

Preliminary Report on Source Protection

**Fahy Group Water Scheme
County Mayo**

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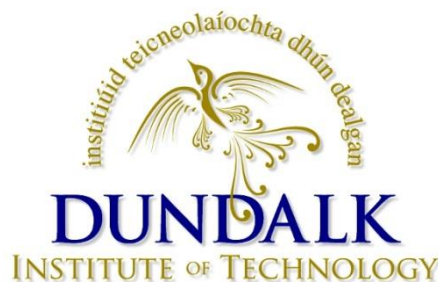


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Executive Summary

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 Fahy 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).

Fahy Group Water Scheme is located approximately 5 km northeast of Westport in County Mayo. The scheme extracts its water from Clogher Lough, a lake with a surface area of approximately 34 ha and a catchment area of approximately 16.9 km². The lake's only outflow stream exits the lake to the north, joining the Moyour River approximately 200 m downstream of Clogher Lough. Clogher Lough is located at an elevation of approximately 26 m, with elevation highest to the southwest of the catchment where it reaches just over 110 m. Clogher Lough has been classified by the Clew Bay Water Management Unit Action Plan as having good ecological status through the extrapolation of regional data.

The bedrock within the catchment area consists predominantly of limestones, sandstones and pebbly grits. Regionally important aquifers are present in the karstified limestone bedrock in the vicinity of Clogher Lough and the south east of the catchment. The combination of aquifer type and subsoil and soil types has resulted in the majority of the catchment being classified as high groundwater vulnerability, meaning that the potential for contaminants to quickly enter the groundwater is high. The karstic nature of the limestone regions also means that the possibility of contaminants being delivered from groundwater into surface water bodies is also high.

The high density of dwellings within the catchment and the subsequent large number of septic tanks/wastewater treatment systems in combination with soil/subsoil thickness and permeability has resulted in the much of the catchment being classed as Very High Risk of nutrient and microbial pathogen contamination of surface waters.

Colour values of the raw water are frequently high and have the potential to exceed the Surface Water Regulations (1989) parametric value for Class A1 waters (although as True Colour has not been monitored by the service provider, AECOM, no direct comparisons can be made).

Trihalomethane values exceeded the Drinking Water Regulations (2007 and 2014) parametric values on 44 % of sampling occasions and values were high regardless of the time of year that sampling was undertaken. A current research collaboration between Fahy GWS and Trinity College Dublin is investigating the raw water quality within the Fahy GWS catchment and its associations with THM formation within the treated water. Such investigations are essential in order to bring THM concentrations to within the treated water to below the Drinking Water Regulations (2014).

Point source pressures (for example wastewater treatment systems and agricultural yards) and diffuse pressures (such as nutrient application to pasture) acting on the surface waters within the catchment are relatively high. Historical nutrient monitoring within the catchment has been limited and although nitrate levels in the drinking water (used here as a proxy for raw water nitrate levels: see Section 6.1.11 for details) are typically low, they can frequently be at levels that can facilitate plant and algal growth and contribute to a decrease in raw water quality. The nutrient data collected through the current research collaboration between Fahy GWS and Trinity College Dublin will provide significant insight into the mechanisms of nutrient delivery into the water courses within the Fahy GWS catchment.

Raw water turbidity can occasionally be high and given the agricultural land use within the catchment, the high number of wastewater treatment systems in areas of high groundwater vulnerability and the Very High Risk of nutrient and microbial pathogen contamination, it is important that the recommendations made in the Scheme's *Cryptosporidium* Risk Assessment report are implemented.

A number of key issues are recommended in Section 7.0 to be addressed in order to improve source protection and maintain high quality water supplies. The most urgent recommendations are:

1. Initiate a raw water faecal contaminant monitoring programme

Given the significant pressures acting within the Fahy catchment, in particular the high risk of faecal contamination of the raw water supply in association with the presumed lack of current faecal contaminant monitoring, it is important for a raw water faecal contaminant monitoring programme to be initiated. For the first year, monitoring timeframes should be sufficient to allow for short-term variations within the data set. Following the first year, timeframes and parameters should be reviewed with regard to raw water quality and available budget.

2. Engage AECOM regarding True Colour monitoring

AECOM should be engaged to discuss the inclusion of True Colour in the current raw water monitoring programme. This would allow comparisons with the Surface Water Regulations (1989) to assess whether the parametric value for True Colour has been historically and presently exceeded. Subsequently, potential mitigation methods may be identified with the aim of reducing high colour values in the raw water supply which may in turn assist in reducing Trihalomethane formation in the treated water supply.

3. Review the current *Cryptosporidium* Risk Assessment Report

The Fahy GWS was classified as Very High Risk in the Ryan Hanley (2006) *Cryptosporidium* Risk Assessment report. The recommendations of this 2006 report (see Appendix 1) should be reviewed and if necessary, a new report should be commissioned with an additional focus on source protection measures to ascertain whether risk of *Cryptosporidium* contamination has been reduced.

4. Initiate a communications drive

Fahy GWS 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 wastewater treatment system management. Encouraging end user interest in water treatment through a Community Open Day and engaging local schools to take an interest in local water resource management are options that could be explored to raise the profile of Fahy GWS and the source protection measures required to help improve the environmental status of the catchment area which could also potentially provide cost-savings in the water treatment process.

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 Fahy 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 Ordnance 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 Fahy 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

Water quality data relating to the catchment area was provided by the National Federation of Group Water Schemes (NFGWS) from April 2008 to December 2013. Raw water and treated water monitoring was undertaken by Earth Tech Ireland from April 2009 to September 2009 and by AECOM from October 2009 onwards. Data was provided by NFGWS in the form of Monthly Status Reports.

A current Trihalomethane research collaboration between Fahy GWS and Trinity College Dublin is assessing the following raw water quality parameters at a number of locations within the Fahy GWS catchment (Connie O'Driscoll, *pers. comm.*): Dissolved Total Organic Carbon (DTOC); Ammonia; Soluble Reactive Phosphorus (SRP), Total Oxidised Nitrogen (TON); and phytoplankton enumeration. The project will also be assessing THM concentrations within the treated water supply. Preliminary data from this monitoring programme was made available by Dr. Connie O'Driscoll, providing both information regarding future water quality monitoring actions and an insight into recent water quality conditions, but only the additional THM data has been presented in this report.

Parameters relevant to source protection were taken from the Monthly Status Reports, analysed temporally and interpreted to highlight potential water quality issues in the Fahy GWS catchment and their potential causes and impacts.

3.0 Overview of the Fahy 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. Fahy GWS abstraction point and its catchment lie within the Western River Basin District (WERBD). Each RBD is subdivided into Water Management Units (WMU), and the Fahy GWS catchment is included within the Clew Bay Water Management Unit for the WERBD, on the boundary of two other WMUs: Conn and Mask. An action plan for the Clew Bay WMU is available from <http://www.wfdireland.ie/docs/>.

The WMU action plan presents an overview of water quality, information relating to potential causes of pollution and actions required to improve water quality to 'good' status (the overarching objective of the WFD is to achieve 'good' status for all water bodies).

In the Clew Bay WMU Action Plan, rivers within the WMU were predominately classed as good to high status (32 and 15 rivers respectively) with only 13 rivers classed as moderate status and 11 as poor status. Of the 10 lakes situated within the WMU, two are classed as high status, six as good and two as poor status. The Clew Bay WMU Action Plan attributes 60 % of the Total Phosphorus (TP) load to diffuse sources, with agriculture accounting for over 40 % of TP. Wastewater treatment plants and forestry account for 40 % and 12 % of TP respectively.

Clogher Lough, from which Fahy GWS abstracts its water, has not been monitored as part of the EPA's Water Framework Lake Water Quality Monitoring Programme, however its overall ecological status has been extrapolated from regional data and classified as good.

4.0 Physical Site Description

4.1 Catchment location and outline

Fahy Group Water Scheme is located approximately 5 km northeast of Westport in County Mayo. The scheme extracts its water from Clogher Lough, a lake with a surface area of approximately 34 ha (Figure 1 and Figure 2). Water flows into the lake from two inflow streams that enter the lough at its southern edge. The inflow streams drain an area to the southeast and southwest of Clogher Lough, a catchment area of approximately 16.9 km². Water flows from the south east through a number of streams which first enter Cogaula Lough before continuing to flow into Clogher Lough. From the south west, a number of streams flow into Doo Lough before continuing to flow into Clogher Lough. Like Clogher Lough, Doo Lough has also been classified as having good ecological status through extrapolation of regional data.

The Group Water Scheme abstraction point (Figure 2) lies at the north-western edge of Clogher Lough. The lake's only outflow stream exits the lake to the north, joining the Moyour River approximately 200 m downstream of Clogher Lough. Clogher Lough is located at an elevation of approximately 26 m, with elevation highest to the southwest of the catchment where it reaches just over 110 m.

4.2 Bedrock geology

The bedrock underlying the Fahy GWS catchment initially appears complex as it is made of a number of different formations (Figure 3). However, the majority of these are comprised of limestone: Aille and Barney Formations (in the immediate vicinity of Clogher and Doo Loughs); Castlebar River and Lough Akeel Formations; Creagh Member; Burrishoole Member; Ardnasillagh Formation; and the Oakport Limestone Formation. The south east of the catchment is solely dominated by these limestone bedrocks. Karstic features may be present in the vicinity of Clogher Lough and the south east of the catchment and in these regions linkages between the surface water and groundwater are an important component of the hydrology. Karstic areas that have little soil/subsoil cover can have high infiltration rates into the bedrock aquifer, and high groundwater flow speeds within the aquifer,

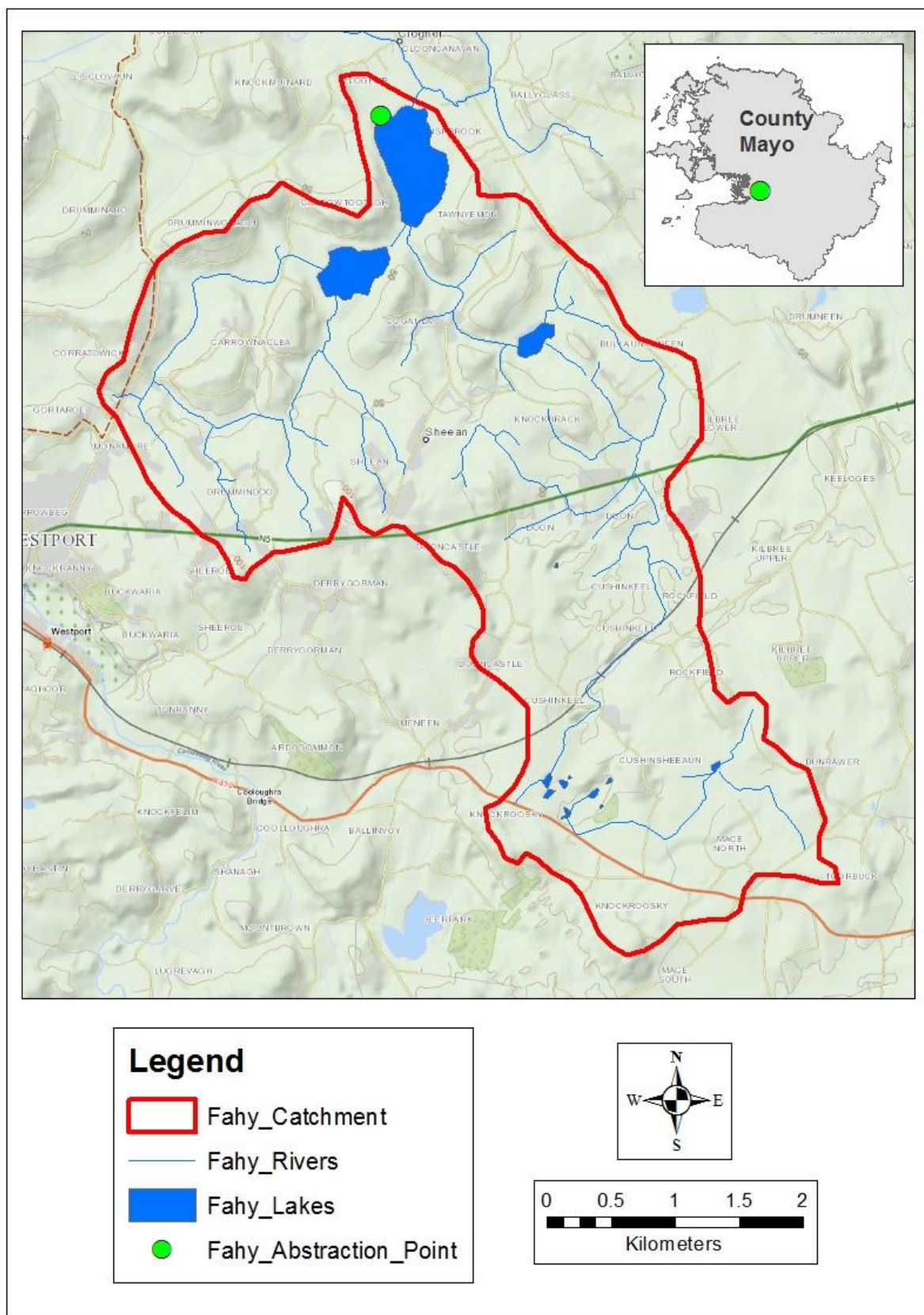


Figure 1: Surface water catchment area for the Fahy GWS.



Figure 2: Clogher Lough facing south from the Fahy GWS treatment plant located close to the abstraction point.

which can result in a reduced capacity for filtration of water-borne contaminants between surface waters and the groundwater system.

The Graffa More Formation situated to the south east of Clogher Lough and the north of Cogaula Lough is made up of red and green conglomerate and sandstone. A band of pebbly grits, metagreywackes and phyllites make up the Westport Grit Formation which runs east-west through the centre of the catchment. A small region of sandstone and pebbly conglomerate (the Moy Sandstone Formation) is situated to the southeast of the Westport Grit formation.

4.3 Bedrock aquifers

An aquifer is an underground body of permeable rock or sand/gravel that yields water in sufficient quantities for use. Regions that are aligned with the limestone bedrocks of the catchment are classified as having the most productive aquifers (Figure 4). The areas in the vicinity of Clogher and Doo Loughs, and the south east of the catchment are classified as regionally important aquifers, with a karstified component. These aquifers are likely to contain large groundwater stores and the porous nature of the karstified landscape in association with shallow soils/subsoils can reduce the potential for contaminant filtration from surface water as it flows into the groundwater, providing a potential pathway for contaminants to quickly enter groundwater.

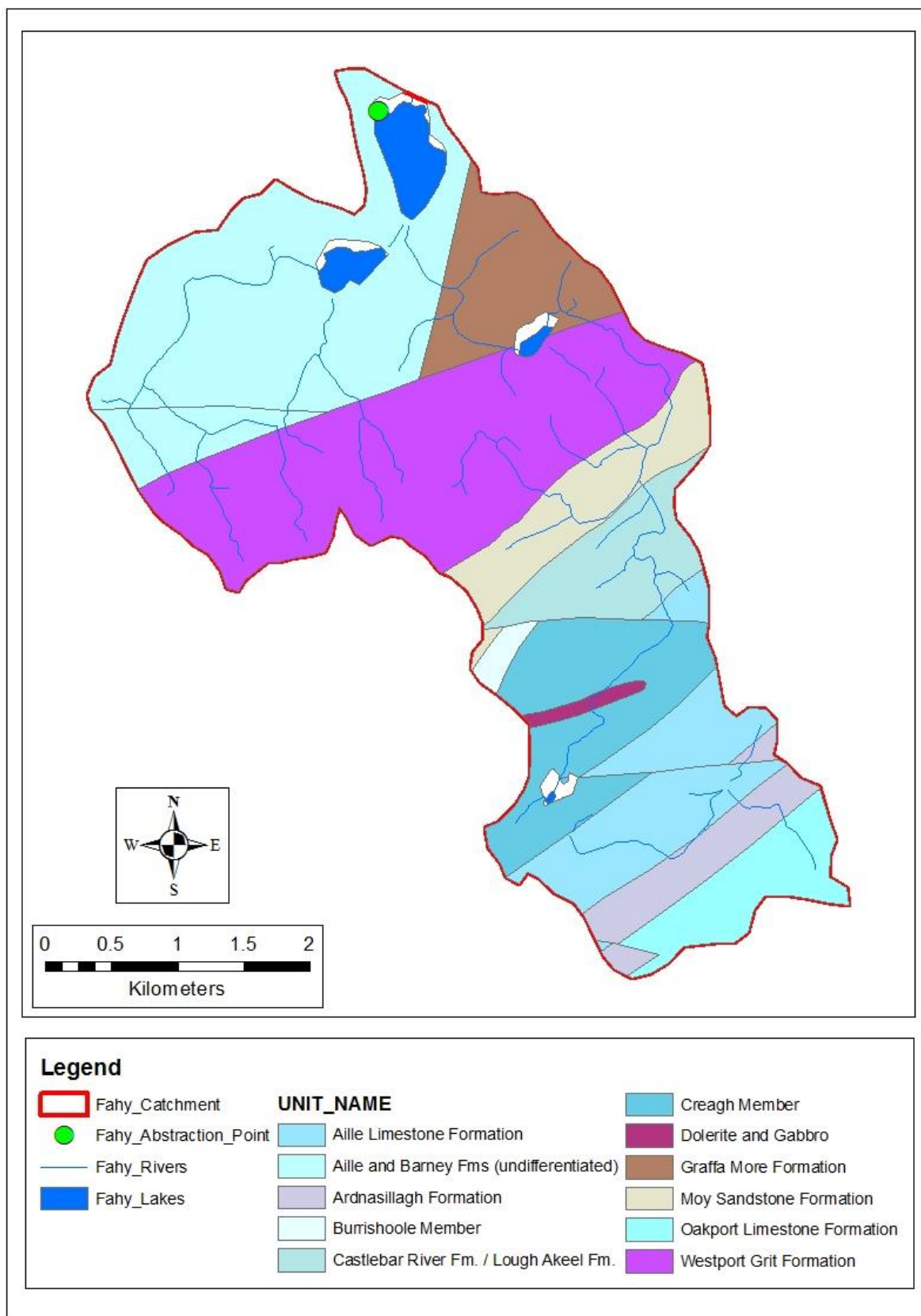


Figure 3: Bedrock geology within the Fahy GWS catchment.

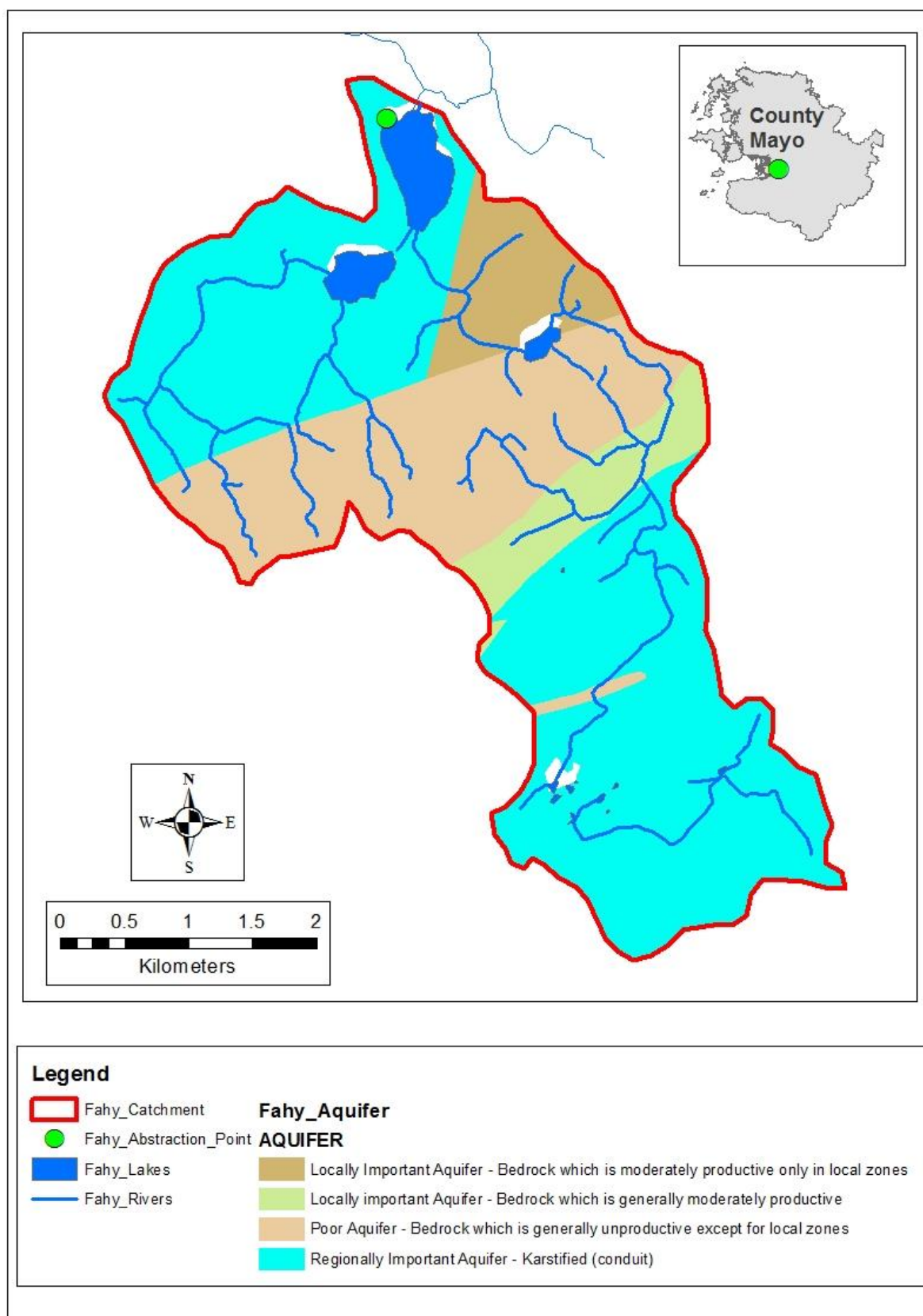


Figure 4: Aquifer types present within the Fahy GWS catchment.

The area to the south east of Clogher Lough and to the north of Cogaula Lough is classified as a locally important aquifer, the bedrock of which is moderately productive only in local zones. The aquifer present in the Westport Grit Formation that runs east-west through the centre of the catchment is classified as a poor aquifer, the bedrock of which is generally unproductive except for local zones. To the south east of this zone lies a locally important aquifer, the bedrock of which is generally moderately productive.

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 is variable throughout the Fahy GWS catchment (Figure 5). To the immediate north of the GWS abstraction point, areas of the highest vulnerability classification are present: E (Rock at or near the surface or karst) and Extreme. The rest of the northern region of the catchment is generally classified as either moderate or low vulnerability. The central and southern regions of the catchment are predominantly classified as high vulnerability, with areas of extreme and E vulnerability classifications present at higher elevations.

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.

Areas of limestone till are present in the north, west and south east of the catchment (Figure 6). The subsoils in the immediate vicinity of Clogher and Doo Loughs are predominantly sandstone till (formed during the Devonian period) and metamorphic till is present in a band through the centre of the catchment. Sandstone till formed during the Lower Palaeozoic era is present in the southernmost region of the catchment whilst areas of cutover peat are present in the vicinity of the water courses throughout the catchment.

4.6 Soils

A variety of soil types are present within the Fahy GWS catchment area (Figure 7). Areas of deep, well drained, calcareous mineral soil are present in the north, west and southwest of the catchment. Much of the remainder of the catchment is a mosaic of both deep, well drained and deep, poorly drained non-calcareous mineral soil. Areas of cutover peat are present in the vicinity of the water courses throughout the catchment. Small areas of mainly shallow, non-calcareous peaty mineral soil of undefined drainage are present in the centre of the catchment at higher elevation.

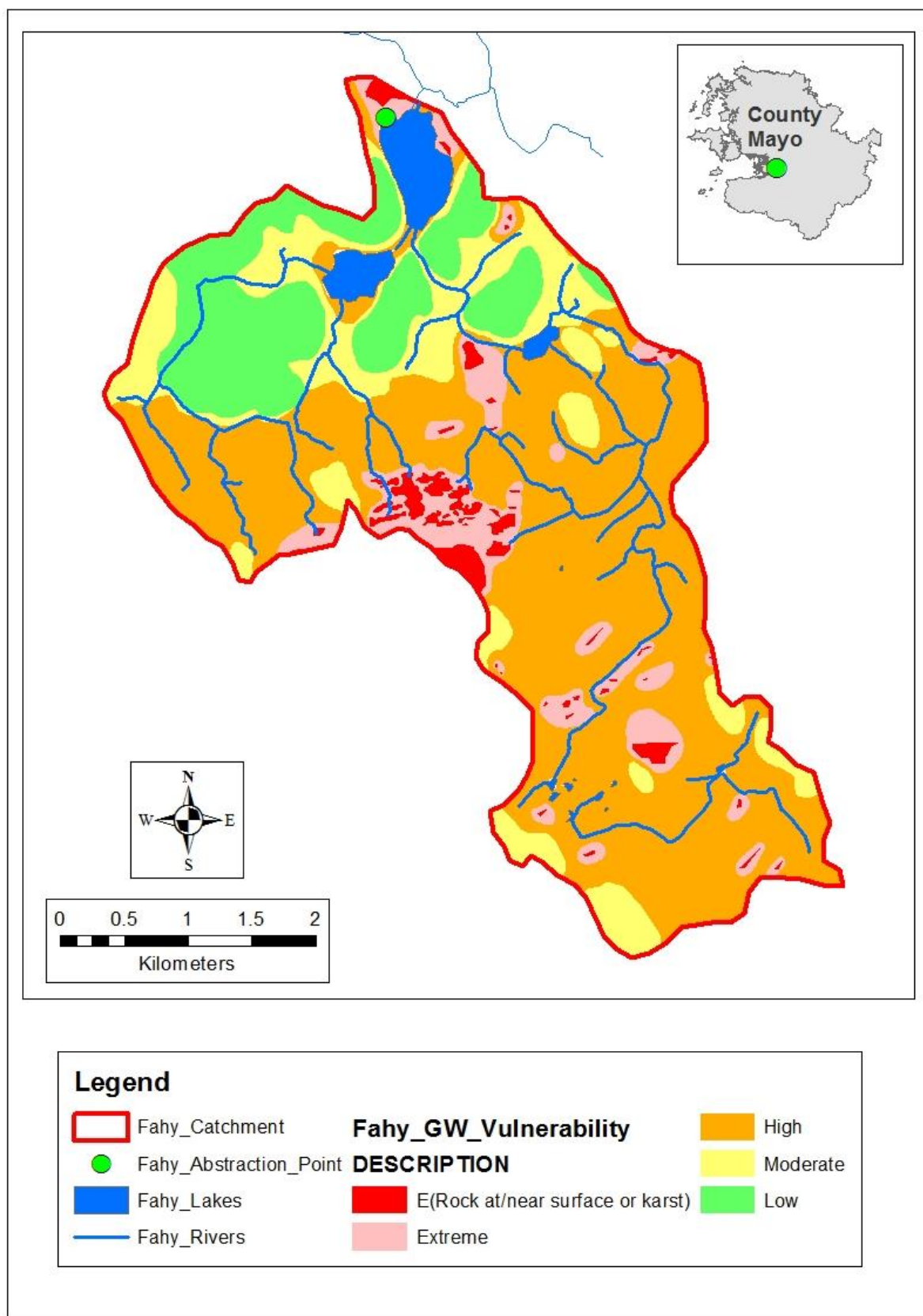


Figure 5: Groundwater vulnerability within the Fahy GWS catchment.

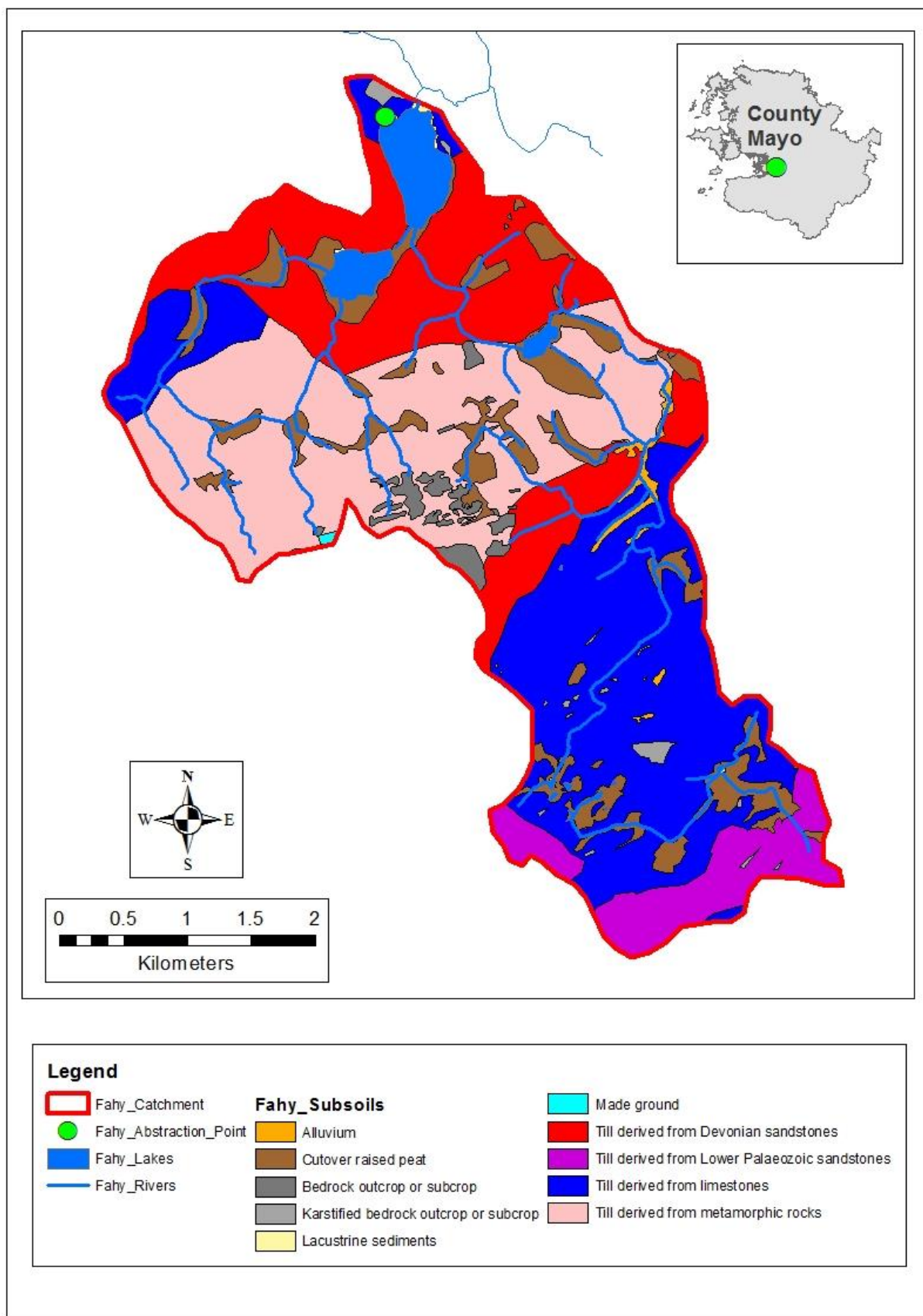


Figure 6: Subsoil deposits within the Fahy GWS catchment.

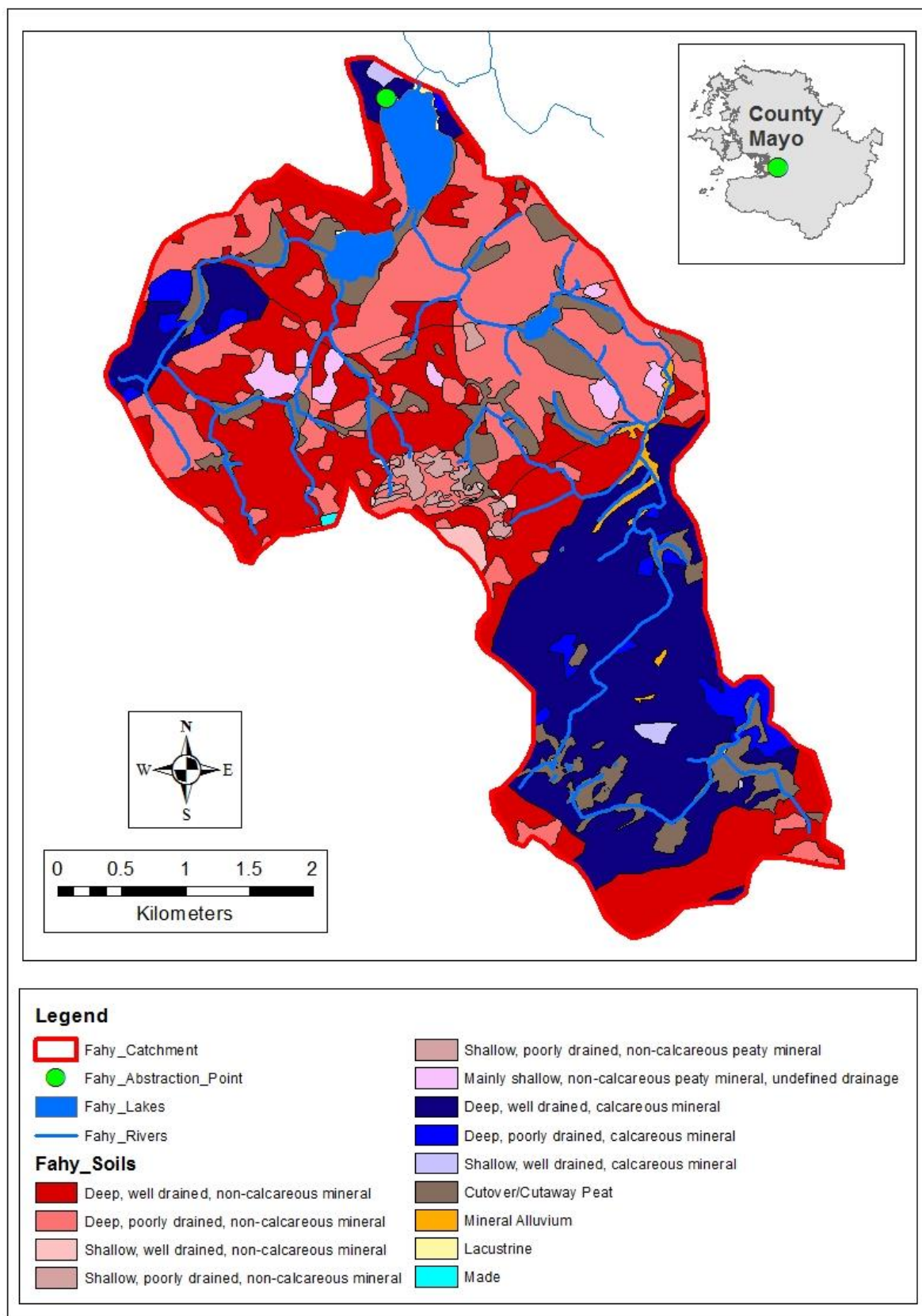


Figure 7: Soil types present within the Fahy GWS.

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 110 m occurs in the south-western area of the catchment and the land falls towards Clogher Lough which has an elevation of approximately 26 m. Clogher Lough itself is surrounded by small hills with relatively gentle slopes leading to the lake (Figure 2) which can facilitate the delivery of nutrients and other contaminants into the raw water supply.

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 Fahy GWS catchment is classified as land principally occupied by agriculture with areas of natural vegetation (Figure 8) with areas of transitional woodland scrub dispersed throughout the catchment. Areas of pasture are present to the south west of Clogher Lough and in the southern region of the catchment. A small area of coniferous forestry is located in the south east of the catchment. An area of non-irrigated land is located in the central south region of the catchment.

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

5.2 Forestry

Forestry plantations present threats to the quality of water bodies during the planting and early growing phase of a forestry 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

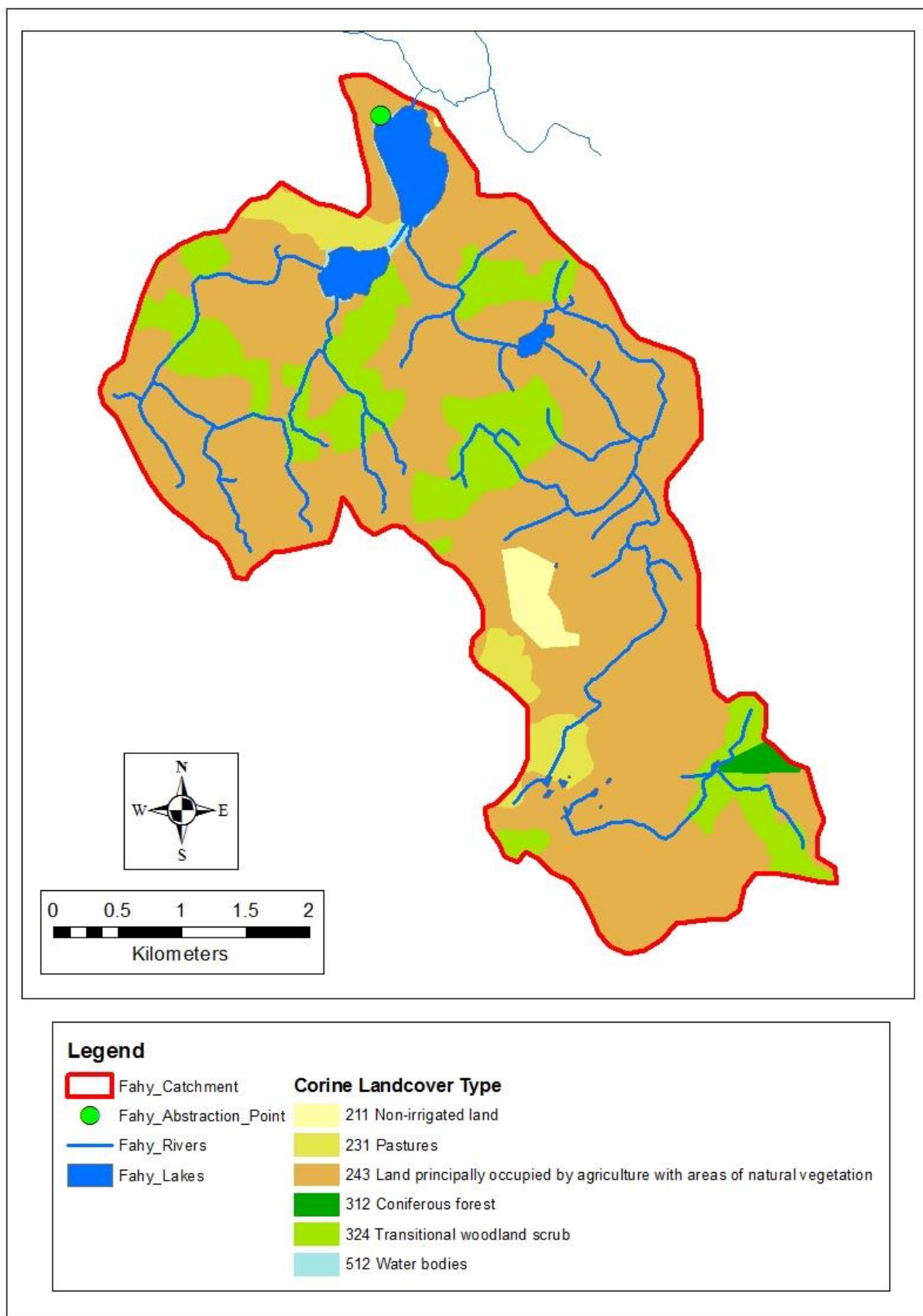


Figure 8: CORINE Land Cover classification within the Fahy GWS catchment.

forestry roads causes disturbance, erosion and compaction of the soil surface resulting in sedimentation and nutrient run-off.

An area of coniferous forest is present in the south west of the catchment but this is unlikely to present a high risk to the water quality of the larger Fahy GWS catchment.

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

There are no IPPC licensed facilities within the Fahy GWS catchment.

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.

The location of dwellings in the Fahy GWS catchment was estimated by viewing the Ordnance Survey map and aerial photography of the area (Figure 9). Whilst dwellings cannot be differentiated from other buildings, some insight into the location of dwellings and associated on-site wastewater treatment plants (usually septic tanks) was gained. There are a limited number of dwellings within the immediate vicinity of Clogher Lough, however dwelling density is relatively high throughout the rest of the catchment, particularly in the western and central regions.

The dwellings in the northern region of the catchment are typically associated with areas of moderate and low groundwater vulnerability whereas those located in the central and south eastern regions are typically associated with areas of high, extreme and, in some cases, the highest groundwater vulnerability classification of E. Soils where dwellings are located are typically well-drained, although a number of dwellings are located within areas of poorly draining soil in the north eastern and north western regions of the catchment.

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). There are a number of domestic wastewater risk classifications within the Fahy GWS catchment area and these are best viewed online via the EPA's geoportal: <http://gis.epa.ie/Envision>. The south east of the catchment is classified as Low Risk and a Non-sensitive area, however risk increases north and westwards. In the vicinity of Cogaula Lough, risk is classified as Moderate (Non-sensitive area) and as High (Non-sensitive area) to the south and east of Cogaula Lough. The risk classification to the south west and west of the catchment, where the greatest density of dwellings occurs, is classified as Very High (Non-sensitive area). The same Very High (Non-sensitive area) classification occurs to the east of Clogher Lough whilst the area to the north of the abstraction point is classified as High risk (Non-sensitive area). Clogher Lough itself is predominantly classified as Low risk (Non-sensitive area).

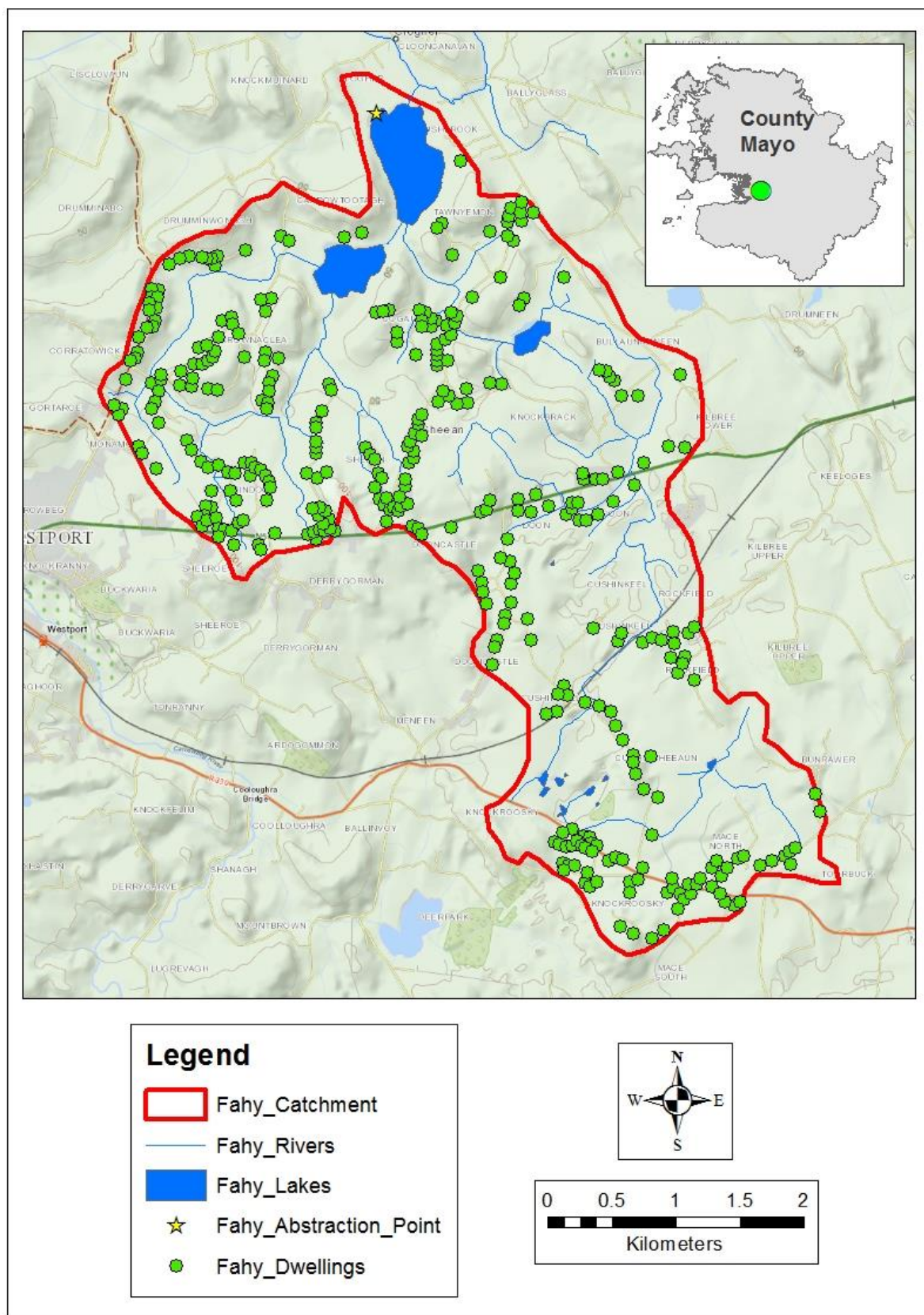


Figure 9: Estimated locations of dwellings (green dots) following examination of Ordnance Survey Map and aerial photography of the Fahy GWS catchment.

5.5 Overall interpretation of catchment land use

The abstraction point for Fahy GWS is located on the northern shore of Clogher Lough, a lake with a surface area of approximately 34 ha. The catchment area extends to the south, covering an area of approximately 16.9 km². Two inflow streams flow into the lake from the south and a single outflow stream exits the lake to the north. The bedrock within the catchment area consists predominantly of limestones, sandstones and pebbly grits. Regionally important aquifers are present in the karstified limestone bedrock in the vicinity of Clogher Lough and the south east of the catchment. The combination of aquifer type and subsoil and soil types has resulted in the majority of the catchment being classified as high groundwater vulnerability, meaning that the potential for contaminants to quickly enter the groundwater is high. The karstic nature of the limestone regions also means that the possibility of contaminants being delivered from groundwater into surface water bodies is also high.

Relatively intensive livestock farming has been noted within the catchment and therefore risk of faecal contamination of the GWS raw water supply is likely to be relatively high. The density of dwellings within the catchment and the subsequent large number of septic tanks/wastewater treatment systems in combination with soil/subsoil thickness and permeability has resulted in the much of the catchment being classed as Very High risk of nutrient and microbial pathogen contamination of surface waters. Ryan Hanley Consulting Engineers undertook a Ryan Hanley Consulting Engineers undertook a *Cryptosporidium* Risk Assessment on behalf of Fahy GWS in 2006, resulting in an overall risk classification of Very High Risk. Further recommendations with regard to the microbial contamination of the raw water supply and monitoring activities are provided in Section 7.0.

Much of the land use within the catchment is agricultural, predominantly being used for livestock grazing. It is likely that these pastures are enriched with slurry/manure/fertiliser and subsequently run-off from these pastures has the potential to deliver nutrients to the surface waters and, where groundwater vulnerability is high, to the groundwaters of the catchment. The analysis of water quality parameters is provided in Section 6.0, with recommendations regarding nutrient management provided in Section 7.0.

6.0 Raw Water Quality

Water quality data relating to the catchment area was provided by the National Federation of Group Water Schemes (NFGWS) from April 2008 to December 2013. Raw water and treated water monitoring was undertaken by Earth Tech Ireland from April 2009 to September 2009 and by AECOM from October 2009 onwards. Data was provided by NFGWS in the form of Monthly Status Reports. Preliminary data from the current water quality monitoring programme was also provided by Dr. Connie O'Driscoll as part of the present Trihalomethane research collaboration between Fahy GWS and Trinity College Dublin. This data provided both information regarding future water quality monitoring actions and an insight into recent water quality conditions, but only the additional THM data has been presented in this report.

Parameters relevant to source protection were taken from the Monthly Status Reports, analysed temporally and interpreted to highlight potential water quality issues in the Fahy GWS catchment and their potential causes and impacts.

Data was recorded by AECOM on behalf of Fahy GWS in two ways: daily measurements that were averaged over the period of each month (here termed 'Monthly Average'); and once monthly spot samples (here termed 'Monthly Spot Samples'). As outlined in Section 6.1.1, monthly spot samples give an indication of the water quality only on that particular sampling occurrence whereas the monthly average data takes into account the variation in water quality observed over the course of a calendar month. Because of this, it is typically the monthly average values that are described below.

Included below are details of important parameters that have not been monitored to date. These parameters have been described and it is noted when such parameters have not been monitored for the Fahy GWS catchment.

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. TOC has not historically been monitored within the Fahy GWS catchment, but it is currently being monitored by Dr. Connie O'Driscoll as part of the Trihalomethane research collaboration between Fahy GWS and Trinity College Dublin.

Due to its association with THM formation, 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 PtCo to 134 mg/L PtCo. The Surface Water Regulations (1989) recommend a value of 20 mg/L PtCo/Hazen (True Colour) for A1 waters. The Drinking Water Regulations (2007 and 2014) recommend a parametric value of 100 µg/L for total trihalomethanes.

Colour was monitored in the raw water by AECOM from April 2009 until December 2013 (Figure 10). From April 2009 until January 2010, colour values are recorded as Apparent Colour (Hazen). After January 2010, there is no description as to whether it is Apparent Colour or True Colour that is recorded. Confirmation has been provided by AECOM that Apparent Colour has been monitored on all occasions and as such, no comparisons can be made with the Surface Water Regulations (1989) parametric value.

Colour values recorded by monthly spot sampling have typically been below the monthly average value except for winter periods in 2010 and 2011/12 (Figure 10). Monthly average colour values have been steadily increasing since November 2011. Monthly average values ranged from a minimum of 11 Hazen recorded in November 2011 to a maximum of 176 Hazen recorded in January 2013, with an average value of 89 Hazen for the sampling period (Figure 10). There is limited association between colour values and monthly rainfall, although high monthly colour values were often recorded in months with high rainfall.

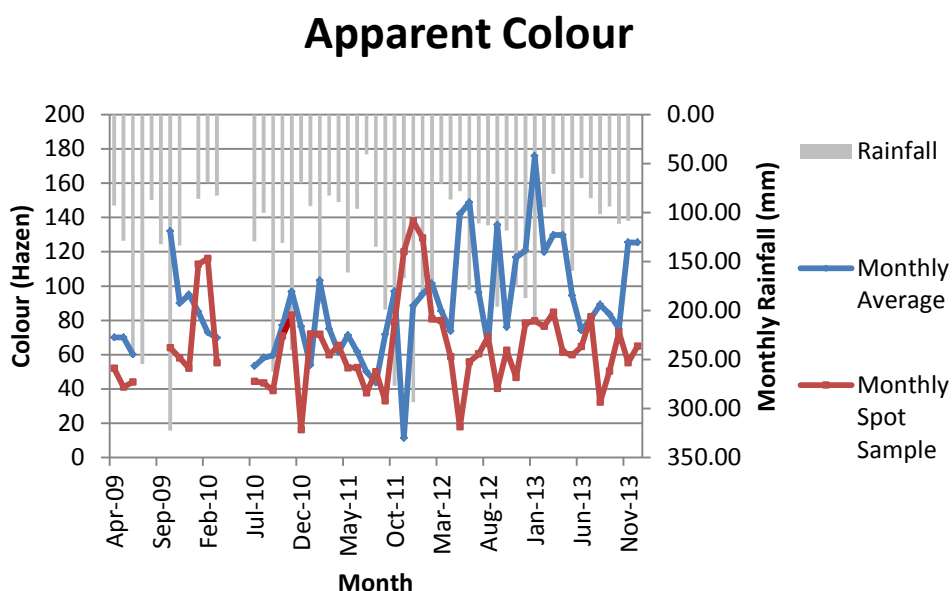


Figure 10: Raw water Apparent Colour (primary axis) from April 2009 until December 2013. Monthly rainfall data (from Newport (Furnace) Met Eireann weather station) is presented on the secondary axis.

Trihalomethanes (THMs) were monitored in the treated water between May 2009 and February 2014 (Figure 11). Data was provided by AECOM and Dr. Connie O'Driscoll (collated from EPA and Mayo County Council data), with the location of the THM sample varying throughout the distribution network. THM values recorded by AECOM were below the limit of detection in April 2012 and this is represented in Figure 11 as a zero value. The maximum value of 205.6 µg/L was recorded in May 2009, whilst the minimum value of 37.4 was recorded in February 2011. An average of 111.3 µg/L was recorded for the sampling period. The Drinking Water Regulations (2007 and 2014) parametric

value of 100 µg/L was exceeded on seven out of 16 sampling occasions (44 % of occasions) and values were high regardless of the time of year of sampling.

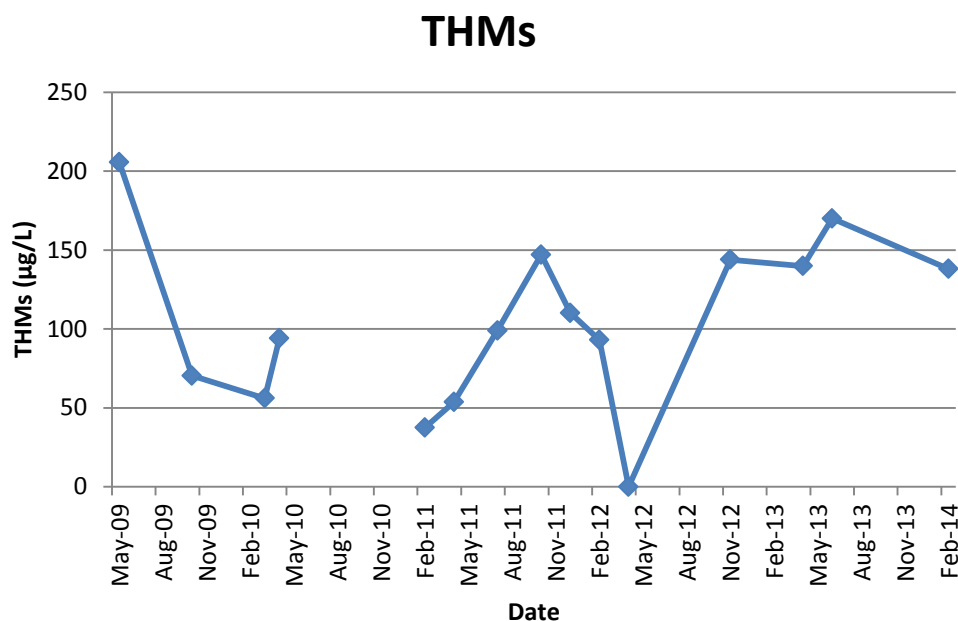


Figure 11: Total Trihalomethanes monitored in the drinking water between May 2009 and F.

6.1.2 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.

pH was monitored in the raw water by AECOM from April 2009 through to December 2013 (Figure 12). Monthly spot samples were reported in the monthly status reports from the first sampling event in April 2009 whereas monthly average values were not reported until July 2010. Values ranged from a minimum monthly average of pH 6.6 in September 2012 to a maximum monthly average of 8.07 in July 2010, with an overall average of pH 7.7 observed over the sampling period. pH values, whether recorded as monthly spot samples or monthly average values, did not fall below the recommended limit for Class A1 waters of pH 5.5 as stated in the Surface Water Regulations (1989). There is limited association between rainfall and pH levels.

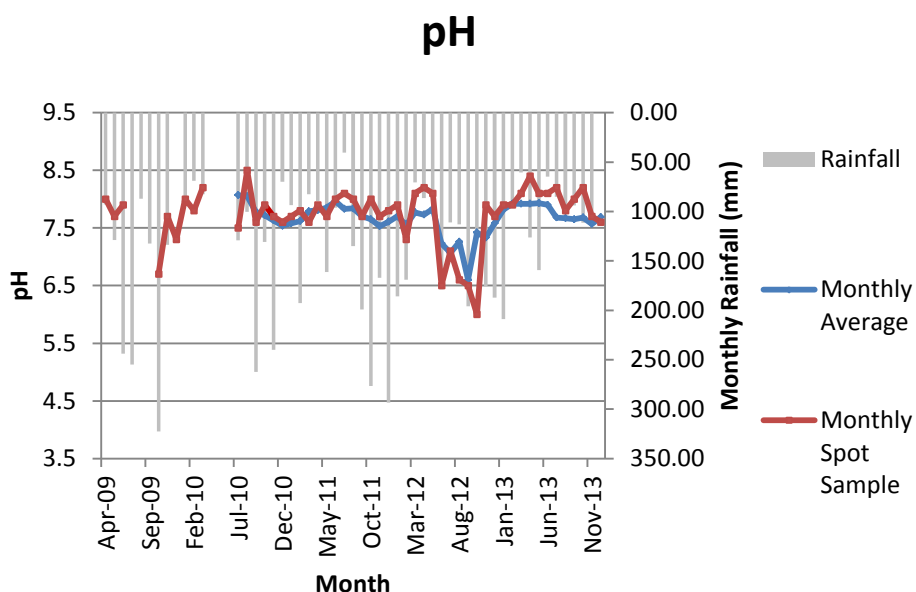


Figure 12: Raw water pH (primary axis) from April 2009 to December 2013. Monthly rainfall data (from Newport (Furnace) Met Eireann weather station) is presented on the secondary axis.

6.1.3 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 Nephelometric Turbidity Units (NTU). Each of these units can be interpreted to mean the same thing.

Turbidity was monitored in the raw water by AECOM from April 2009 until December 2013 (Figure 13). Values ranged from a minimum monthly average of 0.61 NTU in July 2012, to a maximum monthly average of 5.05 NTU recorded in May 2013, with an average of 2.19 NTU for the sampling period. A high value of 14.4 NTU was observed in February 2011 during the monthly spot sampling. There appears to be little obvious relationship between turbidity values and monthly rainfall (Figure 13).

Monthly Average Turbidity

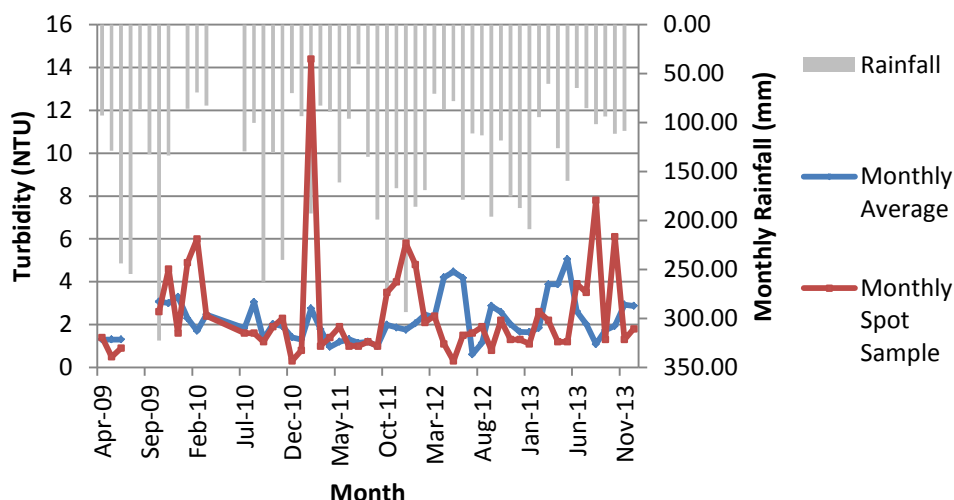


Figure 13: Raw water turbidity (primary axis) from April 2009 until December 2013. Monthly rainfall data (from Newport (Furnace) Met Eireann weather station) is presented on the secondary axis.

6.1.4 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 and chlorides have not been monitored within the Fahy GWS catchment.

6.1.5 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.

No raw water iron monitoring data has been provided for this report, however the *Cryptosporidium* Risk Assessment Report (Ryan Hanley, 2006) mentions that iron parameter exceedences were observed in Clogher Lough monitoring data from November 2000-November 2001 and August 2004 to November 2004 (data not provided for this report).

6.1.6 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.

No raw water manganese monitoring data has been provided for this report, however the *Cryptosporidium* Risk Assessment Report (Ryan Hanley, 2006) mentions that manganese parameter exceedences were observed in Clogher Lough monitoring data from November 2000-November 2001 and August 2004 to November 2004 (data not provided for this report).

6.1.7 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.

Alkalinity has not been monitored within the Fahy GWS catchment.

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).

6.1.8 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 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.

Total Phosphorus has not been monitored within the Fahy GWS catchment. Soluble Reactive Phosphorus (SRP) is currently being monitored by Dr. Connie O'Driscoll as part of the research collaboration between Fahy GWS and Trinity College Dublin.

6.1.9 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.

Chlorophyll has not been monitored within the Fahy GWS catchment. Phytoplankton counts will be monitored by Dr. Connie O'Driscoll as part of the research collaboration between Fahy GWS and Trinity College Dublin.

6.1.10 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 and/or sediment can reduce transparency. Low transparency levels can effect light penetration and also potentially affect the ability of fish to find prey.

Transparency has not been monitored within the Fahy GWS catchment.

6.1.11 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 that 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)

Total Oxidised has not historically been monitored within the Fahy GWS catchment, but is currently being monitored by Dr. Connie O'Driscoll as part of the research collaboration between Fahy GWS and Trinity College Dublin. Nitrate (as NO_3) has been monitored by AECOM in the drinking water on an approximately quarterly basis from April 2009 until December 2013, with additional nitrate monitoring undertaken annually through audit monitoring. As nitrates cannot be removed from the standard treatment process and raw water values are not typically affected during the treatment process, it is valid to use the nitrate concentrations monitored in the drinking water as a proxy for raw water nitrate content.

Of the 20 sampling events, nitrate concentrations were below limits of detection on 15 occasions (75% of occasions: Figure 14). The lowest value of 0.028 mg/L NO_3 was recorded in March 2010, whilst the maximum value of 2.96 mg/L NO_3 was recorded in April 2011. The average value for the sampling period (excluding occasions when values were below the limit of detection) was 1.5 mg/L NO_3 . On no occasions was the Drinking Water Regulations (2007 and 2014) parametric value for

nitrate (50 mg/L NO₃) exceeded. As the treated water nitrate values are being used as a proxy for nitrate levels in the raw water, it can also be concluded that the Surface Water Regulations (1989) have not been exceeded.

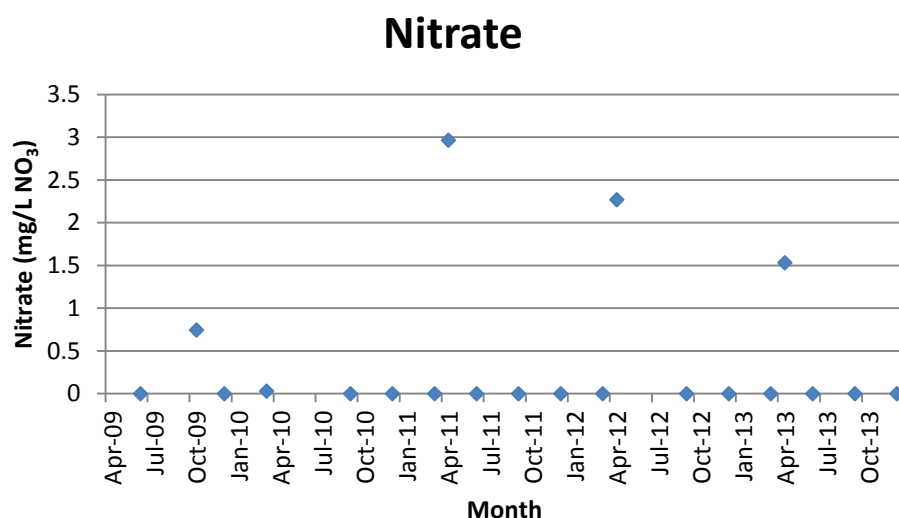


Figure 14: Treated water nitrate values from April 2009 until December 2013.

Ammonium

Ammonium has not historically been monitored within the raw water of the Fahy GWS catchment, but is currently being monitored by Dr. Connie O'Driscoll as part of the research collaboration between Fahy GWS and Trinity College Dublin.

6.1.12 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.

Conductivity has not been monitored within the raw water of the Fahy GWS catchment.

6.1.13 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 than 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.

Dissolved oxygen has not been monitored within the raw water of the Fahy GWS catchment.

6.1.14 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 O₂.

BOD has not been monitored within the raw water of the Fahy GWS catchment.

6.1.15 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 of 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. Following treatment, the Drinking Water Regulations (2007 and 2014) state that Total coliform values above 0 numbers per 100ml are unacceptable.

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.

No raw water *E. coli* monitoring data has been provided for this report, however the *Cryptosporidium* Risk Assessment Report (Ryan Hanley, 2006) mentions that bacteriological parameter exceedences were observed in Clogher Lough monitoring data from November 2000-November 2001 and August 2004 to November 2004.

On no occasion were the Drinking Water Regulations (2007 and 2014) parametric values exceeded for treated water.

Clostridium perfringens

Clostridium perfringens exists as part of the natural bacterial intestinal flora of humans and therefore serves as an indicator of faecal pollution.

No raw water *Clostridium perfringens* monitoring data has been provided for this report, however the *Cryptosporidium* Risk Assessment Report (Ryan Hanley, 2006) mentions that bacteriological parameter exceedences were observed in Clogher Lough monitoring data from November 2000-November 2001 and August 2004 to November 2004.

On no occasion were the Drinking Water Regulations (2007 and 2014) parametric values exceeded for treated water.

Total Coliforms

No raw water Total Coliform monitoring data has been provided for this report, however the *Cryptosporidium* Risk Assessment Report (Ryan Hanley, 2006) mentions that bacteriological parameter exceedences were observed in Clogher Lough monitoring data from November 2000-November 2001 and August 2004 to November 2004.

On no occasion were the Drinking Water Regulations (2007 and 2014) parametric values exceeded for treated water.

6.1.16 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 Fahy GWS catchment, however the EPA have monitored a station (32M01) approximately 800 m downstream of the confluence of the Clogher Lough outflow stream and the Moyour River since 1990 (Table 2). Q-ratings since 2009 have been classified as good and unpolluted (Q4) representing an improvement in water quality and macroinvertebrate diversity since 1990.

Table 2: Biological Quality Ratings (Q Values) for the Moyour River downstream of Clogher Lough

EPA Station ID number	Year							
	1990	1994	1997	1999	2002	2006	2009	2012
32M01	4	3	3	3	3-4	3	4	4

6.4 Overall Interpretation of Water Quality

A limited number of raw water quality parameters have been historically monitored within the Fahy GWS catchment and this presents difficulties in interpreting current raw water quality and the likely impacts of catchment-level activities on that water quality.

Apparent Colour values have been monitored consistently in the raw water by AECOM and reported in the Monthly Status Reports. Apparent Colour is a measure of both dissolved and suspended components whilst the latter are removed by filtration for the measurement of True Colour which is therefore an assessment of dissolved components. True colour should be added to the suite of monitoring parameters in order to allow comparisons with the Surface Water Regulations (1989) parametric value for True Colour for Class A1 waters.

Colour values of the raw water are frequently high and have the potential to exceed the Surface Water Regulations (1989) parametric value for Class A1 waters (although as True Colour has not been monitored, no direct comparisons can be made). As discussed in this report, high levels of colour 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 colour values can be an indication of high organic matter). These THMs have potentially significant health implications. THM values exceeded the Drinking Water Regulations (2007 and 2014) parametric values on 44 % of sampling occasions and values were high regardless of the time of year that sampling was undertaken. A current research collaboration between Fahy GWS and Trinity College Dublin is investigating the catchment water quality within the Fahy GWS catchment and its associations with THM formation within the treated water. Such investigations are essential in order to reduce THM concentrations within the treated water to below the Drinking Water Regulations (2014).

Point source pressures (for example wastewater treatment systems and agricultural yards) and diffuse pressures (such as nutrient application to pasture) acting on the surface waters within the catchment are comparatively high. The density of dwellings, particularly in the west and south of the catchment is relatively high and as a result of the lack of sewerage scheme within the catchment, all residential dwellings will be served by septic tanks/wastewater treatment systems. Point and diffuse sources have the potential to facilitate the delivery of nutrients and microbial pathogens to the surface waters of the catchment. Historical nutrient monitoring within the catchment has been limited, however the current research collaboration between Fahy GWS and Trinity College Dublin will provide significant insight into the mechanisms of nutrient delivery into the water courses within the Fahy GWS catchment. For this source protection study, it has only been possible to use nitrate values monitored within the treated water as a proxy for raw water nitrate concentrations. Values were typically below levels of detection, but on the occasions when nitrate could be detected, it was frequently at levels that can facilitate plant and algal growth and contribute to poor water quality, despite being well below the Surface Water Regulations (1989) parametric value nitrate for Class A1 waters.

Monthly spot sampling has shown that raw water turbidity can be occasionally high. Although turbidity is not a direct indicator of health risk, microbial pathogen levels can be elevated in raw waters of high turbidity. Ryan Hanley (2006) conducted a *Cryptosporidium* Risk Assessment for the Fahy GWS catchment, concluding that the raw water source was classified as Very High Risk.

Without current microbial pathogen monitoring data, it is not possible to ascertain present levels of microbial pathogen contamination.

Raw water pH was consistently within the Surface Water Regulations (1989) parametric value for Class A1 waters and as such raw water pH values are not of a concern with regard to source protection. The raw water pH was typically alkaline, reflecting the nature of the large areas of limestone bedrocks underlying the catchment.

The Clew Bay Water Management Unit Action Plan (2010) classifies the Ecological Status of Clogher Lough as good through the extrapolation of regional data. This is in agreement with the good Q-value status from downstream of Clogher Lough.

7.0 Recommendations

The assessment of geology, soils, land use and water quality data has identified a number of issues within the Fahy 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 Fahy 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 Fahy 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.

Trihalomethane monitoring and management

Trihalomethane concentrations have been shown to be frequently excessive, with values exceeding the Drinking Water Regulations (2007 and 2014) parametric value on 44 % of sampling occasions. Fahy GWS has been proactive in participating in a research collaboration with Trinity College Dublin and these investigations are essential for understanding the processes involved in THM formation within the Fahy GWS treated water supply and for reducing THM concentrations within the treated water to below the Drinking Water Regulations (2014) parametric value.

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.

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.

Consideration of the future development of a raw water monitoring programme

The current research collaboration between Fahy GWS and Trinity College Dublin is assessing the following water quality parameters at a number of locations within the Fahy GWS catchment (Connie O'Driscoll, *pers. comm.*): Dissolved Total Organic Carbon (DTOC); Ammonia; Soluble Reactive Phosphorus (SRP), Total Oxidised Nitrogen (TON); and phytoplankton enumeration. The project will also be assessing THM concentrations within the treated water supply. This monitoring programme will be undertaken on a monthly basis from July 2014 to April 2016 and will provide essential information regarding the delivery of nutrients into water courses within the Fahy GWS catchment as well as providing further understanding on THM formation within the Fahy GWS treated water supply.

Following the delivery of results and recommendations from this research collaboration, Fahy GWS may consider the continuation of a raw water monitoring programme within the GWS catchment in order to continue to improve the quality of its raw water source. Further understanding of catchment-level influences on the quality of raw water can lead to improvements in raw water quality, have environmental benefits and also have potential cost-saving benefits with regard to the water treatment process. A raw water monitoring programme is essential in order for such benefits to be obtained. A raw water monitoring programme should:

- Be designed by appropriately qualified individuals and include SMART objectives (i.e. those that are Specific, Measurable, Achievable, Realistic and Timed) linked to key hypotheses and monitoring questions;
- Consider the inclusion of the monitoring of the following parameters:
 - True colour
 - pH
 - Conductivity
 - Total Oxidised Nitrogen (nitrate and nitrite)
 - Ammonia/Ammonium
 - Total Phosphorus
 - Chlorophyll *a* and/or algal counts (depending on budget constraints)
 - Turbidity
 - Iron
 - Manganese
 - Dissolved Organic Matter
 - Total Organic Carbon
 - *E. coli*
 - *Clostridium perfringens*
 - Total Coliforms
- Have appropriate levels of funding. Some parameters are more expensive to monitor than others, and some will be required to be monitored more frequently than others. The specific design of the monitoring programme in relation to the parameters monitored and the frequency of monitoring will be determined by the budget available;

- Be aligned to other monitoring programmes at county and national levels where appropriate, for example the EPA's Water Framework Directive Lake Water Quality Monitoring Programme;
- Be undertaken for a minimum period of one year to allow for the interpretation of variations within the monitoring data set;
- Incorporate a review of monitoring after the first year (and annually thereafter) to assess the importance of monitoring certain parameters and the frequency of monitoring with regard to available budgets; and
- Data should be fully interpreted, carefully stored and filed for future reference.

Given the presumed lack of faecal contaminant monitoring currently undertaken within the raw water supply, it is recommended that *E. coli*, *Clostridium perfringens* and Total Coliforms are monitored at a minimum of a monthly basis in order to ascertain the level of risk of contamination, in association with the agriculture and farmyard management recommendations listed below. An understanding of raw water faecal contamination levels may assist in potentially reducing levels of chlorination within the treatment process that may in turn help towards reducing THM concentrations within the treated water supply.

AECOM should be engaged to discuss the inclusion of True Colour in the current raw water monitoring programme. This would allow comparisons with the Surface Water Regulations (1989) to assess whether the parametric value for True Colour has been historically and presently exceeded. Subsequently, potential mitigation methods may be identified with the aim of reducing high colour values in the raw water supply which may in turn assist in reducing Trihalomethane formation in the treated water supply.

Agriculture and farmyard management

The Clew Bay Water Management Action Plan has assigned an overall Ecological Status of good to Clogher Lough however this has been made through the extrapolation of regional data rather than a specific water quality monitoring programme. There is high risk of nutrient and microbial pathogen contamination throughout the catchment as identified through groundwater vulnerability, EPA domestic wastewater risk, *Cryptosporidium* risk assessment 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, along with consistent monitoring of *E. coli* and total coliforms in the raw water, to ascertain the level of risk of source contamination. Although it may not be feasible to fence all boundaries to water bodies within the Fahy 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

The implementation of soil nutrient analysis throughout the catchment would be valuable, particularly on land directly bordering water bodies. Soils with high nutrient status are most likely to result in losses to nearby waterways. 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 m³/d or >500 people, no spreading within 200m of the abstraction point (surface water, borehole, spring or well).
- For abstractions >10 m³/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.

Septic Tanks/Wastewater treatment Systems

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). Housing pressures within the Fahy GWS catchment are

high and therefore good OSWTS management is vital within the catchment in order to reduce the potential for nutrients and other contaminants entering surface and ground water bodies.

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/>.

Fahy 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 Mayo 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 Mayo County Council.

High risk systems, along with cattle 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.

Cryptosporidium Risk Assessment

A *Cryptosporidium* Risk Assessment report (Ryan Hanley, 2006) found that the Fahy GWS was classified in the Very High Risk category for *Cryptosporidium* contamination. The recommendations made in this *Cryptosporidium* Risk Assessment report (see Appendix 1) should be reviewed and if deemed necessary, a new *Cryptosporidium* Risk Assessment should be undertaken to ascertain whether the risk has been sufficiently reduced.

7.1 Future Work

Initiate a raw water faecal contaminant monitoring programme

Given the significant pressures acting within the Fahy catchment, in particular the high risk of faecal contamination of the raw water supply in association with the presumed lack of current faecal contaminant monitoring, it is important for a raw water faecal contaminant monitoring programme to be initiated. For the first year, monitoring timeframes should be sufficient to allow for short-term variations within the data set. Following the first year, timeframes and parameters should be reviewed with regard to raw water quality and available budget.

Engage AECOM regarding True Colour monitoring

AECOM should be engaged to discuss the inclusion of True Colour in the current raw water monitoring programme. This would allow comparisons with the Surface Water Regulations (1989) to assess whether the parametric value for True Colour has been historically and presently exceeded. Subsequently, potential mitigation methods may be identified with the aim of reducing high colour values in the raw water supply which may in turn assist in reducing Trihalomethane formation in the treated water supply.

Review the current *Cryptosporidium* Risk Assessment Report

The Fahy GWS was classified as Very High Risk in the Ryan Hanley (2006) *Cryptosporidium* Risk Assessment report. The recommendations of this report (Appendix 1) should be reviewed and if necessary, a new report should be commissioned with an additional focus on source protection measures to ascertain whether risk of *Cryptosporidium* contamination has been reduced.

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 wastewater 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 Fahy GWS catchment. The location of the treatment works on the edge of Clogher Lough presents an opportunity for a community open day when members of the local community and GWS members can learn more about the source of their drinking water, be informed about the treatment process, the work that is required to ensure good quality water reaches their taps and the source protection measures that need to be implemented to ensure good raw water quality.

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 Fahy 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.

8.0 References

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Ryan Hanley (2006). Mayo Group Water Schemes DBO Bundle 2: Risk assessment for *Cryptosporidium* in the water supplies of Group Water Schemes. Report to Mayo County Council.

Appendix 1: *Cryptosporidium* Risk Assessment Report Recommendations

Mayo GWS DBO Bundle 2 *Cryptosporidium* Risk Assessment

Ryan Hanley consulting engineers May 2006

Recommendations

- 5.1** Risk assessment should be reviewed from time to time to take into account the possible effect of any changes in the catchment area and water treatment systems.
- 5.2** Development such as housing, industry and farming activities in the immediate area (300m radius) of the springs should be prevented, and should be controlled in the outer source protection area, as recommended by the Geological Survey of Ireland Groundwater Protection Schemes.
- 5.3** Sanitary authorities or private water suppliers should examine the factors that have contributed to the risk and assess the action that could be taken to reduce the risk assessment score.
- 5.4** It is recommended that treatment facilities and source protection plans be implemented for each of the schemes found to have a *Cryptosporidium* risk under the Mayo GWS DBO Bundle 2 project.