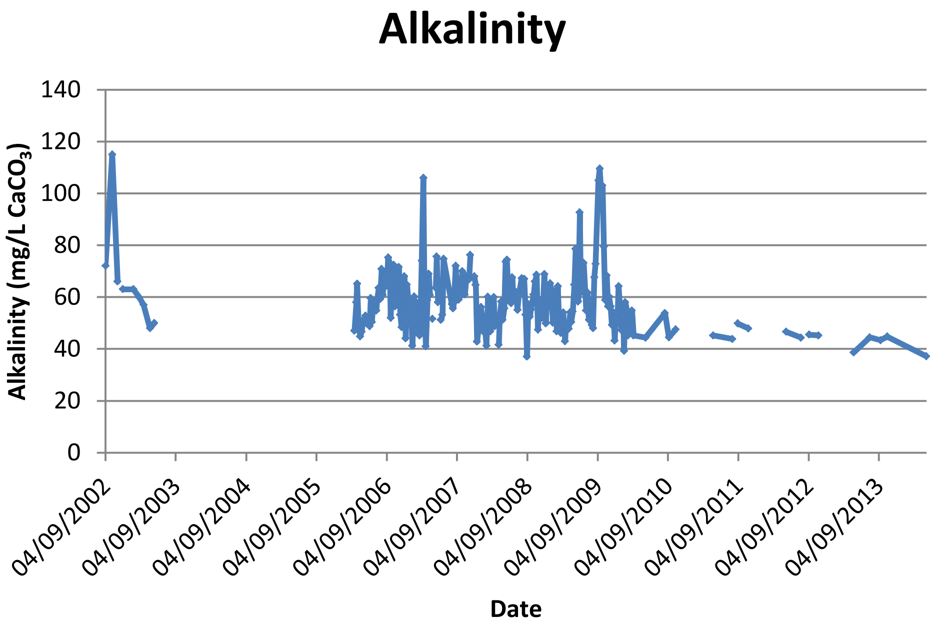

Figure 19: Raw water Total Alkalinity from September 2002 to May 2014.

Eutrophication and Trophic Status (Note)

Eutrophic means well-nourished and eutrophication is the process where water bodies become more eutrophic through the addition of nutrients, primarily nitrogen and phosphorus (N and P). These additional nutrients, often in combination with low flow or still conditions and increased water temperatures, trigger a series of events causing excessive plant and algal growth. The process may culminate in oxygen depletion in waters, fish kills and problems with the treatment of the water for drinking. Water bodies suffer different degrees of eutrophication, termed trophic status. Lakes are often characterised by their trophic status using the following scale: Oligotrophic (low in nutrients and algal growth); Mesotrophic (moderately productive, less clean than oligotrophic bodies); and Eutrophic (high levels of nutrients and algal growth combined with poor water quality). Lakes suffering from excessive eutrophication can be classed as hypertrophic. Trophic status is typically determined by algal abundance (using Chlorophyll *a* assessments as an indicator of abundance) or total phosphorus concentration (the most important nutrient in the eutrophication process).

6.1.9 Total Phosphorus

Phosphorus occurs widely in nature but much of the phosphorus found in surface waters occurs as a result of anthropogenic activities. Human and animal wastes contain large amounts of phosphorus and therefore agriculture and wastewater treatment plants are large sources of phosphorus and often provide pathways for phosphorus to enter the aquatic environment. Artificial fertilisers used in agriculture and forestry are also primary sources of phosphorus. Phosphorus and, to a lesser extent, nitrogen are the two key drivers of eutrophication events in the freshwater aquatic environment (see Eutrophication and Trophic Status Note, above, for details on eutrophication) as they are the primary nutrients required by the algae and plants that can flourish during eutrophication events. Eutrophication can lead to a loss of biological diversity (particularly of sensitive and/or desirable species), increased plant growth, the development of algal scums and a general deterioration in water quality. Eutrophication is the largest threat to Irish water quality and is of great importance to drinking water sources. Increased algal abundance can create problems in treatment plants and decomposing algae can release toxins into the water and cause taste and odour problems. The management of phosphorus levels entering the aquatic environment is central to the long-term viability of many drinking water sources.

The NFGWS provided Total Phosphorus data from September 2002 to July 2003, and Cavan County Council provided Total Phosphorus data from April 2007 to May 2014 (Figure 20). Values ranged from a minimum of 9 µg/L recorded in October 2007, to a maximum of 146 µg/L recorded in May 2003, with an average value of 39.6 µg/L recorded for the sampling period. This average Total Phosphorus value places Nadregeel Loughs within the moderate quality class for Total Phosphorus (Table 2).

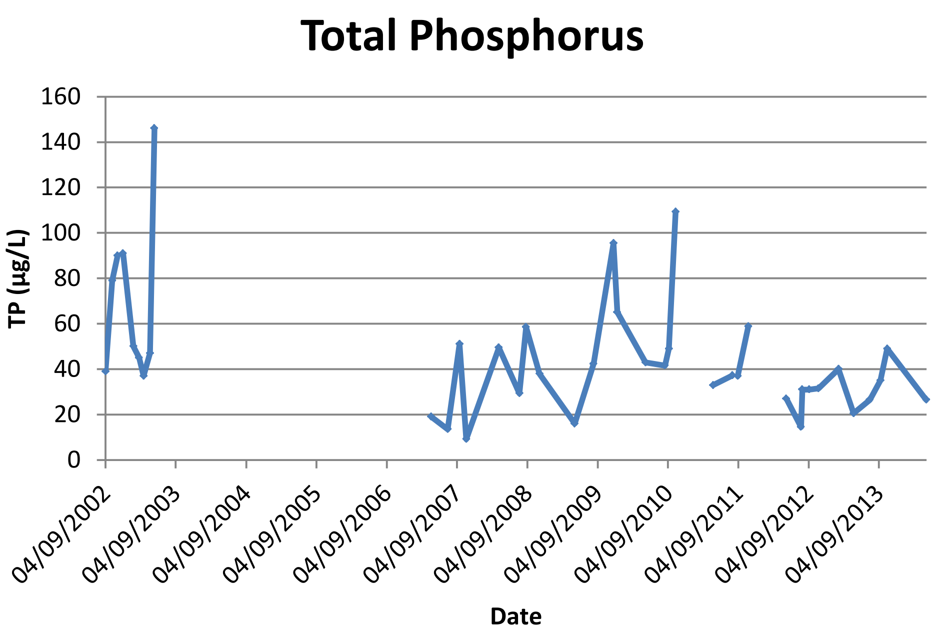

Figure 20: Raw water Total Phosphorus from September 2002 until May 2014.

Table 2: Quality classes for total phosphorus concentrations (µg P/L) in Irish Lakes (adapted from Lucey, 2009).

	High Quality	Good Quality	Moderate Quality	Poor Quality	Bad Quality
Total Phosphorus Concentration	<10 µg/L	>10 – 25 µg/L	>25 – 50 µg/L	>50 – 100 µg/L	>100 µg/L

6.1.10 Chlorophyll

Chlorophyll is used as an indicator of overall algal abundance within a water source. High levels of chlorophyll can indicate high algal abundance which can have negative implications for the treatment process and lead to taste and odour problems in treated water. Chlorophyll values are typically greatest in the summer when the water temperatures are warmer, and light availability is high. It is monitored as chlorophyll *a*, the most abundant form of chlorophyll in lake algae.

The NFGWS provided Chlorophyll data from September 2002 to July 2003, and Cavan County Council provided Chlorophyll data from April 2007 to May 2014 (Figure 21). In April 2011, the Chlorophyll value was recorded as below the limit of detection and is represented in Figure 21 as a zero value. When recorded above the limit of detection, values ranged from a minimum of 4 mg/m^3 recorded in November 2009 and May 2010, to a maximum of 79 mg/m^3 recorded in June. The average value for the sampling period was 20.16 mg/m^3. This average value places the Nadregeel Loughs outside of the Surface Water Regulations (2009) good-moderate quality boundary for chlorophyll for Lake Type 7 (Moderate alkalinity (20-100 mg/L $CaCO_3$, deep (>4 m) and small (<50 ha).

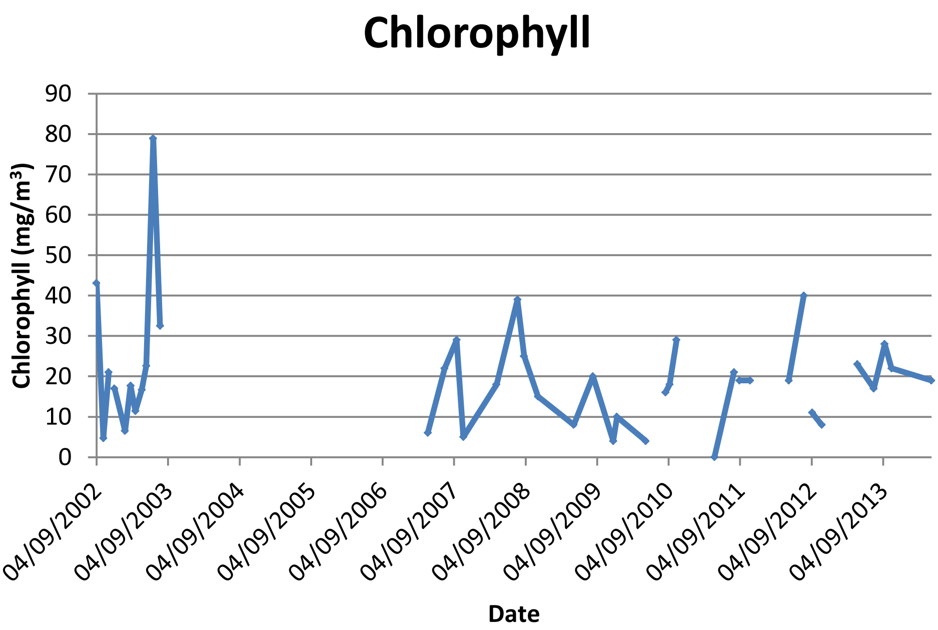

Figure 21: Raw water Chlorophyll from September 1999 to May 2014.

Algae data have not been provided for this report. The Veolia Monthly Status Report (MSR) for July 2006 stated that moderate levels of blue-green algae were detected in the raw water, although no impacts on taste or odour were reported.

6.1.11 Transparency

Transparency can give an indication of the presence of suspended matter within a water body and is measured using a Secchi disk (a coloured disk). The disk is lowered through the water until it can no longer be seen by the naked eye and the distance lowered recorded: the greater the distance, the greater the transparency. The transparency of the water can be used as an overall indicator of quality as algae, coloured TOC compounds, and/or sediment can reduce transparency. Low transparency levels can effect light penetration and also potentially affect the ability of fish to find prey.

Cavan County Council provided Transparency data from April 2007 to May 2014 (Figure 22). Values ranged from a minimum of 1 m transparency recorded on eight occasions, to a maximum of 3 m transparency recorded in April 2007 and April 2011, with an average value of 1.52 m transparency recorded for the sampling period.

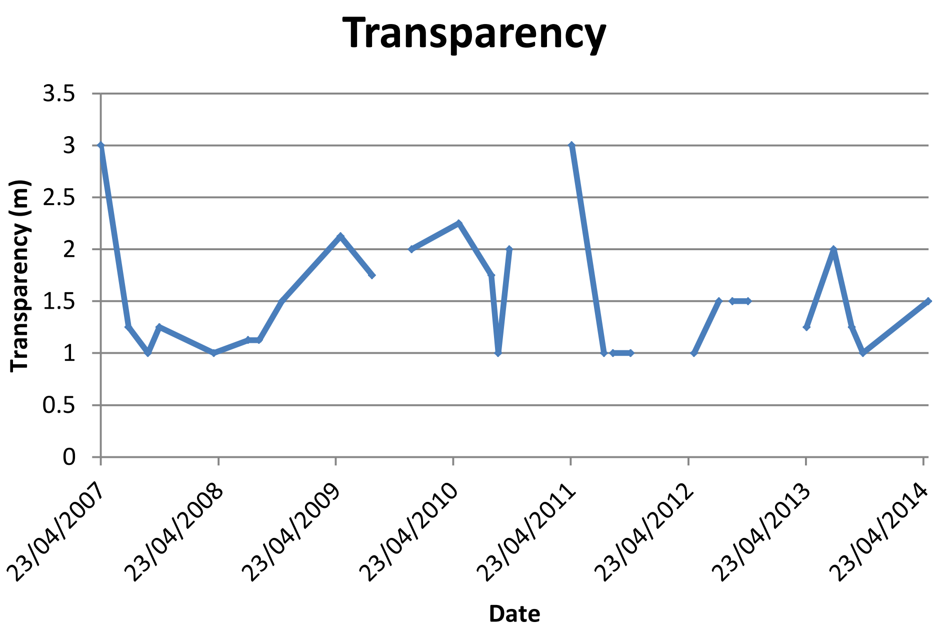

Figure 22: Raw water transparency from April 2007 to May 2014.

6.1.12 Nitrogen

Nitrogen, together with phosphorus, is central to the development of eutrophication as nitrogen is a key nutrient for plant and algal growth. Although approximately 78% of the earth's atmosphere is made up of nitrogen gas, this form of nitrogen is not available as a nutrient to plants. Instead it is converted to different forms such as ammonium, nitrite and nitrate through the nitrogen cycle. Nitrate is the most common form of nitrogen that exists in aquatic environments and typically originates from human and animal wastes as well as from the application of artificial fertilisers to agricultural lands. The Surface Water Regulations (1989) recommend a parametric value of 50 mg/L NO_3 for Class A1 waters. Nitrite is an intermediate form between ammonium and nitrate and typically only represents a small proportion of nitrogen in water. Nitrite and nitrate are often presented together as Total Oxidised Nitrogen (TON). As well as having environmental implications with regards to nutrient enrichment, high levels of nitrate in drinking water can have important health implications. Large amounts of nitrate in drinking water can cause methemoglobinemia in pregnant women and infant children, with those under 6 months particularly vulnerable. Methemoglobinemia, also known as 'blue baby syndrome' reduces the ability of the red blood cells to carry oxygen as a result of nitrate in the drinking water being converted into nitrite by stomach bacteria. This nitrite is absorbed into the blood and results in the conversion of haemoglobin to methemoglobin which does not efficiently carry oxygen. Severe cases can lead to brain damage and death. Importantly, *nitrates and nitrites cannot be removed from raw water during the standard treatment process*. The Drinking Water Regulations (2014) stipulate maximum acceptable values of 50 mg/L for nitrate and 0.5 mg/L for nitrite. The Surface Water Regulations (1989) parametric value for nitrate is also 50 mg/L NO_3 for Class A1 waters.

The source of ammonia in the aquatic environment is most likely from human and animal waste and high concentrations of ammonia can indicate pollution from these sources. Ammonia also arises from peat drainage. In aquatic environments, ammonia (NH_3) is frequently ionised to ammonium (NH_4^+) and equally ammonium can be converted back into ammonia. The pH of the water is the major factor than influences the ionisation of ammonia to ammonium and at the typical pH of most Irish freshwaters; it is ammonium that is the most common form. Although naturally present in small amounts in aquatic environments, values of over 0.1 mg/L N is interpreted as an indication of human waste pollution or industrial contamination. With regards to lake quality classes based on total ammonia levels (NH_4^+ plus NH_3), the Surface Water Regulations (2009) state that bodies must have ≤0.040 mg N/L as a mean for high status (or ≤0.090 95%ile) and ≤0.065 mg N/L as a mean for good status (≤0.140 95%ile). Following treatment, the Drinking Water Regulations (2014) parametric value for ammonium is 0.3 mg/L.

Total Oxidised Nitrogen (TON)

The NFGWS provided TON data from July 1999 to April 2003, and Cavan County Council provided TON data from April 2007 to May 2014 (Figure 23). Of the 33 sampling events, TON concentrations were below limits of detection on 11 occasions and these are represented in Figure 23 as zero values. When TON values were recorded above limits of detection, values ranged from a minimum of 0.013 mg/L N recorded in May 2010, to a maximum of 2.52 mg/L N recorded in February 2012. The average value for the sampling period was 0.37 mg/L N. On no occasions was the Surface Water Regulations (1989) parametric value for nitrate exceeded.

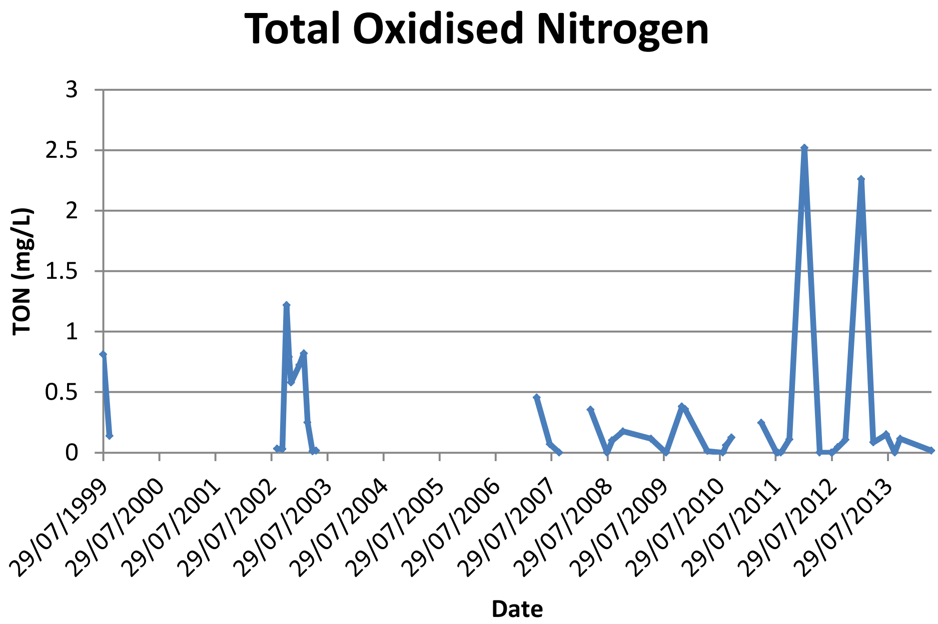

Figure 23: Raw water Total Oxidised Nitrogen values from March 1999 until April 2014.

Ammonia

The NFGWS provided Total Ammonia data from July 1999 to June 2013 (Figure 24). Of the 135 sampling events, Total Ammonia concentrations were recorded as zero values on 41. The maximum value was 0.5 mg N/L recorded in January 2008. The average value for the sampling period was 0.05 mg N/L. This average value places the Nadregeel Loughs within the Surface Water Regulations (2009) good quality class for Total Ammonia.

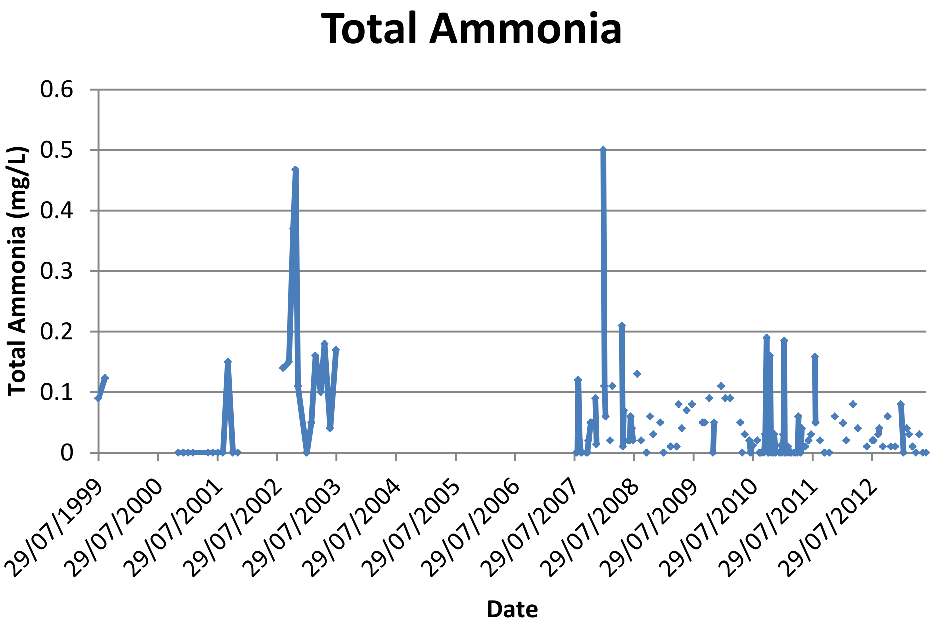

Figure 24: Raw water Total Ammonia values from July 1999 until June 2013.

6.1.13 Conductivity

The ability of water to conduct an electrical current is quantified as the conductivity of water and is an indication of the mineral salt content of the water body. Conductivity itself has no direct health or sanitary significance in freshwater environments, and the Surface Water Regulations (1989) specify a limit of 1000 µS/cm at 20°C for Class A1 waters.

The NFGWS provided Conductivity data from July 1999 to May 2003, and Cavan County Council provided Conductivity data from April 2007 to May 2014 (Figure 25). Values ranged from a minimum of 152 µS/cm recorded in December 2002, to a maximum of 206 µS/cm recorded in September 2001, with an average value of 173 µS/cm recorded for the sampling period. On no occasions was the Surface Water Regulations (1989) parametric value of 1000 µS/cm for Class A1 waters exceeded.

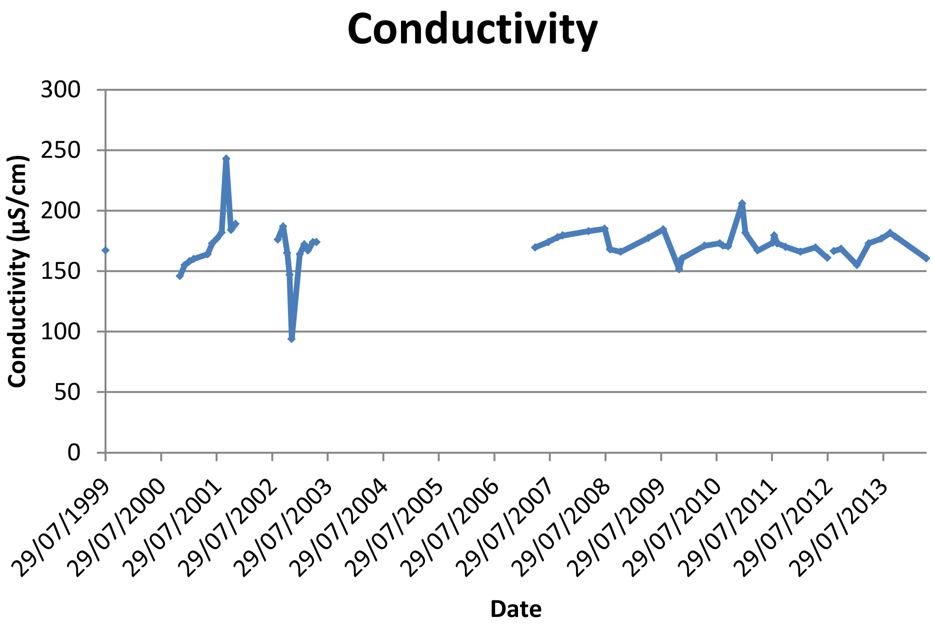

Figure 25: Raw water Conductivity values from July 1999 until May 2014.

6.1.14 Dissolved Oxygen (DO)

The amount of oxygen dissolved within a water body is important for fish survival. If a water body is suitable for fish survival then it generally meets the quality requirements for most other forms of water consumption.

Dissolved oxygen saturation is dependent on water temperature: warmer waters typically contain less dissolved oxygen then colder waters. Summer temperatures resulting in lower DO levels, in combination with low water levels can leave aquatic environments particularly vulnerable to organic pollution. DO saturation and concentration can also be affected by photosynthesis, with increased eutrophication and photosynthesis leading to high oxygen concentrations during daylight hours, and these high oxygen concentrations can be depleted at night when respiration takes over from photosynthesis.

Cavan County Council provided Dissolved Oxygen Saturation data from April 2007 to May 2014 (Figure 26). Values ranged from a minimum saturation of 69 % recorded in May 2010, to a maximum saturation of 120 % recorded July 2008. An average dissolved oxygen saturation value of 91 % was recorded for the sampling period.

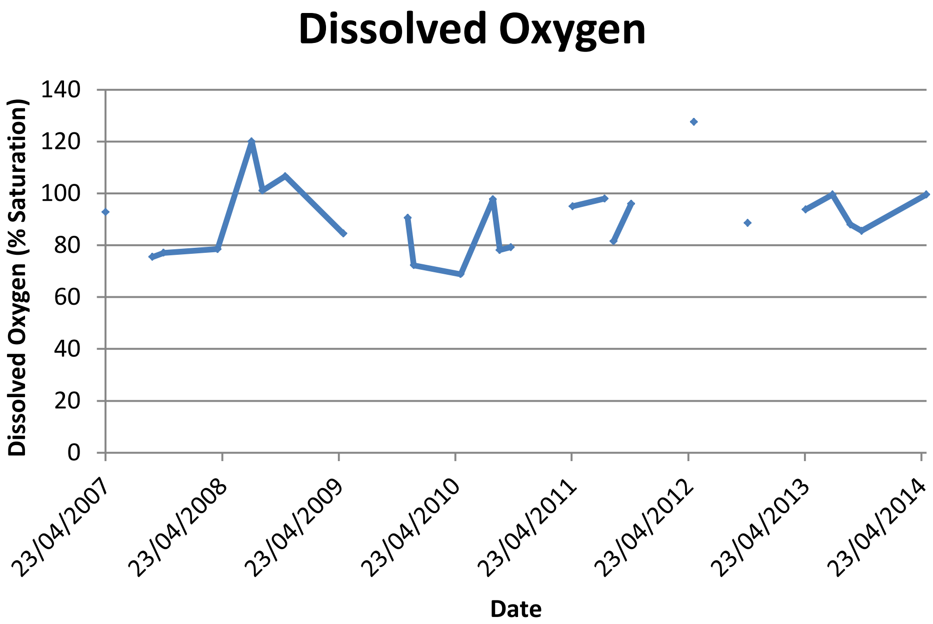

Figure 26: Raw water Dissolved Oxygen saturation from April 2007 until May 2014.

6.1.15 Biological Oxygen Demand (BOD)

Unpolluted water is typically saturated with dissolved oxygen, but when organic pollution enters a water body, bacteria break it down through a process that uses available oxygen, thus reducing DO levels. The Biological Oxygen Demand (BOD) is a measure of the oxygen demand required to break down organic waste. BOD is the amount of dissolved oxygen taken up by bacteria degrading organic material in the dark at 20 °C over five days. The Surface Water Regulations (1989) recommend the value for BOD in Class A1 Waters to be 5 mg/L O_2.

Biological Oxygen Demand has not been monitored within the Billis Lavey GWS catchment.

6.1.16 Coliforms

Faecal coliforms such as *Escherichia coli* (*E. coli*) originate in animal or human wastes. A typical measurement of coliforms is Total Coliforms which include faecal and soil-born coliforms. Total coliforms is used as an indicator or pathogenic organisms within a water body and the Surface Water Regulations (1989) recommend that Class A1 waters should not exceed 5,000 total coliforms per 100ml, or 1,000 faecal coliforms per 100ml. The Drinking Water Regulations (2007 and 2014) state that Total Coliform values above 0 numbers per 100ml in treated water is unacceptable.

Faecal coliforms and *E. coli*

Escherichia coli bacteria are present in high numbers in human and animal faeces and are rarely found in waters in the absence of faecal pollution.

Faecal coliforms and *E. coli* have been monitored between July 1999 to February 2013 and November 2002 to February 2013 respectfully, although no data were available from June 2003 to January 2011 (Figure 27). Values for faecal coliforms ranged from a minimum of 0 MPN/100 ml recorded on seven occasions, to a maximum of 380 MPN/100 ml recorded in September 1999. An average value for faecal coliforms of 23 MPN/100 ml was recorded between July 1999 and February 2013. *E. coli* values ranged from a minimum of 0 MPN/100 ml recorded in May 2003, to a maximum of 69 MPN/100 ml recorded in February 2013, with an average value for *E. coli* of 23 MPN/100 ml recorded between November 2002 and February 2013. The Surface Water Regulations (1989) parametric value for faecal coliforms was not exceeded on any occasion. The values of Faecal Coliforms and *E. coli* are typically below levels of concern and should be consistently removed through standard treatment practices.

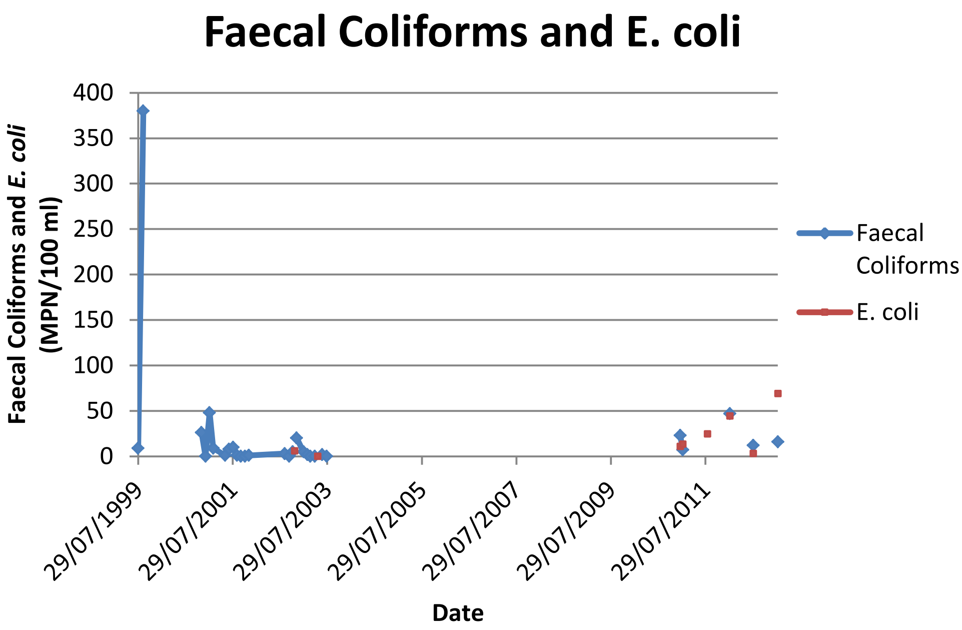

Figure 27: Raw water Faecal Coliform and *E. coli* values from March 1999 until October 2011.

Clostridia
Clostridia, such as *Clostridia perfringens*, exist as part of the natural bacterial intestinal flora of humans and therefore serve as an indicator of faecal pollution.

Clostridia were monitored on eight occasions between November 2002 and February 2013. Values ranged between a minimum of zero cfu/100 ml recorded in May 2003 and August 2011, to a maximum of 55 cfu/100 ml recorded in January 2011. An average of 21 cfu/100 ml was recorded for the sampling period.

Total Coliforms
The NFGWS provided Total Coliform data from July 1999 to February 2013, although no data were available from June 2003 to January 2011 (Figure 27). Values ranged from a minimum of 0 counts/100 ml recorded on three occasions, to a maximum of 1,553 counts/100 ml recorded in August 2012. An average value of 92 counts/100 ml was recorded for the sampling period. The Surface Water Regulations (1989) parametric value for Class A1 waters was not exceeded on any occasion.

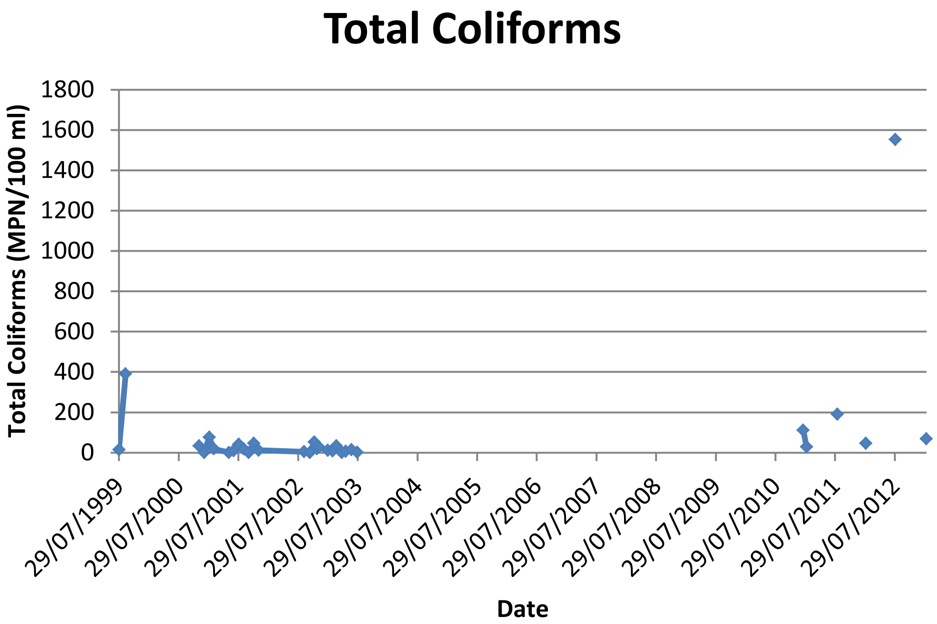

Figure 28: Raw water Total Coliforms values from July 1999 until February 2013.

6.1.17 Biological data

Q values

Clabby *et al.* (2006) state that in the presence of pollution, characteristic and well documented changes are induced in the flora and fauna of rivers and streams. Organic pollution that impacts the aquatic macroinvertebrate communities are particularly well documented, with changes occurring due to varying sensitivities of different species to the stresses caused by pollution.

Macroinvertebrate diversity declines in the presence of pollution and sensitive species are progressively replaced by more tolerant species as pollution increases. The EPA classify benthic aquatic macroinvertebrates into five arbitrary 'indicator groups' based on sensitivity to pollution, with Group A being the most sensitive and Group E being the most tolerant. These groups, in combination with physico-chemical assessment of water quality, are used to produce Quality (Q) Values. The values range from Q1 to Q5, with Q5 waters having the greatest macroinvertebrate diversity (with sensitive species present) and good water quality; and Q1 waters having the little macroinvertebrate diversity (with communities dominated by tolerant species) and poor water quality.

Macroinvertebrates have not been monitored within the Billis Lavey GWS catchment.

6.3 Tellus Border Soil Geochemistry and Water Chemistry

The Tellus Border Project (www.tellusborder.eu) was an Interreg IVA-funded regional mapping project collecting geo-environmental data on soils, water and rocks across the six border counties of the Republic of Ireland that ran from 2011 until December 2013. As well as using an aircraft to collect information on the physical properties of soils and rocks, the project took approximately 3,500 soil and stream water samples and analysed their chemistry. Data collected by the Tellus Border project is freely available from their website.

Figure 29 shows the Tellus Border sample locations within the Billis Lavey GWS catchment. Three soil sediment samples and two stream water and stream sediment samples were collected from within the catchment. Rather than showing a large number of figures depicting the variation of a number of parameters between Tellus Border Sample locations, Table 3 and Table 4 show the data for a number of key parameters for soil sediment and stream waters that are of relevance to source protection compared against ranges and average values for the same parameters across the whole of the six county sampling area of the Tellus Border project.

It is important to note that these Tellus Border values are one-off spot measurements and therefore it is difficult to draw specific conclusions without being able to examine a number of sampling events, particularly for stream water chemistry, to view the range of a certain parameter over the course of time.

6.3.1 Soil Geochemistry

Soil pH is acidic, but close to the mean value recorded across the whole of the Tellus Border survey area (Table 3). Loss on ignition (a surrogate for carbon content) is relatively low whilst aluminium levels are relatively high, in comparison to the mean Tellus Border values. Copper values are higher than the Tellus Border mean value at locations one and three whilst iron levels are above the mean Tellus Border values at locations one and two. Manganese levels are higher than the mean Tellus Border value at location one, but lower than the mean value at locations two and three. Phosphorus values at all three locations are higher than the overall Tellus Border mean value, and are particularly high at location two, potentially indicating high levels of fertiliser application in the area. Arsenic and mercury levels are close to or below the mean Tellus Border Value and are below levels of concern.

6.3.2 Stream Waters

pH values within the stream waters of the catchment are slightly alkaline (Table 4) given the sedimentary bedrock and typically acidic soils present within the catchment. The parameters Chloride, Sulphate, Phosphate and Nitrate can be indicators of point source pollution from septic tanks. Chloride levels are elevated at location A, whilst Sulphate levels are elevated at location B. Nitrate levels are relatively high at both locations, yet are close to the mean Tellus Border value. Phosphorus levels are elevated at location A and potassium levels are higher than the Tellus Border mean value at both sample locations. Manganese levels are higher than the Tellus Border mean value at both locations, but particularly at location B, whilst are values at both locations are below the mean Tellus Border value. Concentrations of arsenic and lead are below levels of concern.

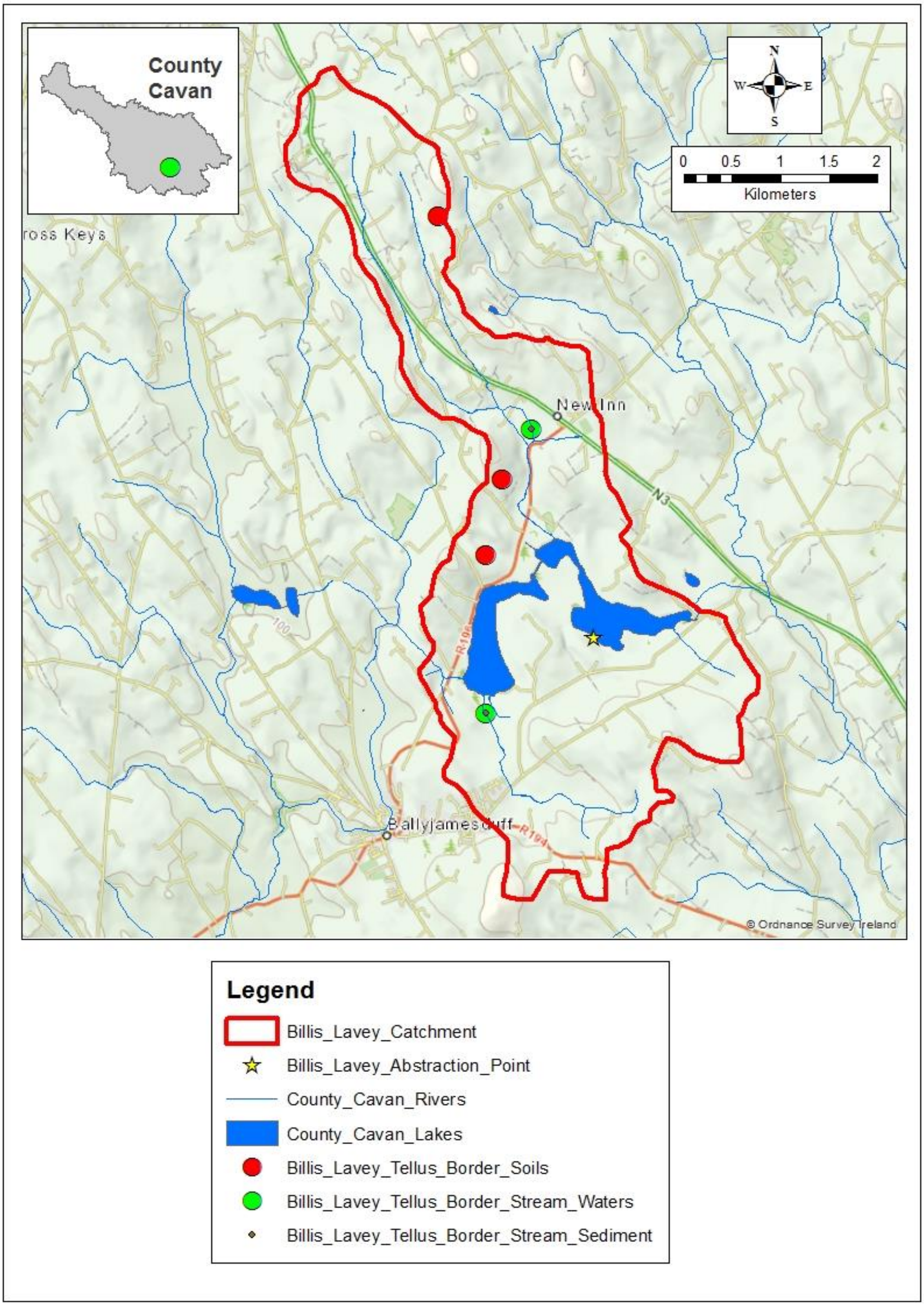

Figure 29: Tellus Border Soil, Stream Water and Stream Sediment sample locations within the Billis Lavey GWS catchment.

Table 3: Tellus Border soil geochemistry parameters across four of sampling locations within the Billis Lavey GWS catchment (Figure 29). Range values and average values are calculated from the entire Tellus Border dataset.

Sample Location Number (Figure 29)	pH	Loss on Ignition (%)	Aluminium (%)	Calcium (%)	Copper (mg/Kg)	Iron (%)	Manganese (mg/Kg)	Phosphorus (mg/Kg)	Arsenic (mg/Kg)	Mercury (mg/Kg)
1	4.46	15.3	1.75	0.11	38.13	2.61	560.5	860	6.7	0.06
2	5.01	18.6	2.00	0.33	21.81	2.81	429.3	1110	4.8	0.08
3	4.03	17.3	1.62	0.1	46.45	1.81	333.8	950	5.8	0.08
Tellus Border Range Values (Min-Max)	2.55 - 7.78	0.63 - 98.5	0.005 - 3.62	0.005 - 15	0.25 - 413.14	0.05 - 15	1 - 8351.5	25 - 3850	0.5 - 960.8	0.005 - 1.66
Tellus Border Average (mean) Value	4.51	35.11	1.06	0.46	22.66	1.94	461.7	805.40	6.50	0.10

Table 4: Tellus border stream water parameters across four of sampling locations within the Billis Lavey GWS catchment (Figure 29). Range of values and average values are calculated from the entire Tellus Border dataset.

Stream Water Sample Location	pH	Conductivity (µS/cm)	Chloride (mg/L)	Sulphate (mg/L)	Nitrate as NO_3 (mg/L)	Nitrite as NO_2 (mg/L)	Phosphate (mg/L)	Aluminium (µg/L)	Phosphorus (mg/L)	Potassium (mg/L)	Calcium (mg/L)	Manganese (µg/L)	Iron (µg/L)	Arsenic (µg/L)	Lead (µg/L)
A	7.82	271	34.44	9.58	2.43	0.01	0.05	33.5	0.04	3.22	29.18	99.45	559.4	0.50	0.06
B	7.77	194	18.19	22.49	2.23	0.11	0.05	20.7	0.01	2.00	24.89	125.71	391.9	0.37	0.03
Tellus Border Range Values (Min-Max)	**4.07 - 11.75**	**2 – 39,000**	**0.176 - 12,600**	**0.05 - 1662**	**0.025 - 86.43**	**0.005 - 5.042**	**0.05 - 5.29**	**0.5 - 734.4**	**0.005 - 2.04**	**0.01 - 250.39**	**0.15 - 306.03**	**0.1 - 5647.92**	**0.5 - 20234.9**	**0.02 - 8.38**	**0.0005 – 3.72**
Tellus Border Average Value	**7.29**	**219**	**28.77**	**9.71**	**2.31**	**0.02**	**0.07**	**57.16**	**0.03**	**1.74**	**30.82**	**85.57**	**575.67**	**0.44**	**0.12**

6.4 Overall Interpretation of Water Quality

A number of raw water quality parameters have been monitored within the Billis Lavey GWS catchment allowing the interpretation of both historical and recent raw water quality and the likely impacts of catchment-level activities on that water quality.

True Colour values exceeded the Surface Water Regulations (1989) parametric value for Class A1 waters on 92 % of sampling occasions. As discussed in this report, high levels of colour do not represent health risks. However, upon treatment with chlorine, Trihalomethanes (THMs) can be produced when the chlorine reacts with naturally occurring organic matter in the raw water (high colour values can be an indication of high organic matter). The high True Colour values and relatively high Total Organic Carbon (TOC) values observed in the raw water have contributed to the occasionally high THM values in the treated water. The fact that THM levels have not exceeded the Drinking Water Regulations (2007 and 2014) parametric value may be due to the Dissolved Air Floatation (DAF) treatment process undertaken on the raw water prior to chlorination. Alternatively, given the high True Colour and relatively high TOC values, the THM sampling frequency may not be sufficient to identify whether the THM parametric value is being exceeded. It may be prudent for Billis Lavey GWS to undertake a specific THM monitoring programme during the period of late summer through to early winter (when True Colour and TOC values are typically highest) in order to ensure that THM values are consistently within the Drinking Water Regulations (2014). Therefore recommendations regarding THM monitoring are given in Section 7.0.

Raw water Iron concentrations exceeded the Surface Water Regulations (1989) on 4.8 % of occasions. However it is the Manganese levels in the raw water that present a greater issue. The Surface Water Regulations (1989) parametric value for Manganese was exceeded on 91 % of occasions, with the average value recorded over the sampling period being over three times the parametric value. Manganese occurs naturally in soils and groundwaters and subsequently there are limited source protection measures available that may reduce levels to within the Surface Water Regulations (1989). Manganese is a common constituent of sedimentary rocks such as sandstone and its associated glacial till subsoils such as those found within the Billis Lavey catchment. There is potential for manganese-rich groundwater to be delivered into Nadregeel Loughs through shallow cracks and fissures in the bedrock having percolated through the local subsoils. Manganese levels were particularly elevated in the stream waters to the south of the western lake of the Nadregeel Loughs as shown by the Tellus Border data. The levels of manganese in the treated water have not been assessed as part of this report and it is recommended that these levels are reviewed to assess whether levels do not exceed the Drinking Water Regulations (2007 and 2014) on a regular basis (see Section 7.0 for further recommendations).

Nutrient levels within the Nadregeel Loughs, whilst not excessive, do represent a significant risk to raw water quality. Eutrophication is the over-enrichment of waters with nutrients, leading to increased algal biomass and phosphorus is typically the main limiting nutrient in this process. Eutrophication is the largest threat to Irish water quality and is of great importance to drinking water sources. Increased algal abundance can create problems in treatment plants and decomposing algae can release toxins into the water and cause taste and odour problems. The management of phosphorus levels entering the aquatic environment is central to the long-term viability of many drinking water sources.

The average Total Phosphorus value for the sampling period places Nadregeel Loughs within in the moderate quality class for Total Phosphorus (Table 2), however, levels have exceeded the 0.02 mg/L P that have been observed to contribute to water quality deterioration and eutrophication (Brogan *et al*., 2001) on 35 out of 40 sampling occasions (88 % of occasions).

In addition to these elevated Total Phosphorus levels, Total Oxidised Nitrogen values have also been frequently high, particularly in February 2012 and February 2013. This means that the two key nutrients for plant and algal growth, nitrogen and phosphorus, are readily available within the Nadregeel Loughs. Subsequently chlorophyll levels, which are representative of algal abundance, are outside of the good-moderate quality class boundary. High Chlorophyll values observed in July 2008 and 2012 correspond with periods of high Dissolved Oxygen values (super saturation) which are representative of algal blooms. Frequent algal blooms can have significant implications for water quality and potential health implications for consumers and although no algal data have been provided for this report, it was stated in the July 2006 Monthly Status Report from Veolia that a blue-green algal bloom had occurred. A reduction in the level of nutrients entering Nadregeel Loughs will, in the longer term, lead to less frequent algal blooms and subsequently improvements in the efficiency of the treatment process.

Given the relatively high density of dwellings and subsequently high numbers of on-site waste water treatment systems, there are two likely primary sources of nutrients within the Erne Valley GWS catchment: diffuse pollution from agricultural practices; and point source pollution from septic tanks/wastewater treatment systems.

Although there is limited levels of intensive agriculture within the immediate surrounds of the western lake of the Nadregeel Loughs, the agricultural activities undertaken within the catchment area and the spreading of slurry within the catchment is likely to contribute to the elevated nutrient levels observed within the lakes. The location of a commercial coniferous forestry on the northern shore of the eastern lake of the Nadregeel Loughs, directly opposite the Billis Lavery GWS abstraction point, presents potential risks to the quality of the raw water supply under certain management scenarios such as felling, planting, the spreading of fertiliser and road construction. Engagement with the forestry owners and managers is recommended in order to mitigate these risks.

The relatively high dwelling density coupled with the Very High or High Risk of nutrients and bacterial contamination of water courses from domestic wastewater treatment systems means that the correct management of septic tanks/wastewater treatment systems is very important within the Billis Lavey GWS catchment to maintain good raw water quality.

Although present within the raw water supply, levels of Faecal and Total Coliforms have typically been relatively low and should be managed through standard treatment processes.

A number of recommendations are provided in Section 7 based on the assessment of physical properties and raw water quality data from within the catchment.

7.0 Recommendations

The assessment of geology, soils, land use and water quality data has identified a number of issues within the Billis Lavey GWS catchment that are recommended to be addressed in order to improve source protection and maintain a high quality raw water supply.

Put source protection on the agenda

Within many group water schemes the importance of source protection is often underestimated or neglected. It is recommended that source protection be installed as an item on the agenda at all Billis Lavey GWS meetings (AGM, Committee meetings, etc.). This will ensure that important issues within the catchment are discussed and addressed as appropriate. For example, the findings of this report should be discussed as a starting point. Issues around source protection measures and potential pollution within the catchment should also be discussed.

Reporting of potential pollution issues

The Billis Lavey GWS should encourage committee members and people with connections to the scheme to report potential pollution issues. Members should be able to call the scheme staff to report pollution incidents in confidence. The scheme staff can then decide how to proceed with investigation, either dealing with the problem themselves or passing relevant information on to the County Council.

Develop a protocol for dealing with offenders

The committee should agree a protocol for dealing with potential pollution incidences. From the moment the staff receive knowledge, there should be a procedure in place. The protocol should reflect the seriousness of individual issues with some being dealt with by the scheme and more serious incidences being reported directly to the appropriate authority. Having a protocol in place ensures that all complaints are dealt with in an agreed and equitable manner.

Cryptosporidium Risk Assessment

The Billis Lavey GWS *Cryptosporidium* Risk Assessment Report (TJ O'Connors and Associates, 2008) found that the Billis Lavey GWS was classified in the Moderate Risk category for *Cryptosporidium* contamination. The recommendations made in this C*ryptosporidium* Risk Assessment report, which would result in the risk score being reduced to the Low Risk category, were:

- A new turbidity meter installed on the filter outlet, linked to the telemetry and alarmed;
- The existing raw water turbidity meter to be linked to the telemetry and alarmed.

Other measures that were recommended by TJ O'Connors and Associates (2008) to be implemented to reduce risk ratings further include:

- Catchment inspections to be carried out at least monthly to establish a defined monitoring procedure;
- The development of official procedures for notification of irregularities within the catchment; and
- Installing fencing to prevent access to water courses in consultation with relevant landowners.

These recommendations should be reviewed and implemented if not already done so.

Assess Treated Water Manganese Levels

Only raw water quality has been assessed through this report. Given the high levels of manganese present in the raw water, it is recommended that the data for treated water manganese levels is reviewed to assess whether the Drinking Water Regulations (2007 and 2014) parametric value for manganese has been frequently exceeded.

Agriculture and farmyard management

Levels of nutrients within the Nadregeel Loughs, whilst not excessive, are at levels that can contribute to the deterioration of raw water quality. Potentially dangerous blue-green algal blooms have been observed historically, and there is high to very high risk of nutrient and microbial pathogen contamination throughout the catchment as identified through groundwater vulnerability, EPA domestic wastewater risk and water quality monitoring data. The primary sources of nutrient enrichment and microbial contamination of freshwater systems are diffuse agricultural pollution and point source pollution (frequently from domestic wastewater treatment systems). Therefore a number of key issues related to these pollution sources are addressed below:

(a) Fencing of water bodies

Livestock access to water bodies can lead to potential contamination issues with regard to nutrient input and faecal coliforms. A survey of fencing and livestock access was not undertaken as part of this report and this is recommended as some areas do allow the possibility of direct livestock access to the lakes. There may also be areas of direct livestock access to the inflow streams. Although it may not be feasible to fence all boundaries to water bodies within the Billis Lavey GWS catchment, limiting livestock access could significantly reduce potential faecal contamination of the GWS water source and remove a potential source of direct nutrient input.

(b) Nutrient management

Although there is limited intensive agriculture undertaken within the fields immediately surrounding the Billis Lavey GWS abstraction point and the eastern lake of the Nadregeel Loughs, nutrient levels have been elevated, and Tellus Border soil and water sampling identified areas where there may be nutrient excess issues. The implementation of soil nutrient analysis at priority areas within catchment would be valuable, particularly on land directly bordering water bodies. Knowledge of soil nutrient status would allow farmers to match fertiliser application to their needs and to save money by not applying fertiliser to fields that do not require it. This analysis would be beneficial to both the GWS and the farmers and therefore the costs could be shared.

Nutrient management plans, if not already in place, should be developed with landowners within the catchment, particularly those whose land borders a water body. Nutrient management planning is a best management practice that helps to make the most efficient use of available nutrients and avoid pollution. Significant financial savings per hectare can be made through efficient nutrient management, providing benefits to both the farmer and the environment.

Scheme members should be aware of potential problems caused by agriculture and the relevant rules and regulations relating to spreading of fertiliser and manure (European Communities (Good Agricultural Practice for Protection of Waters) Regulations 2014).

Some important points include:

- No chemical fertiliser applied within 2m of surface waters;
- No organic fertiliser/soiled water spread within 20m of a lake shoreline;
- No organic fertiliser/soiled water spread within 5 m of surface water course UNLESS slope is >10%, then the setback distance is 10 m. The setback distance is 10 m regardless of slope for 2 weeks before and after the closed period.
- For abstractions >100 m^3/d or >500 people, no spreading within 200m of the abstraction point (surface water, borehole, spring or well).
- For abstractions >10 m^3/d or >50 people, no spreading within 100m of abstraction point (as above).

Also, fertilisers (including manure) 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 water, soil condition, ground cover and rainfall – there is significant risk of causing water pollution.

To increase compliance, the scheme should undertake a communications initiative to remind Scheme members of their legal obligations and the benefits to the scheme of complying within this code of good agricultural practice.

(c) Engage with forestry owners and managers

Under certain management scenarios such as felling, planting, spreading of fertiliser and road construction, the location of a small commercial coniferous forest on the northern shore of the eastern lake of the Nadregeel Loughs directly opposite the Billis Lavey GWS abstraction point, can present potential risks to the quality of the raw water supply in terms of nutrient and sediment contamination. It is recommended that Billis Lavey GWS engage with the forestry owners and managers to in order to understand when these management actions may be carried out. to discuss future management actions and their potential impact on raw water quality. Billis Lavey GWS should seek to understand where future felling, planting, nutrient enrichment and roadway construction and maintenance works will be carried out and undertake a risk assessment of likely impact to raw water quality at the abstraction point. Billis Lavey GWS can then develop a management action plan in response to the potential scenarios outlined in the risk assessment.

Septic Tanks/Wastewater Treatment Systems

Because dwelling density within the Billis Lavey GWS catchment is high, recommendations from the National Source Protection Pilot Project suggest that education should be provided to householders regarding the correct care and maintenance of their on-site wastewater treatment systems (OSWTSs). Although the proportion of the town of Ballyjamesduff that occurs within the catchment area is supplied by a public sewage system, the number of domestic wastewater treatment systems within the catchment is likely to be high. This is reflected in the Very High to High risk categories for nutrient and bacterial contamination of surface and groundwaters that are present throughout the majority of the catchment. Therefore the correct management of these domestic wastewater treatment systems is essential in order to maintain a good quality raw water supply.

The Water Services (Amendment) Act (2012) aims to regulate wastewater discharges from all homes that are not connected to the public sewer network. Regulation includes registration and inspection of all OSWTSs. The Environmental Protection Agency has produced a Code of Practice for Wastewater Treatment for Single Houses which is available from the EPA website: https://www.epa.ie/water/wastewater/guidance/cop/.

Billis Lavey GWS should instigate a communications initiative to provide Scheme members with the following advice with regards to ensuring that all wastewater treatment systems within the catchment are functioning properly:

- All wastewater treatment systems should be properly installed by a competent person and a certificate of installation should be obtained upon completion.
- Have the septic tank/wastewater treatment system inspected and de-sludged once a year.
- Only permitted waste contractors should remove the sludge –a list of contractors is available from Cavan County Council.
- If effluent is observed sitting on the ground near the tank/system then the system should be checked for blockages and emptied if required. If due to poor drainage then expert advice should be sought by contacting Cavan County Council.

High risk systems, along with agricultural yards which are situated within areas of poor soil drainage, high groundwater vulnerability and are located on ground that slopes steeply towards a water source should be inspected as a priority in order to ensure that potential risk of contamination from these point sources is reduced.

Trihalomethane monitoring

As discussed in this report, relatively high levels of raw water colour that are present in the Billis Lavey GWS raw water supply do not represent health risks. However, upon treatment with chlorine, THMs can be produced when the chlorine reacts with naturally occurring organic matter in the raw water (high true colour values can be an indication of high organic matter). These THMs have potentially significant health implications and further information on THMs and their monitoring within Ireland is provided by the Environmental Protection Agency: http://www.epa.ie/pubs/advice/drinkingwater/DrinkingWaterGuide4_v8.pdf.

Although THM concentrations in the Billis Lavey GWS treated water did not exceed the Drinking Water Regulations (2007) on any occasion, given the recent high True Colour and the lack of recent Trihalomethane data, the Trihalomethane sampling frequency may not have been sufficient to detect any occasion when the parametric value was exceeded. Trihalomethane monitoring has historically been undertaken during the period when True Colour values are typically highest (late summer to early winter), but the frequency of sampling may need to be increased and therefore it may be prudent to undertake a short-term THM monitoring programme over the course of one year that concentrates on the late summer to early winter period, but also includes a minimum of two samples taken during the remainder of the year.

These monitoring timeframes will identify the frequency of when the Drinking Water Regulations (2014) parametric value for THMs id exceeded. The following mitigation methods for raw water are advised by the EPA if THM levels are found to be high in the treated water:

- Improve raw water management, including storage, intake management and monitoring and control (e.g. raw water turbidity monitors or automation of coagulant dosing based on raw water conditions);
- Install automatic shut off when water quality is poor.
- Examine the option for using an alternative raw water source.

The challenge remains between maintaining low THM levels whilst increasing chlorine treatment to remove coliform contamination. It is in this arena where source protection and the catchment-level management actions outlined in this report are important.

7.1 Further Work

1. Put Source Protection on the agenda

Including source protection issues on the agenda of committee meetings increases the profile and awareness of source protection issues within the Billis Lavey catchment, and brings into focus the recommendations made within this report. Developing a protocol for dealing with potential pollution incidences would be a good first step for the committee to address.

2. Consider initiating a short-term Trihalomethane monitoring programme

Although Trihalomethane (THM) concentrations have not exceeded the Drinking Water Regulations (2007 and 2014), despite sampling frequency being low, levels have been high on occasion. It is recommended that a one year monitoring programme is instigated, with sampling frequency focussed on the period between late summer and early winter when the possibility of THM formation is likely to be greatest as a result of high True Colour and organic content within the raw water supply.

3. Review the recommendations made in the Billis Lavey *Cryptosporidium* Risk Assessment Report

Billis Lavey GWS has been classified as being at Moderate Risk of *Cryptosporidium* contamination. The recommendations made within the C*ryptosporidium* Risk Assessment report should be reviewed and implemented if not already applied.

4. Engage with forestry owners and managers

Identifying future forestry management plans and actions will enable Billis Lavey GWS to assess the risk to raw water quality at its current abstraction point associated with each forestry management action and to develop its own management action plan in response to the potential scenarios outlined in the risk assessment.

5. Initiate a communications drive

The Scheme should undertake a communications initiative to remind Scheme members of their legal obligations with regards to nutrient enrichment practices, to recommend Good Agricultural Practices and to highlight the importance of waste water treatment system management. Highlighting the importance of Scheme members' actions in regards to improving raw water quality could also raise awareness for facilitating improvements in environmental status of all the water bodies within the Billis Lavey GWS catchment.

Blatant disregard of good agricultural practices and regulations regarding the spreading of slurry/manure/artificial fertiliser on land adjacent to water courses should be reported to Cavan County Council.

Consideration should be given to engaging local schools to take an interest in local water resource management issues and to encourage students to undertake projects that can ultimately help raise the profile of Billis Lavey GWS and the source protection measures required to help improve the environmental status of the catchment area whilst also providing cost-savings in the water treatment process.

6. Engagement of Cavan County Council

Given the location of the Local Authority abstraction point in the western lake of the Nadregeel Loughs, Billis Lavey GWS should engage with Cavan County Council regarding the communication of Good Agricultural Practices and domestic wastewater treatment system maintenance in order to work together to raise the profile of these issues and to attempt to increase the potential for community uptake. This is of particular importance where dwellings are located within the catchment and may be impacting on raw water quality but are not members of the Billis Lavey GWS and its distribution network.

8.0 References

Brogan, J, Crowe, M. and Carty, G. (2001). Developing a national phosphorus balance for agriculture in Ireland. Environmental Protection Agency, Ireland.

Clabby, K.L, Lucey, J. and McGarrigle, M.L. (2006). Interim report on the biological survey of river Quality. Results of the 2004 investigations. Environmental Protection Agency. ISBN 1-84095-186-9.

Clabby, K.L., Bradley, C., Craig, M., Daly, D., Lucey, J., McGarrigle, M., O'Boyle, S., Tierney, D. and Bowman, J. (2008). Water Quality in Ireland 2004 – 2006. Environmental Protection Agency.

EPA (2013a). National Inspectorate Plan 2013. Domestic Wastewater Treatment Systems. Environmental Protection Agency.
http://www.epa.ie/pubs/reports/water/wastewater/EPA_National_Inspection_Plan_2013.pdf.

EPA (2013b). A risk-based methodology to assist in the regulation of domestic wastewater treatment systems. Environmental Protection Agency.
https://www.epa.ie/pubs/reports/water/wastewater/EPA_DWWTS_RiskRanking.pdf.

Irvine, K., Allott, N., DeEyto, E., Free, G., White, J., Caroni, R., Kennelly, C., Keaney, J., Lennon, C., Kemp, A., Barry, E., Day, S., Mills, P., O'Riain, G., Quirke, B., Twomey, H. and Sweeney, P. (2001). Ecological assessment of Irish lakes – Final Report. Environmental Protection Agency.

T.J. O'Connors and Associates (2008). East Cavan Water Treatment Project Risk Assessment for *Cryptosporidium*. Report to Cavan County Council.