Preliminary Report on Source Protection

Glencorrib Group Water Scheme

County Mayo

Dr Alec Rolston

Centre for Freshwater and Environmental Studies

Dundalk Institute of Technology

DKIT CENTRE FOR FRESHWATER AND ENVIRONMENTAL STUDIES

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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 Glencorrib 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).

Glencorrib Group Water Scheme is located in County Mayo, approximately 12 km north west of the town of Headford, County Galway. The GWS abstracts its water from Ballynally Bay within the northern basin of Lough Corrib, the second largest lake in Ireland that is protected under both the EU Habitats and Birds Directives. The wider Lough Corrib catchment is large, covering 3,084 km^2, encompassing Lough Mask and Lough Carra to the north as well as stretching over 50 km to the east of Lough Corrib; and up to elevations of over 500m in the west of the catchment. In comparison, the Glencorrib GWS sub-catchment, which delineates the area within which surface water flows towards the Glencorrib GWS abstraction point, is smaller, covering 19.6 km^2. The bedrock geology of Lough Corrib catchment is dominated by limestone formations in the east of the catchment; and sandstone and granite formations in the west of the catchment. This geology affects the groundwater aquifer as well as the soils and subsoils of the catchment. The karstified nature of the bedrock which underlies much of the Glencorrib GWS sub-catchment facilitates the regionally important aquifer and also the high and extreme vulnerability of groundwater to contamination by pollutants throughout much of the sub-catchment. Importantly, the geographic area through which groundwater moves through the karstified landscape is likely to be different to that delineated for surface water (the Glencorrib GWS sub-catchment). Subsequently, land use or human actions which take place locally but which are outside of the delineated Glencorrib GWS sub-catchment may still have the potential to impact on the Glencorrib GWS raw water supply. Increasing the understanding of groundwater influence at the Glencorrib GWS abstraction point is an important action for consideration.

Soils and subsoils types are varied throughout the Lough Corrib catchment, but are typically alkaline within the Glencorrib GWS sub-catchment, reflecting the limestone bedrock geology of the local area.

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. This, in association with the risk of nutrients and bacteria entering surface waters, means that care must be taken to ensure that domestic wastewater treatment systems located within the Glencorrib GWS sub-catchment are properly installed and maintained. The dwelling density in the sub-catchment is

locally dense in places, and all dwellings are located within the three highest groundwater vulnerability classifications. High risk systems, along with cattle yards which are situated within areas of poor soil drainage and high groundwater vulnerability should be inspected as a priority to ensure that potential risk of contamination from these point sources is reduced. The management of waste from livestock within the Glencorrib GWS sub-catchment should also be strongly considered given the predominant pasture land cover within the sub-catchment, and the potential for both nutrients and microbial pathogens to swiftly enter both groundwater and surface water.

The raw water quality data analysed throughout this report has been provided by the EPA from eight sampling sites throughout the upper basin of Lough Corrib. In addition, data provided by Mayo County Council for reporting treated drinking water quality has been used to assess certain parameters from 2014 onwards.

True colour values in the upper basin of Lough Corrib were occasionally high, with the Surface Water Regulations (1989) parametric value being exceeded frequently. Dissolved Organic Carbon levels were shown to be occasionally high, but there is limited data available throughout the upper basin of Lough Corrib. As discussed in this report, high values of True Colour are not harmful in themselves, however they can be indicative of high DOC levels and subsequently during the treatment process, chlorine reacts with DOC to form Trihalomethanes (THMs). The higher the DOC levels and the higher the chlorine disinfection concentrations as well as the longer the residence time in storage reservoirs, the greater the likelihood of THMs forming. In the treated water supply, Trihalomethanes did not exceed the Drinking Water Regulations (2014) parametric value on any occasion. THM concentrations in drinking water are typically highest between late summer and early winter when the possibility of THM formation is likely to be greatest due to often higher levels of DOC in the raw water. Yet, all of the THM monitoring was undertaken outside of this time period and therefore it is possible that the Drinking Water Regulations (2014) were exceeded, given the high (but not excessive) THM concentrations present on occasion.

The pH values recorded across all sampling locations reflect the limestone nature of much of the underlying bedrock within the Lough Corrib catchment. This is also highlighted in the high alkalinity of the water. It is therefore likely that this hard water may impact on consumer appliances such as kettles and washing machines.

Total Phosphorus concentrations were observed to be occasionally high at a number of EPA sampling sites and have the potential to contribute to algal blooms within the upper basin of Lough Corrib. In addition, Total Oxidised Nitrogen concentrations are also high enough to support algal blooms. However, in general, nutrient levels throughout the upper basin of Lough Corrib are not excessive and this is highlighted by the relative infrequent algal blooms suggested by the Chlorophyll *a* and Dissolved Oxygen data.

During the site visit to Glencorrib GWS undertaken as part of this report, a number of head of cattle were observed freely accessing the water within 30 m of the Glencorrib GWS abstraction point.

This livestock access so close to the abstraction point, combined with the potential for animal wastes to be spread on the land locally, the nearby location of a large slatted shed, and the potential for domestic waste water treatment systems within the Glencorrib sub-catchment to contaminate surface waters and groundwaters, microbial assessment of the raw water is required. This is likely undertaken through the Glencorrib GWS Monthly Status Reports provided by the GWS DBO contractor, but this data has not been made available for this report.

The water bodies flowing in to the upper basin of Lough Corrib have generally been classified as being not at risk of deteriorating or achieving Good status in the future. However, the Owenriff river has been classified as being at risk, and the risk designation for the upper basin of Lough Corrib itself is currently under review. Therefore, there is potential for the water quality of the raw water abstracted by Glencorrib GWS to deteriorate into the future. This may be accentuated by the karstic limestone geology which underlies much of the east of the Lough Corrib catchment and indeed the Glencorrib GWS sub-catchment. The karstic geology means that there is reduced natural remediation of contaminants which can swiftly enter both surface waters and groundwaters which flow towards the Glencorrib GWS abstraction point.

Given the size of the wider Lough Corrib catchment, there are limited source protection measures that can be put in place without long-term integrated catchment management between a wide number of stakeholders. As Lough Corrib is of significant environmental importance as an SAC and SPA, as well as being a source of drinking water, such integrated, collaborative management will be essential to improve the water quality of the lake into the future.

Subsequently, the recommendations made in Section 7.0 are mindful of the wider, larger catchment-scale issues, but are focussed on the smaller geographical unit of the Glencorrib GWS sub-catchment. By focussing at this smaller geographical scale upon issues that are likely to be immediately affecting the water quality of the northern basin of Lough Corrib and the embayment from which Glencorrib GWS abstract their water, there are actions that can be undertaken that are more achievable and are likely to result in localised improvements in water quality rather than attempting to address the much larger catchment-scale issues that require significant resource investment.

The key recommendations made by this report are:

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 Glencorrib GWS sub-catchment and the wider Lough Corrib 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. Modify Trihalomethane sampling

THM monitoring frequently took place outside of the period when Dissolved Organic Carbon values are typically highest (and subsequently the probability of THM formation is greatest). Glencorrib GWS should ensure that THM monitoring is undertaken on at least a monthly basis between July and November, and periodically (e.g. every two months) for the remainder of the year.

3. Engage the National Federation of Group Water Schemes and Geological Survey of Ireland

The karstic nature of the underlying geology of the Glencorrib GWS sub-catchment indicates strong potential for groundwater influencing the water quality of Lough Corrib and for contaminants to swiftly enter the groundwater. The geographical area from which groundwater may be delivered to the Glencorrib GWS abstraction point is likely to be different to that of the surface water catchment delineated in this report. Therefore, Glencorrib GWS should engage both the National Federation of Group Water Schemes and the Geological Survey of Ireland to attempt to fully understand the potential contribution of groundwater to the GWS abstraction point.

4. Engage with Glencorrib sub-catchment residents with regard to on-site waste water treatment system (septic tank) maintenance

Residents within the Glencorrib GWS sub-catchment should be engaged to ensure septic tanks are maintained and serviced regularly in order to reduce the potential for nutrient, microbiological and other contaminants entering surface water and groundwater bodies.

Following engagement with the Geological Survey of Ireland (see above), any septic tanks located outside of the Glencorrib GWS sub-catchment delineated in this report, but within any delineated groundwater zone of contribution, should also be maintained and serviced regularly.

The NFGWS has recently completed a pilot septic tank engagement project in collaboration with the EPA, and Glencorrib GWS should contact the NFGWS to discuss septic tank management and engagement mechanisms.

5. Fencing land with livestock access to local water bodies

Restricting direct livestock access to the embayment from which Glencorrib GWS abstracts its raw water will assist in reducing potential nutrient and faecal contamination of the raw water source. This action, in combination with improving septic tank maintenance, will help to improve water quality for the GWS and potentially reduce treatment costs in the longer term. Engagement with local landowners will be necessary, and Glencorrib GWS could consider:

- Sharing the costs of any fencing installed close to the abstraction point
- The provision of water for livestock that have been restricted from accessing water through fencing.

6. Initiate a communications drive

Glencorrib GWS should consider undertaking a communications initiative to remind scheme members and residents within the GWS sub-catchment 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. The picturesque location of the treatment works 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 GWS and the source protection measures required to help improve the environmental status of the sub-catchment area whilst also providing cost-savings in the water treatment process.

7. Engage Funshinna Cross GWS

Funshinna Cross Group Water Scheme also abstracts raw water from Ballynally Bay. Therefore, they share the same sub-catchment as Glencorrib GWS and sub-catchment-scale recommendations made in this report are applicable to both Funshinna Cross GWS and Glencorrib GWS. Subsequently, any implementation of sub-catchment-scale management actions, or engagement of local communities could be undertaken in partnership to reduce potential duplication of actions.

8. Engage Mayo County Council regarding wider catchment-scale issues

Larger scale water quality issues within the wider Lough Corrib catchment can only be addressed through an integrated approach to catchment management. As a number of Group Water Schemes abstract from Lough Corrib, Lough Mask and Lough Carra, consideration should be given to collectively engaging Galway and Mayo County Councils with the aim at assisting in management actions for improving the water quality within the wider Lough Corrib catchment, providing benefits for all GWS within the catchment as well as local communities.

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-sourced 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).

The report provides a physical site description of the Glencorrib Group Water Scheme (GWS) catchment and explains how this is relevant to water quality. The potential impact of land use is discussed and available water quality data are 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 (OSI) and provided under license by the Geological Survey of Ireland (GSI). A number of national digital Geographical Information System Layers (GIS) were available from a number of sources (Table 1), and were clipped to the catchment area of Glencorrib GWS. This allowed detailed descriptions of, for example, land cover using an EU-wide standardised system (CORINE), 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 has been collated from the Environmental Protection Agency and Mayo County Council.

Parameters relevant to source protection were extracted from the datasets and analysed and interpreted to highlight possible water quality issues and their potential causes and impacts within the Glencorrib GWS catchment. Also included 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.

3.0 Overview of Lough Corrib and the Water Framework Directive

Under the Water Framework Directive (WFD, 2000/60/EC) first round of River Basin Management Planning, the island of Ireland was divided into eight River Basin Districts (RBDs), two of which are international with boundaries shared by the Republic of Ireland and Northern Ireland. In March 2017, the second draft River Basin Management Plan (RBMP) was released for public consultation. This new, whole-of-Ireland RBMP, released in 2018 (https://www.housing.gov.ie/sites/default/files/publications/files/rbmp_full_reportweb.pdf) revised the organisational structure of water management for the WFD. In addition, the website http://www.catchments.ie provides catchment information, data and maps for the whole of Ireland, and can be accessed to investigate wider catchment-scale information relating to Glencorrib GWS.

The second-round WFD RBMP summary for the Corrib catchment is currently in development and not available from www.catchments.ie. Subsequently, the following description is based on the first-round WFD RBMPs. Each RBD is subdivided into Water Management Units (WMU), and Lough Corrib and its catchment are included within the Corrib WMU. An action plan from the first-round WFD RBMP for the Corrib WMU is available from http://www.wfdireland.ie.

This 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) within the Corrib WMU. Rivers within the

Corrib WMU varied in status but 66% were classed at high or good status, with the remainder classified at moderate or poor status. Of the lakes situated within the WMU, 65% were classified as being of high or good status, with the remainder classified at moderate status. The Upper Lough Corrib basin, from which Glencorrib GWS abstracts its raw water, was classified as being at moderate status.

The Corrib WMU Action Plan attributes over 90 % of the Total Phosphorus load as diffuse, with agriculture accounting for over 80 % Total Phosphorus. A total of 11,021 on-site water treatment systems (OSWTS) or septic tanks are located within the WMU, with 3,671 OSWTS lying within 78 river water bodies which are posing a risk to water quality as a result of their location.

4.0 Physical Site Description

4.1 Catchment location and outline

Glencorrib Group Water Scheme (Figure 1) is located in County Mayo, approximately 12 km northwest of the town of Headford, County Galway. Glencorrib GWS abstracts its raw water from Ballynally Bay, an embayment located in the western region of the Lough Corrib upper basin. Lough Corrib is the second largest lake in Ireland, with an area of approximately 18,240ha, and is the most southerly lake within the Great Western Lakes system of Lough Corrib, Lough Mask and Lough Carra. The lake consists of two well-defined basins: to the north is the upper basin; and to the south, the shallower lower basin. Lough Corrib is protected under both the EU Habitats Directive and the EU Birds Directive, and is subsequently listed as a Special Area of Conservation and a Special Protected Area respectively. The lower basin of Lough Corrib contains lime-rich waters which support the most extensive beds of stoneworts (Charophyte plants) in Ireland and which are an important food source for waterfowl. In contrast, the upper basin contains more oligotrophic and acidic waters. A number of habitats and species are protected under the EU Habitats and Birds Directive, and further information can be found on the National Parks and Wildlife website: https://www.npws.ie/protected-sites.

The catchment of Lough Corrib is large, covering 3,084 km^2, with a large number of rivers and streams flowing into each of Lough Carra, Lough Mask and the two Lough Corrib basins (Figure 2). This large catchment creates difficulties regarding identifying realistic recommendations and management actions for Glencorrib GWS to implement with the aim in improving both raw water and treated water quality. Subsequently, a smaller sub-catchment (covering approximately 19.6 km^2, termed the Glencorrib GWS sub-catchment: Figure 3) has been delineated, within which land use is likely to have a more localised impact on the quality of the raw water abstracted by Glencorrib GWS. This report outlines the land use within the wider Lough Corrib catchment and where appropriate highlights specific items of note within the Glencorrib GWS sub-catchment.

Figure 1: Top – Glencorrib GWS treatment plant facing west towards the main body of the Lough Corrib upper basin; Bottom – The location of the treatment plant (and abstraction point) and the close proximity of a local farm.

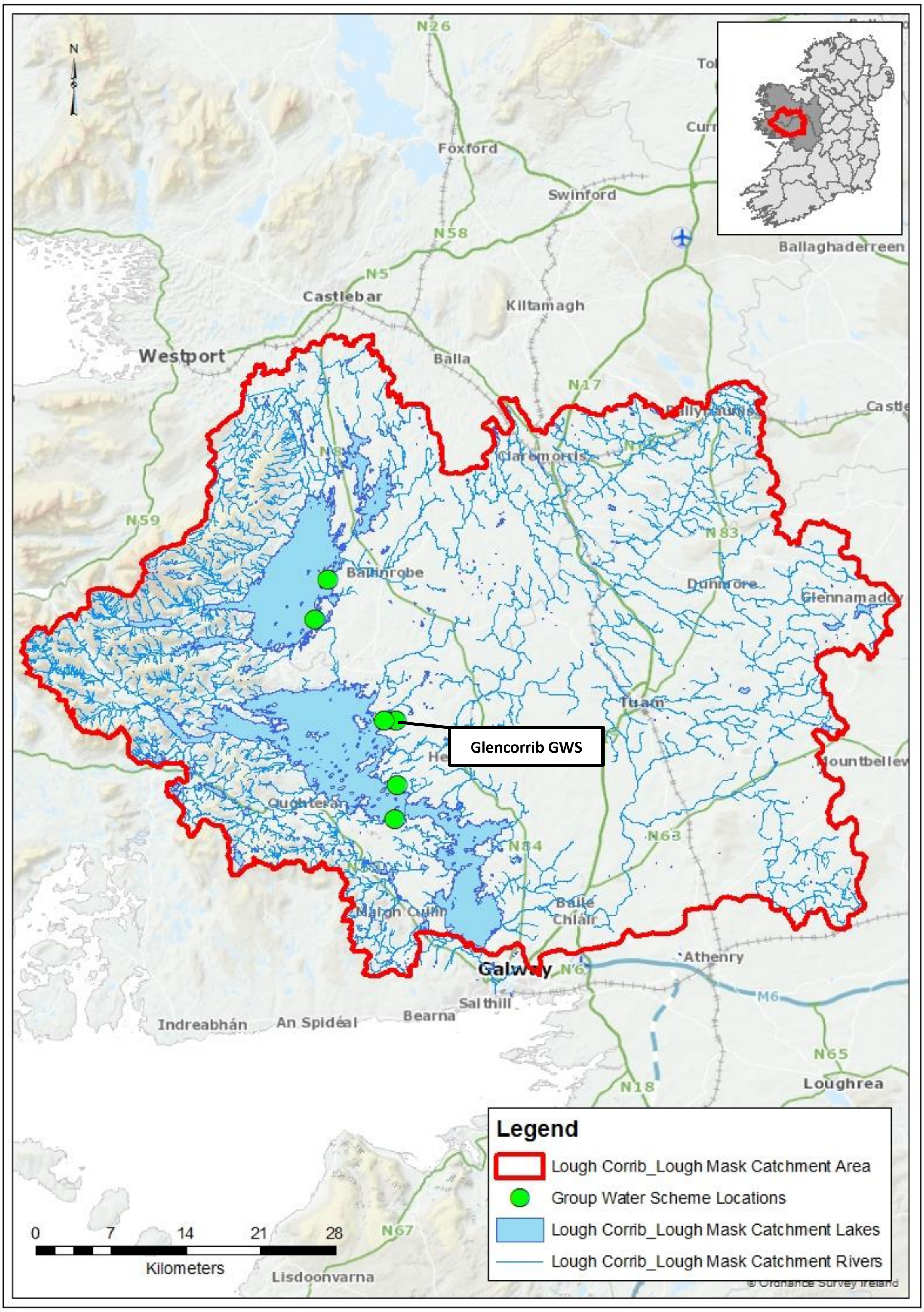

Figure 2: Lough Corrib catchment area, the locations for all GWS abstracting from Lough Mask and Lough Corrib, including Glencorrib GWS.

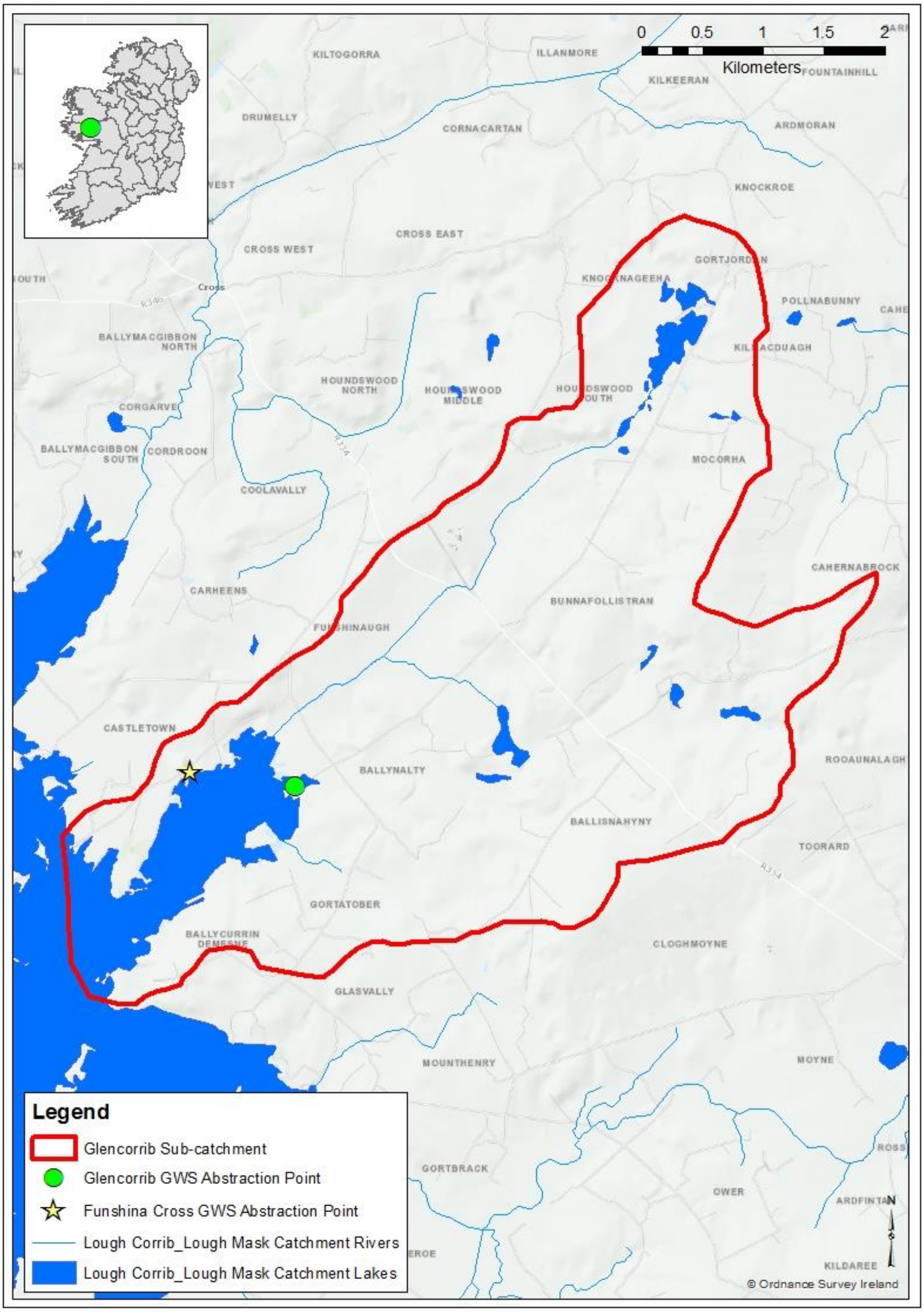

Figure 3: The Glencorrib GWS sub-catchment, including the location of Funshinna Cross GWS abstraction point, which shares the same sub-catchment.

4.2 Bedrock geology

The bedrock underlying the Corrib catchment consists of many geological formations (Figure 4). Typically, the bedrock to the west of the catchment are sedimentary (e.g. sandstones, slates and greywacke) or granite. However, to the east of Loughs Corrib, Mask and Carra, and to the immediate west of the lower basin of Lough Corrib, the bedrock is typically alkaline in nature, consisting of limestone and calcareous shales.

The bedrock of much of the Glencorrib GWS sub-catchment consists of limestones and some shales classified within four different formations (Figure 5). Limestone is a sedimentary rock and the solubility of limestone in water and weak acids leads to a karst landscape. 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, which can result in a reduced capacity for filtration of water-borne contaminants between surface waters and the groundwater system.

4.3 Bedrock aquifers

An aquifer is an underground body of permeable rock or sand/gravel that yields water in sufficient quantities for use. The west of the Lough Corrib catchment is dominated by a poor aquifer, the bedrock of which is generally unproductive except for local zones (Figure 6). Smaller areas of a locally important aquifer, the bedrock of which is generally moderately productive are present to the west and north of the upper basin of Lough Corrib, and to the north of Lough Mask. Much of the east of the Lough Corrib catchment is classified as a regionally important aquifer, the bedrock of which is dominated by conduit flow. Areas of a locally important aquifer, the bedrock of which is moderately productive only in local zones are present in the northeast and southeast of the large catchment, and to the northeast of the upper Lough Corrib basin, and to the north of Lough Mask.

There are three main aquifer types within the Glencorrib sub-catchment (Figure 7). The aquifer to the north and eastern boundaries of the catchment is classified as a regionally important aquifer consisting of karstified bedrock dominated by conduit flow. Much of the catchment is classified as a locally important aquifer, the bedrock of which is moderately productive only in local zones. The Glencorrib GWS abstraction point is located above a locally important aquifer, the bedrock of which is karstified to a limited degree or limited area.

The karstified aquifers present within the Glencorrib GWS sub-catchment and the wider Lough Corrib catchment are likely to contain large groundwater stores. Springs and swallow holes typical of a karstified environment are present within this locality. As mentioned above, 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.

In addition, the geographic area through which groundwater moves through the karstified landscape is likely to be different to that delineated for surface water (represented as the Glencorrib GWS sub-catchment). Subsequently, land use or human actions which take place locally but which are outside of the delineated Glencorrib GWS sub-catchment may still have the potential to impact on the Glencorrib GWS raw water supply. Increasing the understanding of groundwater influence at the Glencorrib GWS abstraction point is an important action for consideration.

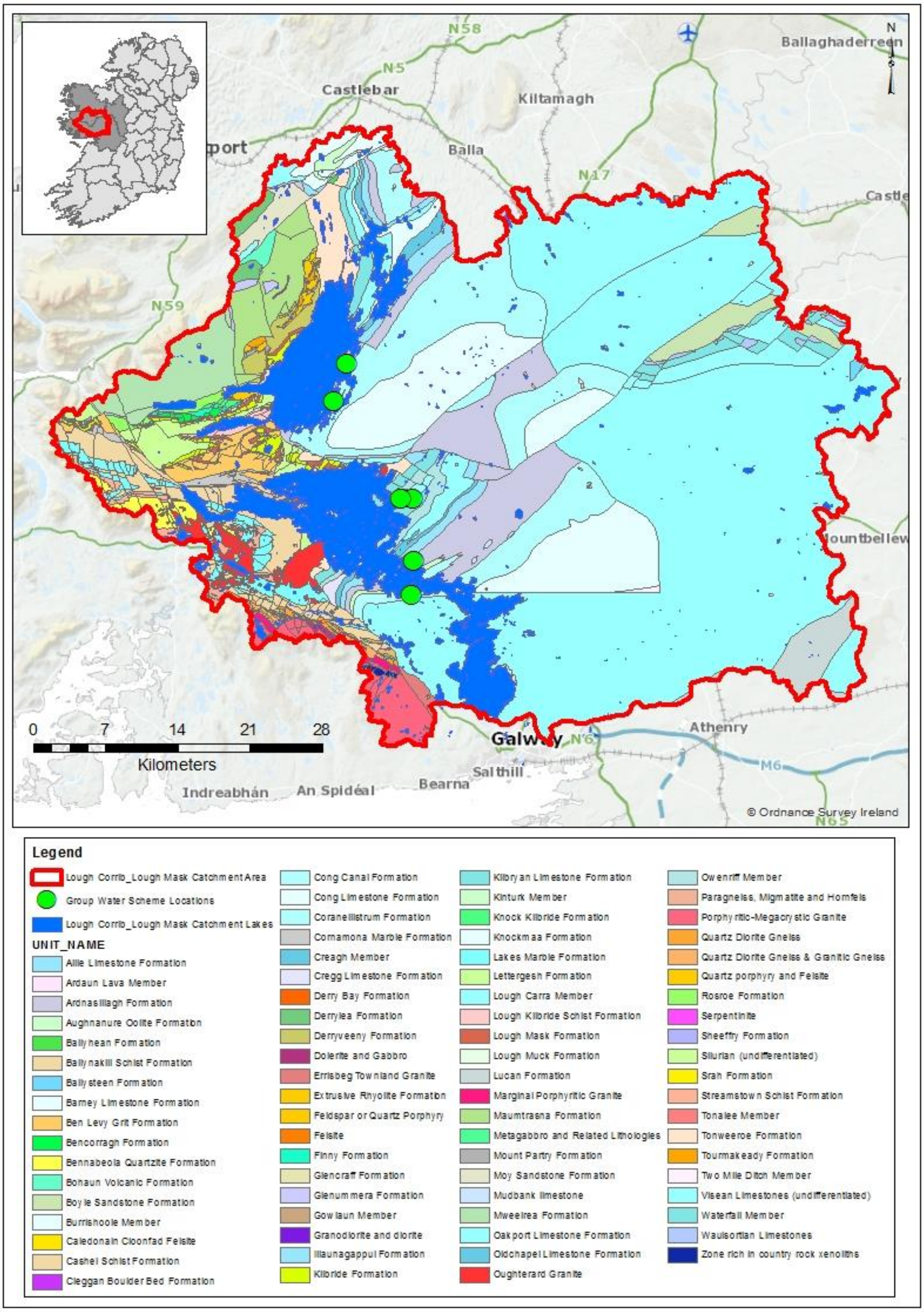

Figure 4: Bedrock geology within the Lough Corrib catchment.

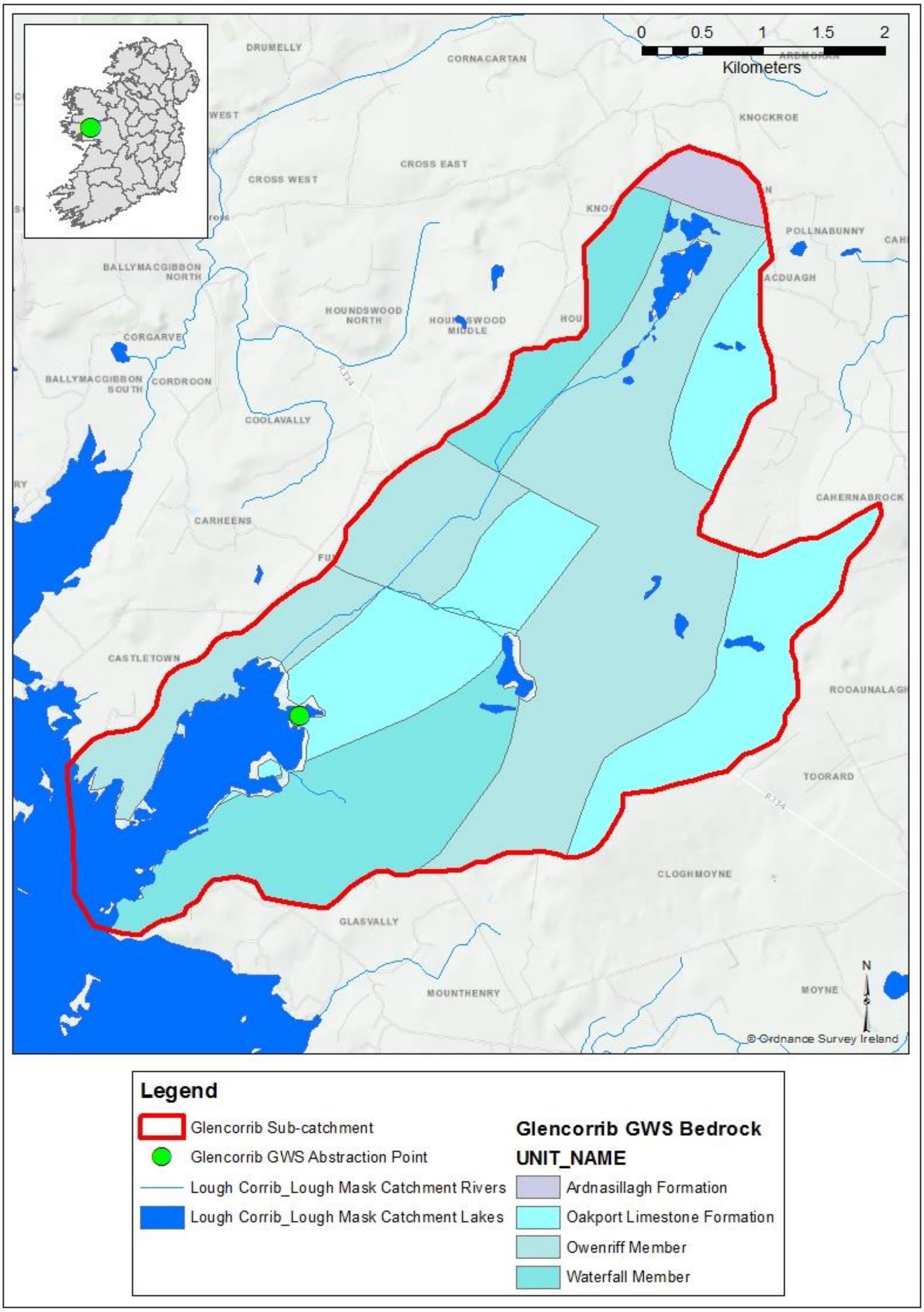

Figure 5: Bedrock geology within the Glencorrib GWS sub-catchment.

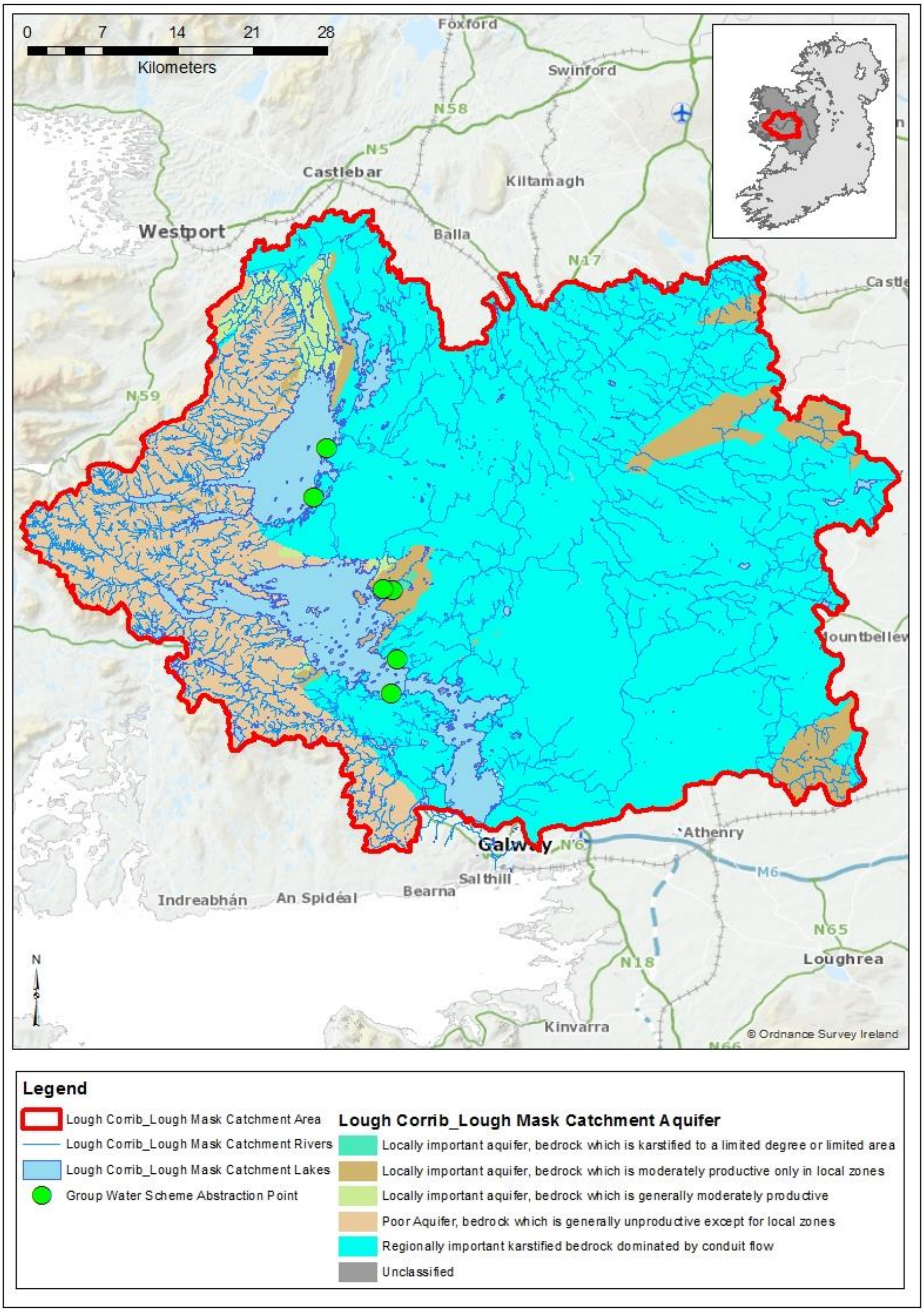

Figure 6: Aquifer types present within the Lough Corrib catchment.

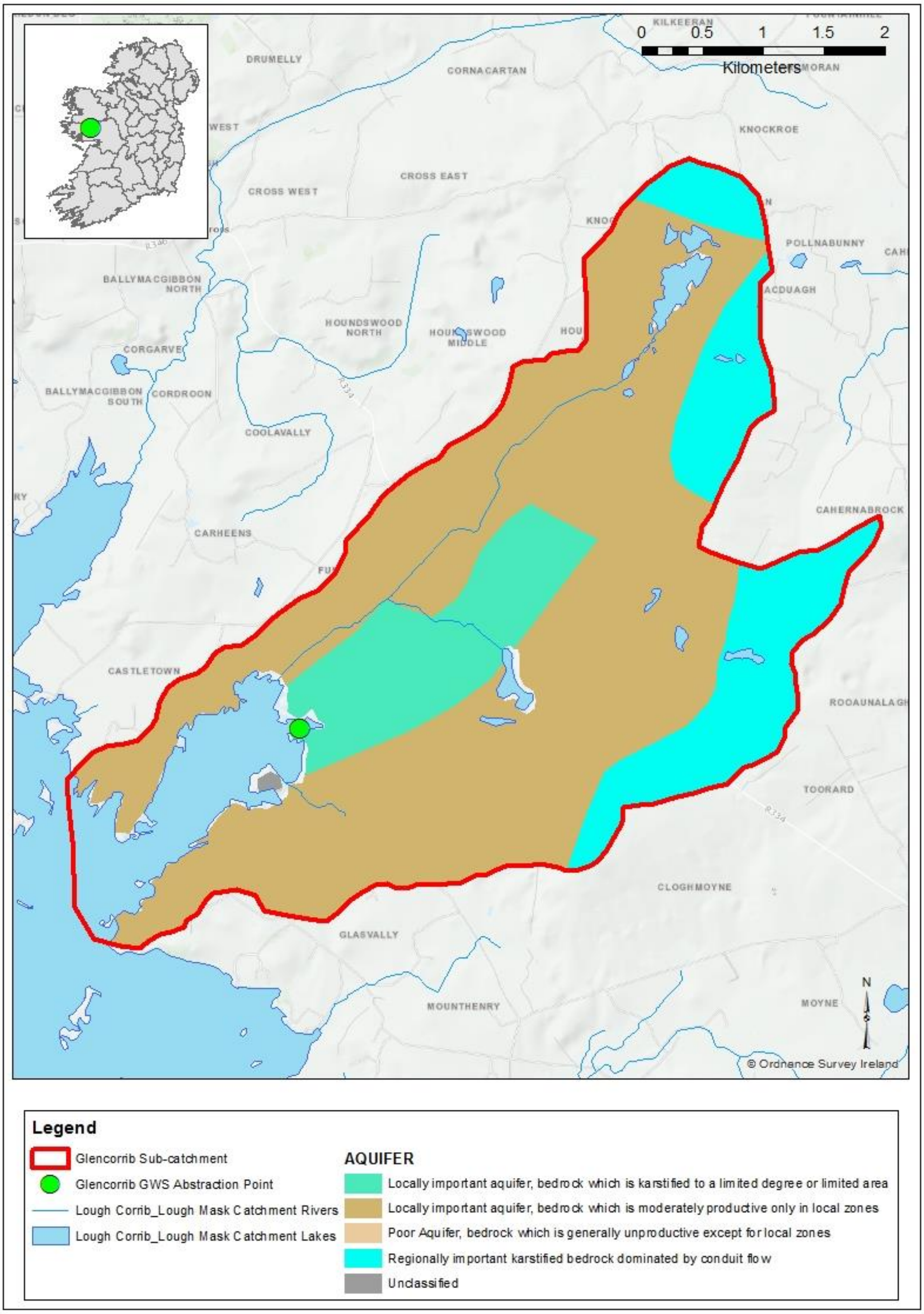

Figure 7: Aquifer types in the Glencorrib GWS sub-catchment

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 wider Lough Corrib catchment is complex, with all vulnerability classifications present (Figure 8). The northeast, southeast of the catchment and an area to the east of the lower basin of Lough Corrib are dominated by areas of low and moderate groundwater vulnerability. Areas to the east of the upper basin of Lough Corrib and to the east of Lough Carra are dominated by zones of high groundwater vulnerability. Areas of extreme groundwater vulnerability are present to the south of the Lough Corrib catchment, interspersed with areas of the highest groundwater vulnerability, E (rock at or near the surface, or karst). Larger areas of this highest groundwater vulnerability classification are present in the northwest of the Lough Corrib catchment, to the west of the lower Lough Corrib basin and to the south of the upper Lough Corrib basin.

The three highest groundwater vulnerability classifications are present within the Glencorrib GWS sub-catchment (Figure 9). The GWS abstraction point is located within an area of the highest groundwater vulnerability classification, E, which is present throughout much of the eastern and western regions of the sub-catchment. Areas of high groundwater vulnerability are located in the southern and northern regions of the catchment.

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.

Much of the subsoils to the east of the Lough Corrib catchment are classified as till derived from limestones, interspersed with large areas of peat and smaller areas of gravels (Figure 10). Till derived from Devonian sandstones is present in the far northeast of the catchment. Subsoils to the west of the two Lough Corrib basins are dominated by peats interspersed with areas of till derived from both limestones and metamorphic rocks. To the west of Lough Mask, subsoils are dominated by bedrock outcrop or subcrop with areas of till derived from sandstones present to the northeast of the upper basin of Lough Corrib, situated between Lough Corrib and Lough Mask, and also along the western shore of Lough Mask and in the northwest of the catchment.

Till derived from limestone is present throughout much of the Glencorrib GWS sub-catchment, with smaller areas of bedrock outcrop or subcrop, or karstified bedrock outcrop or subcrop present to the east and west of the sub-catchment (Figure 11). These outcrops and subcropbs are associated with the highest groundwater vulnerability classifications within the sub-catchment. A small area of cutover raised peat is present in the south of the sub-catchment; and till derived from sandstones and shales is present in the northwest of the sub-catchment.

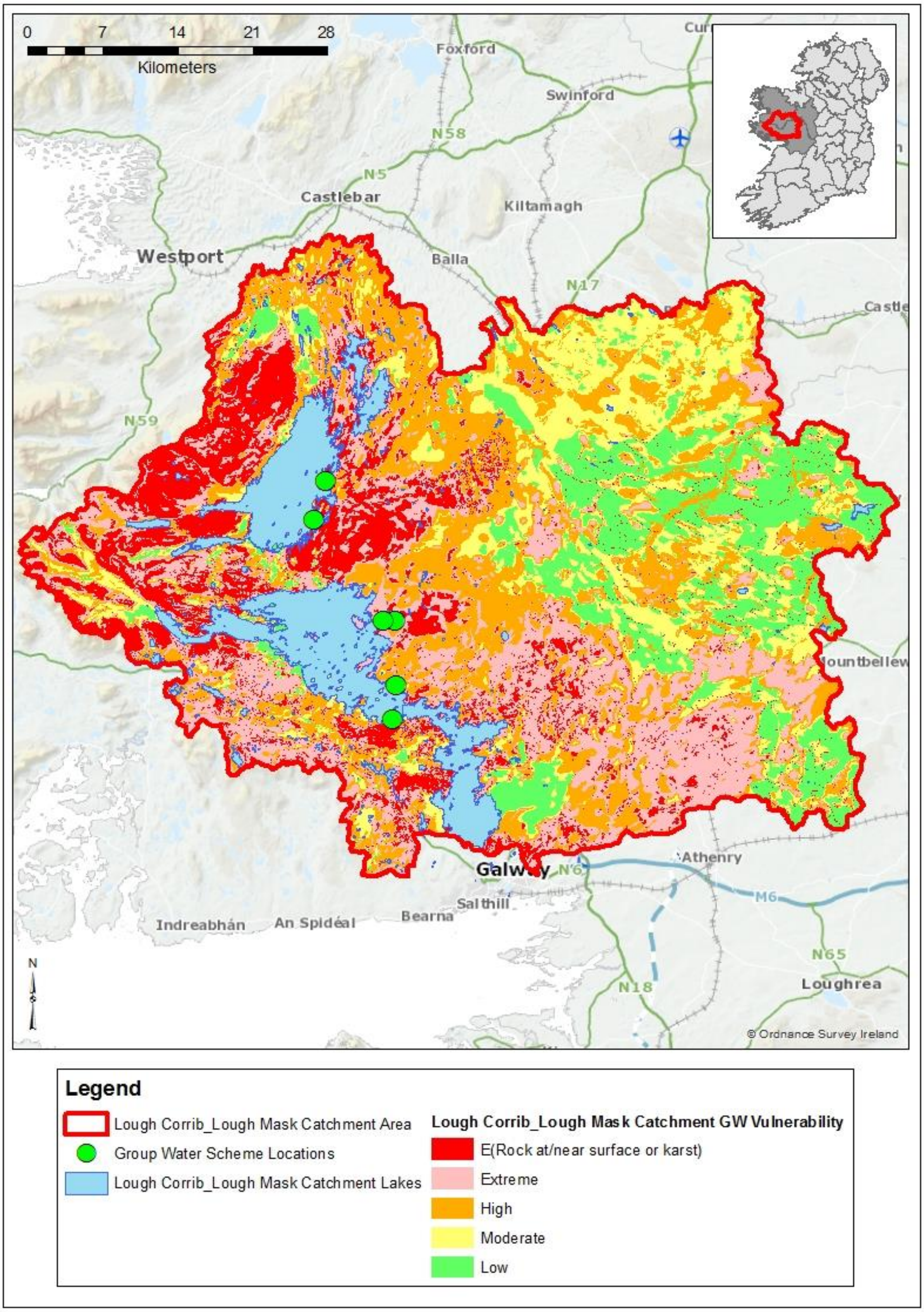

Figure 8: Groundwater vulnerability within the Lough Corrib catchment.

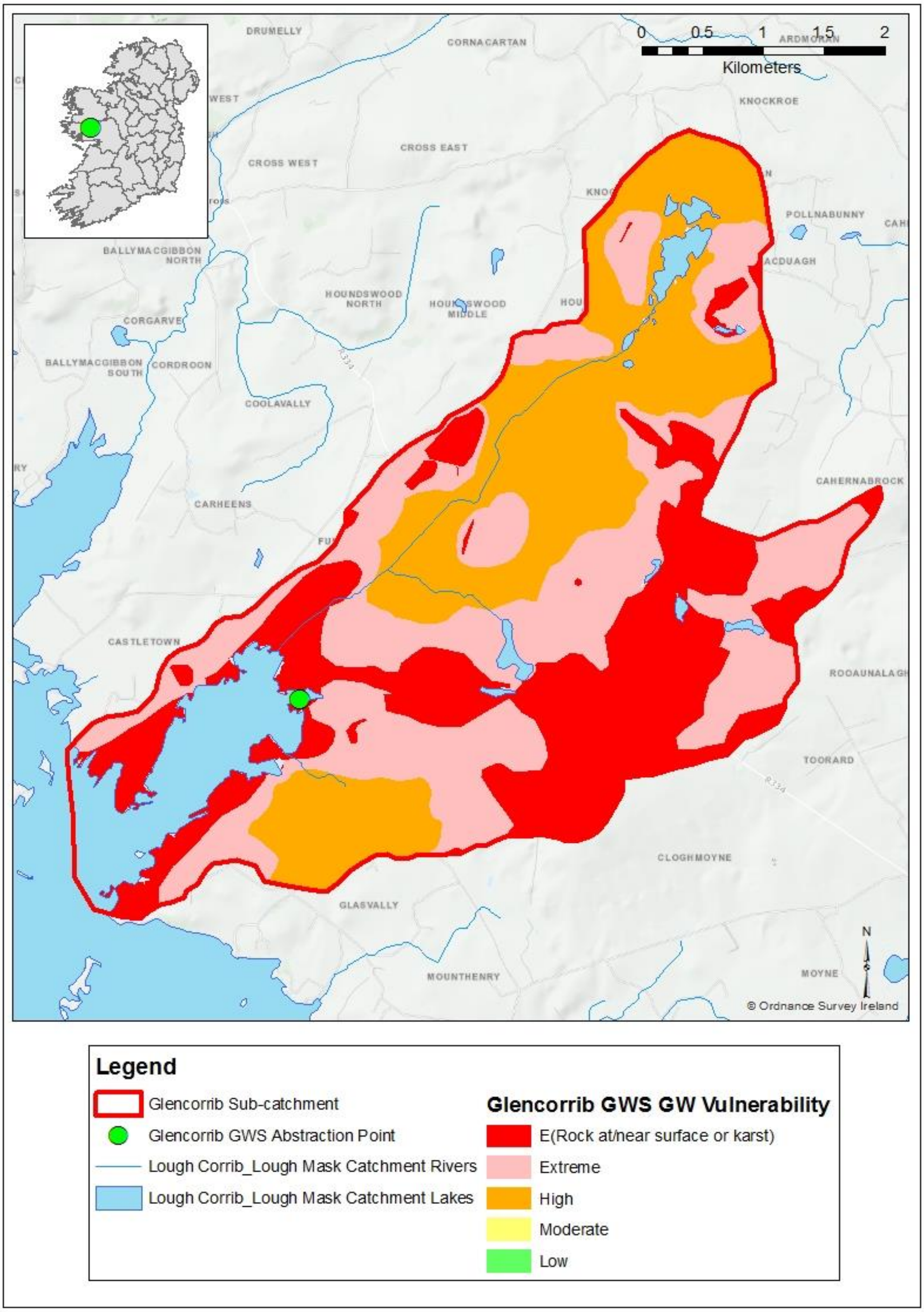

Figure 9: Groundwater vulnerability within the Glencorrib GWS sub-catchment

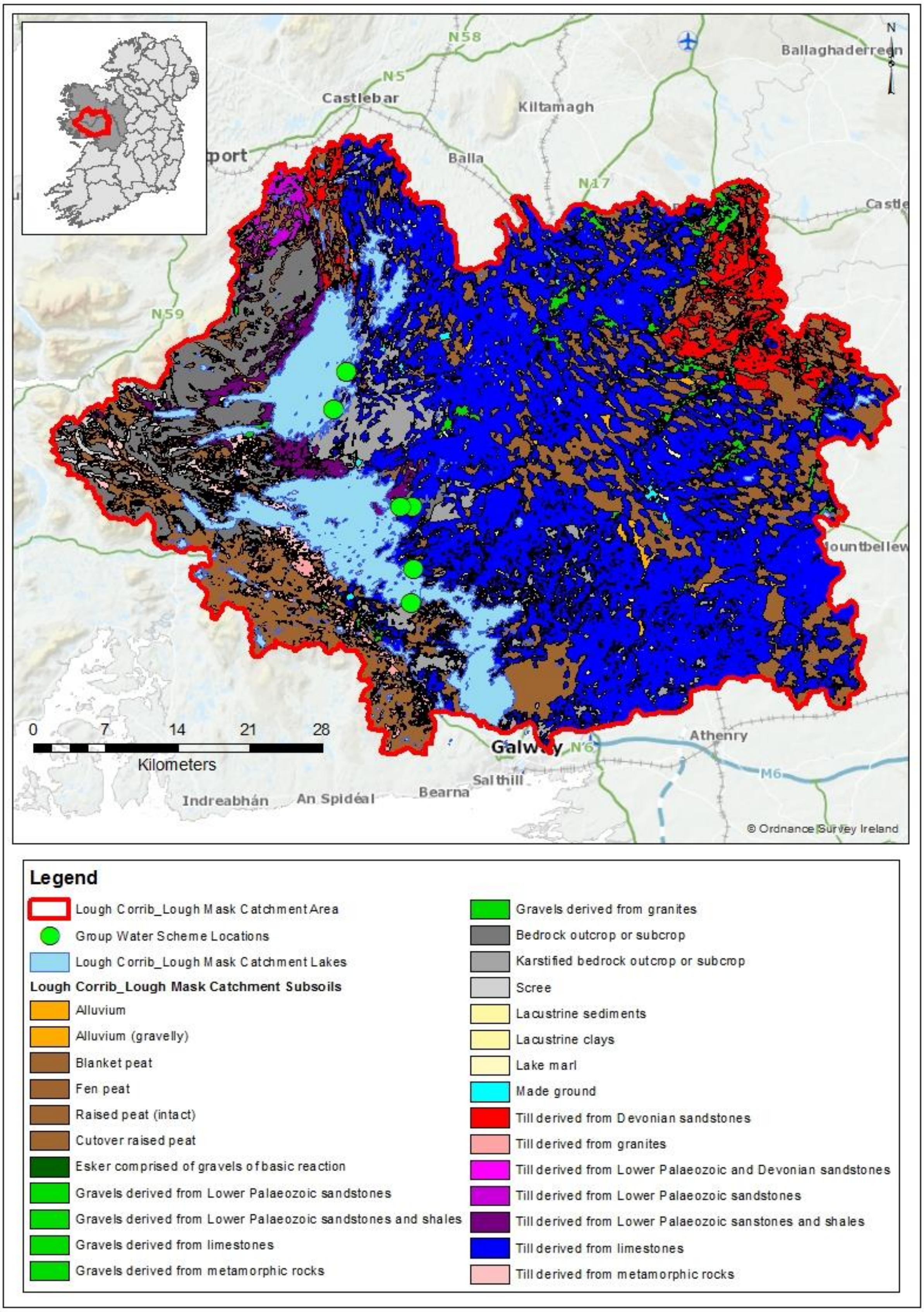

Figure 10: Subsoil deposits within the Lough Corrib catchment.

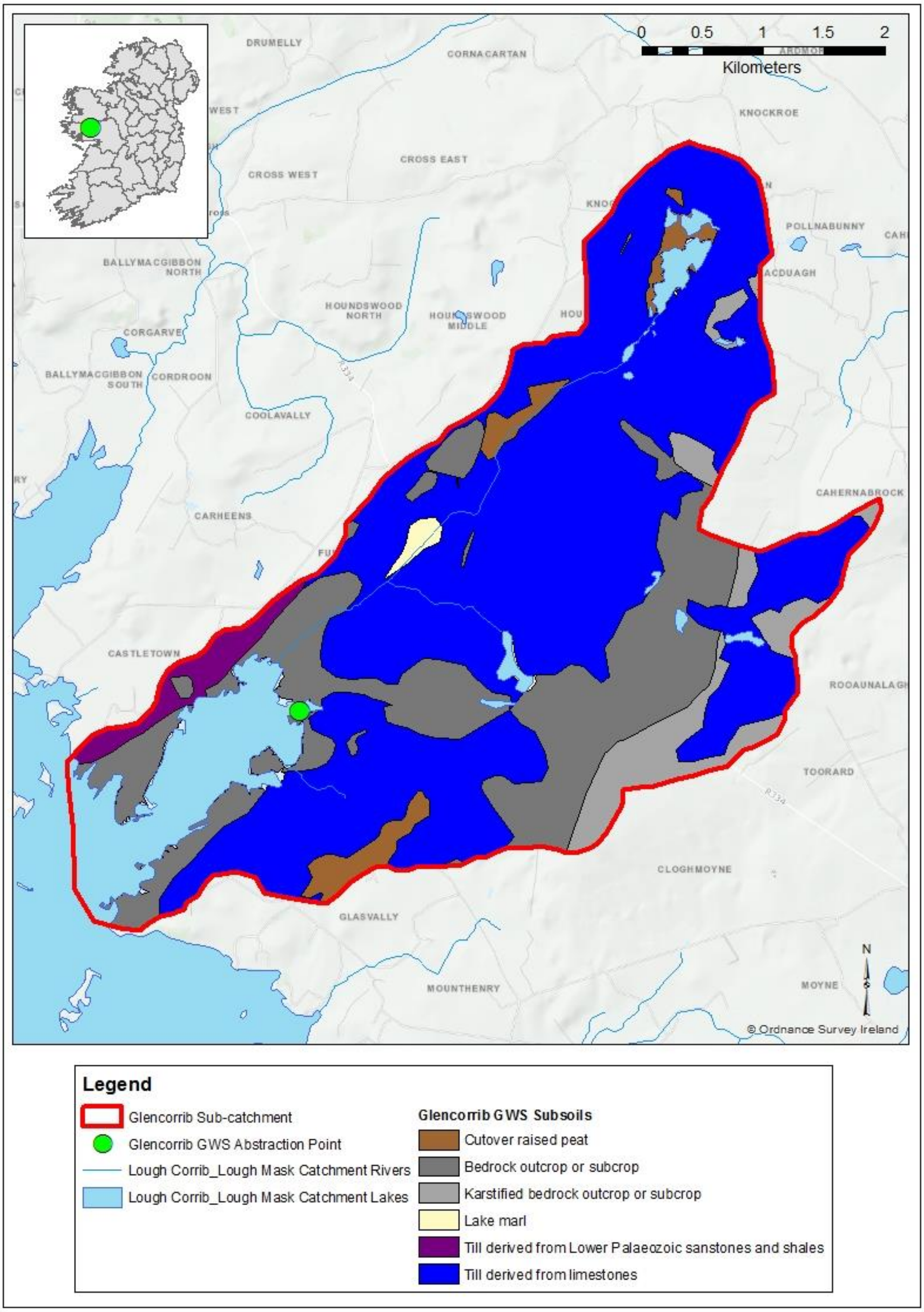

Figure 11: Subsoil deposits within the Glencorrib GWS sub-catchment

4.6 Soils

As for subsoils, the soils present within the Lough Corrib catchment reflect the underlying bedrock (Figure 12, Figure 4). In the west of the catchment, soils are typically acidic; to the east, soils are typically alkaline, interspersed with areas of acidic peaty soils and, in the northeast of the catchment, acidic mineral soils (Figure 12).

Within the Glencorrib GWS sub-catchment, the soils are typically alkaline (basic), predominantly deep, well drained mineral soils, with smaller areas of poorly drained soil present throughout. Shallow, basic, well drained mineral soil is present in association with bedrock outcrops or subcrops (and therefore the highest groundwater vulnerability classifications) (Figure 13, Figure 11). An area of cutover/cutaway peat is present in the south of the catchment; and a small area of acidic, deep, well drained mineral soil is present to the north west of the sub-catchment (in association with the till subsoils derived from sandstones and shale). A small area of marl-type alluvium is present in the mid-north of the catchment.

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 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 elevations within the Lough Corrib catchment are present to the west of the catchment, with some areas in excess of 600m.

The slope of the land also influences groundwater flow directions and water table gradients. Groundwater gradients (the amount of slope of the water table) are determined by the amount of rainfall replenishing the groundwater, and the ability of the aquifer to transmit the groundwater. Poor aquifers tend to have the steepest gradients and regionally important aquifers tend to have the flattest gradients.

The exact impact of the slopes within the Lough Corrib catchment and Glencorrib GWS sub-catchment could only be assessed in a more detailed study, but the potential interactions between the geology, soils, land use and slope will be discussed in more detail below.

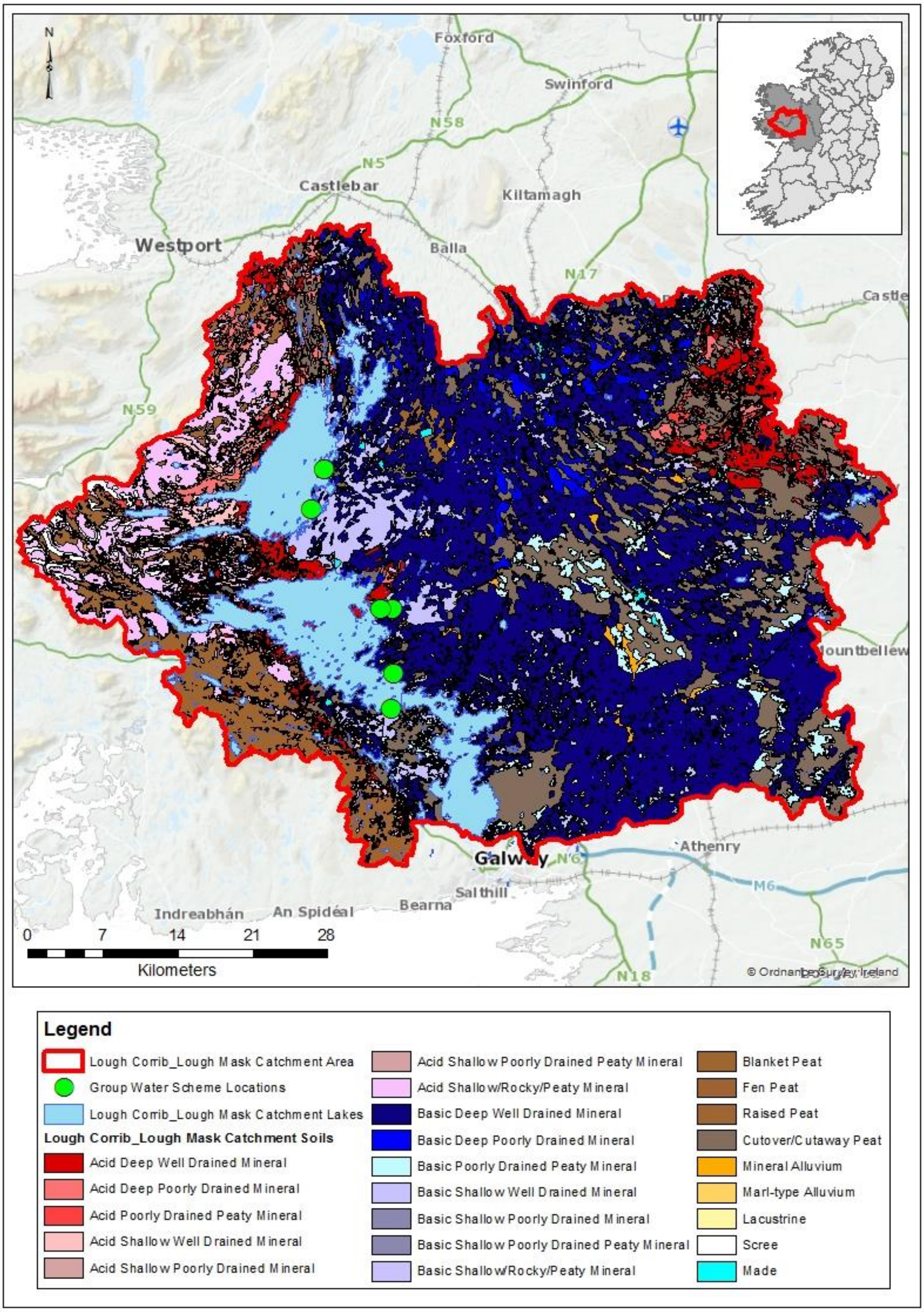

Figure 12: Soil types present within the Lough Corrib catchment.

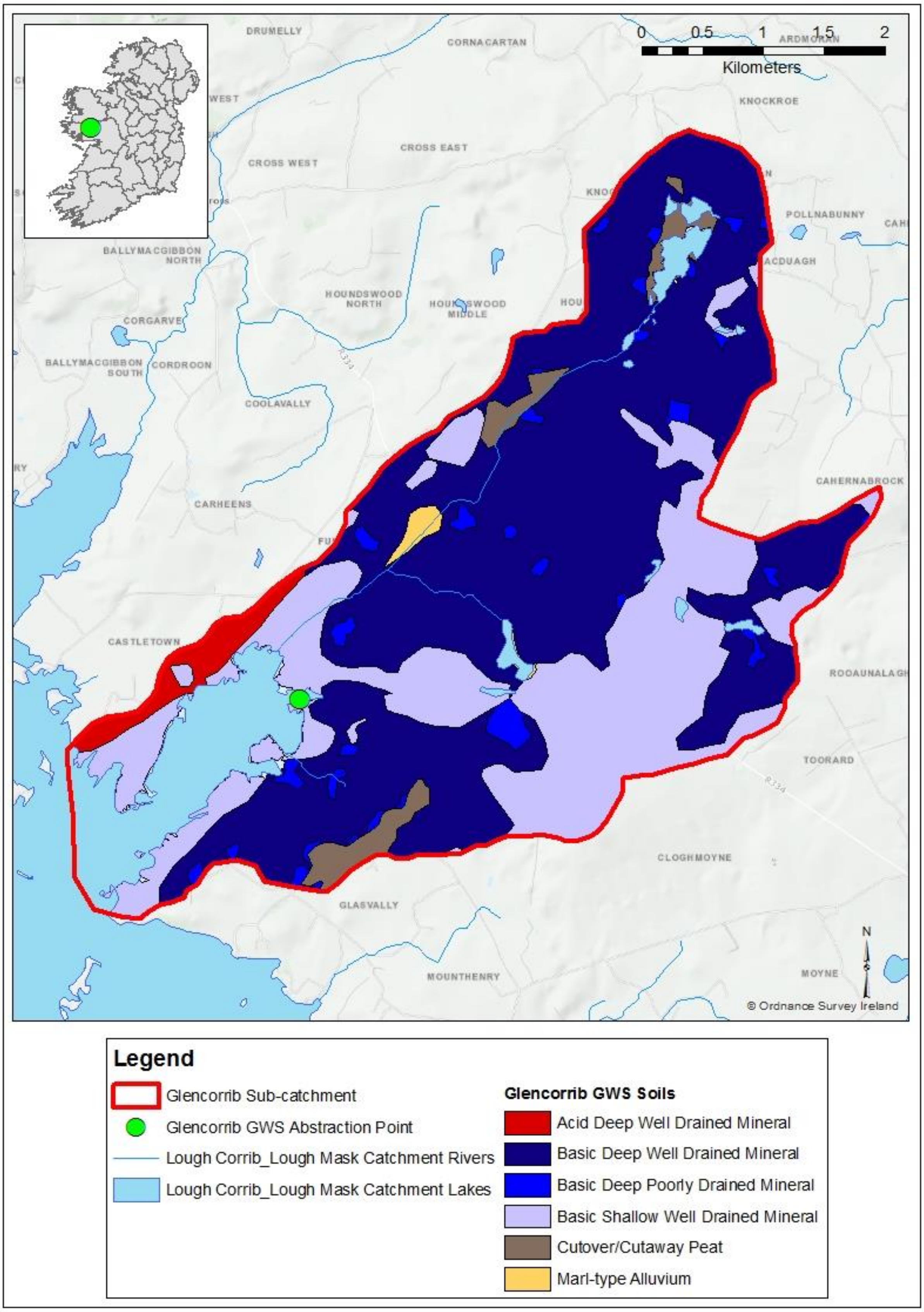

Figure 13: Soil types within the Glencorrib GWS sub-catchment

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.

There are a wide range of land cover classifications within the Lough Corrib catchment (Figure 14). The higher elevations in the west of the catchment are classified predominantly as peat bogs, natural grassland, forest (including coniferous forest plantations) and land principally occupied by agriculture with areas of natural vegetation. The east of the catchment is dominated by pastures interspersed with areas of peat bog, non-irrigated land, forest (including coniferous forest plantations) and land principally occupied by agriculture with areas of natural vegetation. In addition, a number of urban areas are located throughout the catchment.

The Glencorrib GWS sub-catchment land cover classification is dominated by pastures and land principally occupied by agriculture with areas of natural vegetation area of non-irrigated land located in the east of the sub-catchment (Figure 15). Areas of non-irrigated land are present in the north and east of the sub-catchment; and inland marshes are associated with the lake located in the north east of the sub-catchment.

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

5.2 Forestry

Forestry plantations can 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 runoff from planted land. During felling, sediment loss, siltation and nutrient release can also occur. In addition, the exposure of un-vegetated soil can lead to the run off of P in soil suspension. The construction of forestry roads and drainage trenches cause disturbance, erosion and compaction of the soil surface resulting in sedimentation and nutrient run-off.

While there are a number of coniferous forest plantations located throughout the wider Lough Corrib catchment, there are no such plantations present within the Glencorrib GWS sub-catchment.

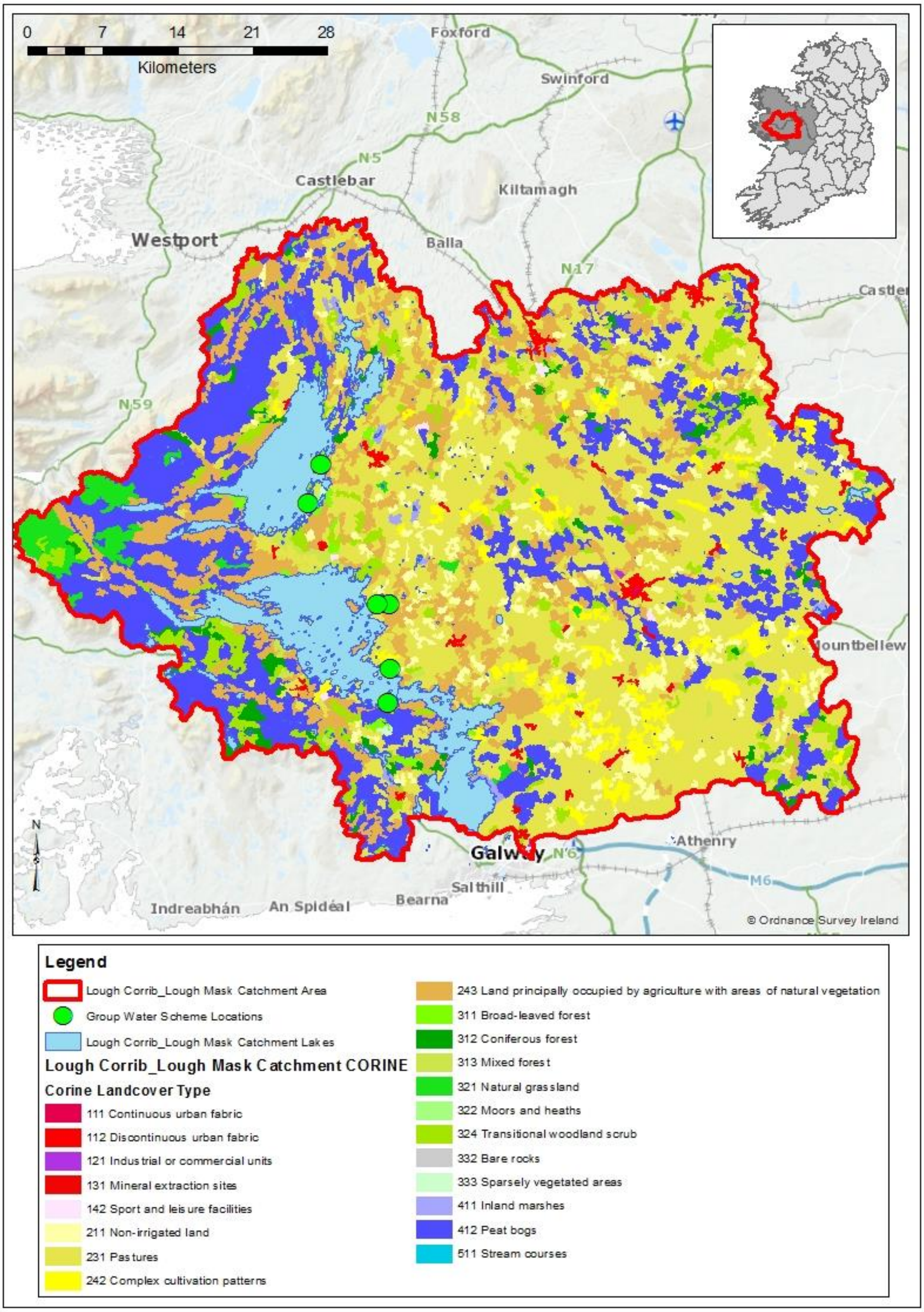

Figure 14: CORINE Land Cover classification within the Lough Corrib catchment.

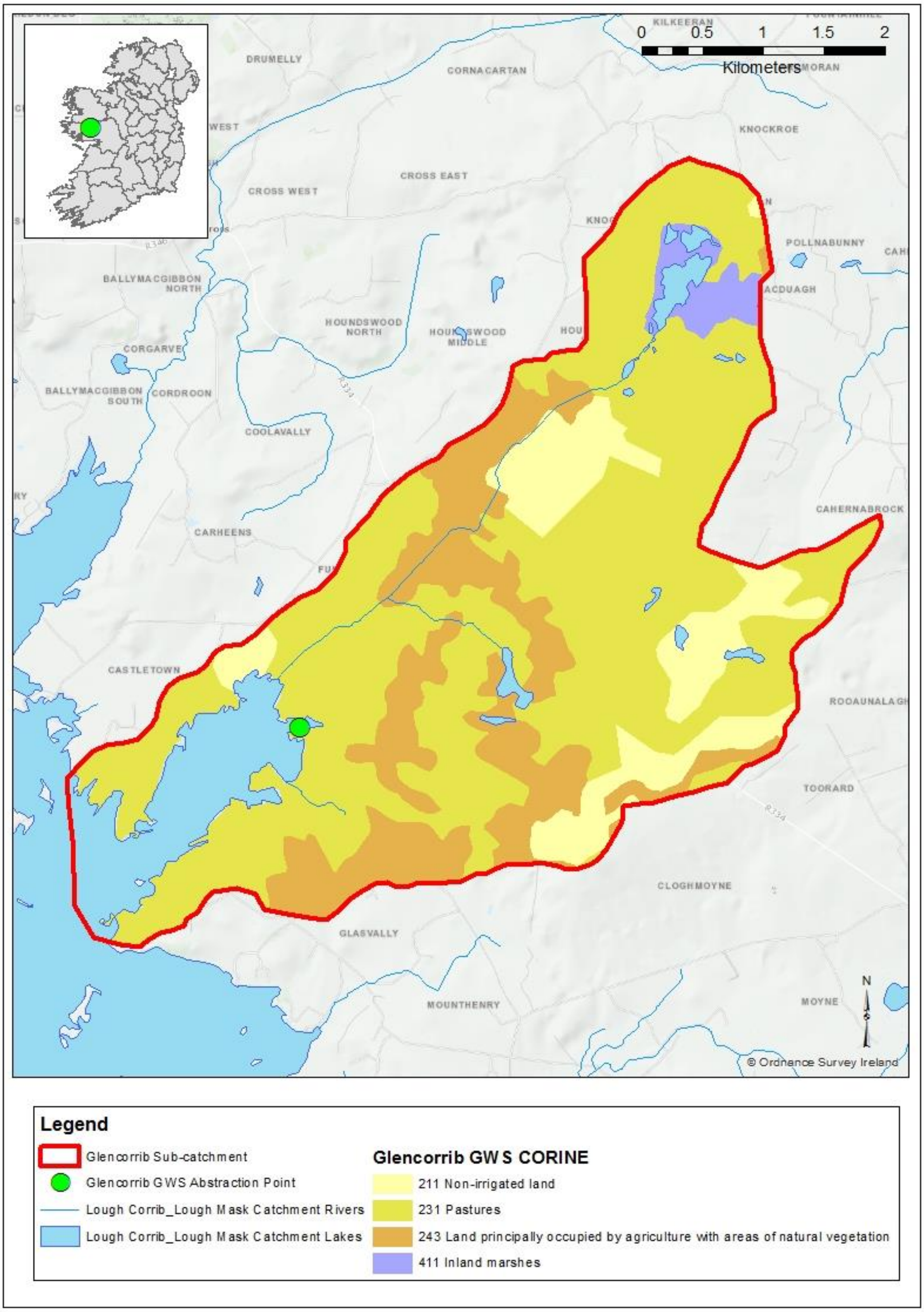

Figure 15: CORINE Land Cover classification within the Glencorrib GWS sub-catchment.

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

Integrated Pollution Prevention Control (IPPC) is a licensing process under EU Directive 96/61/EC, the enforcement of which is the authority of the EPA. The aim of an IPPC license is to prevent or reduce emissions to air, water and land, to reduce waste and use energy and resources efficiently. An IPPC license must be obtained by certain categories of industry that are subject to thresholds. The EPA is responsible for monitoring emissions and dealing with any infringements on licenses.

There are 13 IPPC licences granted within the Lough Corrib catchment: three in County Galway; and 10 in County Mayo. None of the business granted the IPPC licences are in close proximity to the Glencorrib GWS sub-catchment and therefore the potential of any direct impact on the Glencorrib GWS raw water supply is minimal.

In addition, there is a licenced waste facility located within the Lough Corrib catchment at Carrowbrowne on the Headford Road. As above, the likelihood of any direct impact on the Glencorrib GWS raw water supply is negligible.

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 little natural filtration afforded by thin or absent subsoils before effluents enter the bedrock aquifers and the groundwater system and where soil drainage is poor/subsoil permeability are low (i.e. where there is inadequate percolation capacity and effluent backs up and runs overland or is piped to surface water receptors).

Given the size of the Lough Corrib catchment, it is unrealistic to attempt to map the locations of dwellings within this large catchment area. Therefore, only those dwellings located within the Glencorrib GWS sub-catchment have been estimated by viewing the Ordnance Survey map and aerial photography of the area (Figure 16).

All dwellings within the Glencorrib GWS sub-catchment are located within areas of the three highest groundwater vulnerability classifications: E, Extreme and High. Therefore the wastewater treatment systems located within these areas represent a significant risk of contaminants entering the groundwater and subsequently entering the GWS raw water source given the karstic limestone geology of the area and the groundwater pathways that are likely present that can swiftly deliver contaminants to the raw water source area.

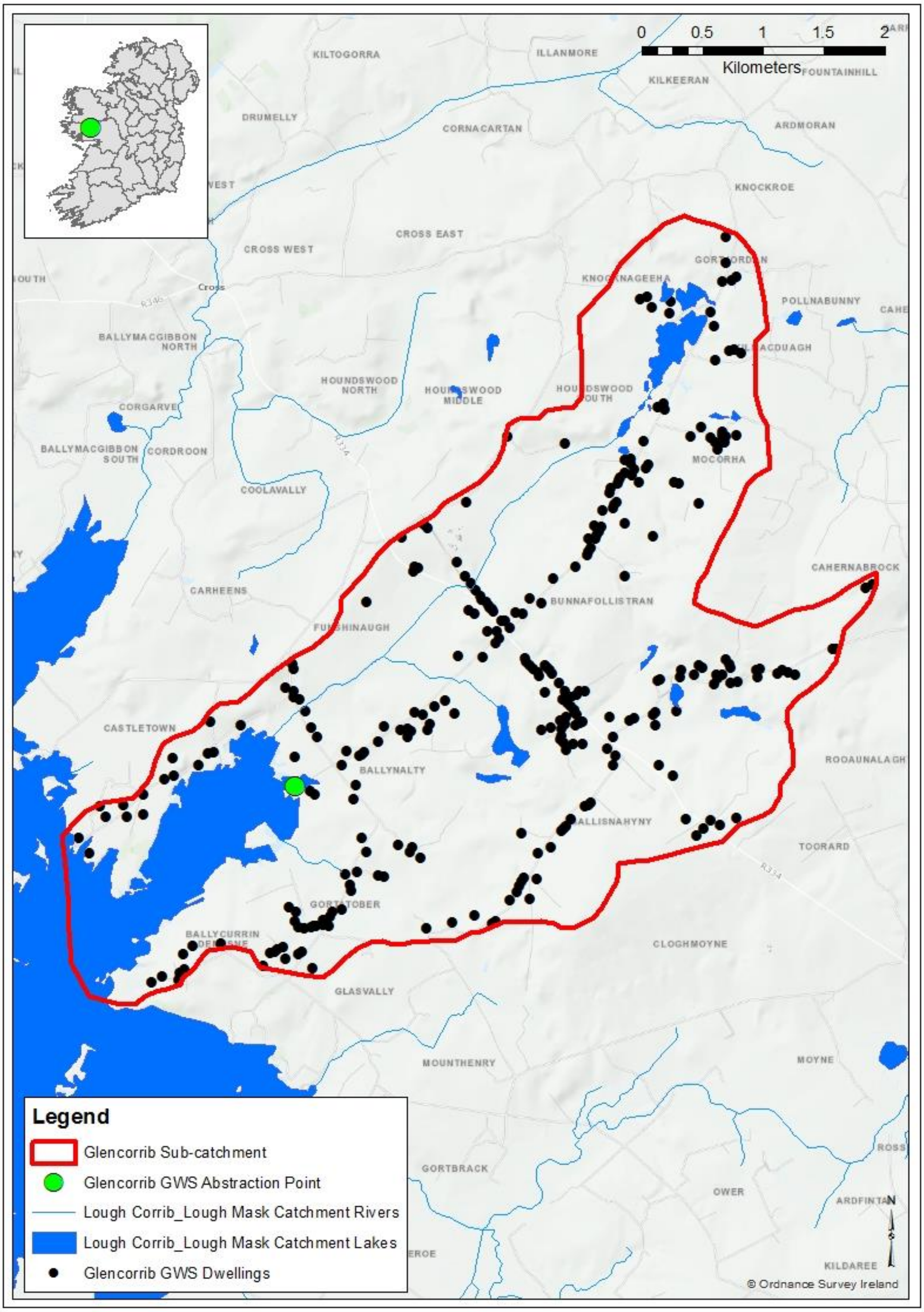

Figure 16: Estimated location of dwellings following examination of Ordnance Survey maps and aerial photography of the Glencorrib GWS sub-catchment.

5.5 Overall interpretation of catchment land use

Glencorrib Group Water Scheme is located in County Mayo, approximately 12 km north west of the town of Headford, County Galway. The GWS abstracts its water from the northern basin of Lough Corrib, the second largest lake in Ireland that is protected under both the EU Habitats and Birds Directives. The wider Lough Corrib catchment is large, covering 3,084 km^2, encompassing Lough Mask and Lough Carra to the north as well as stretching over 50 km to the east of Lough Corrib; and up to elevations of over 500m in the west of the catchment. In comparison, the Glencorrib GWS sub-catchment, which delineates the area within which surface water flows towards the Glencorrib GWS abstraction point, is smaller, covering 19.6 km^2. The bedrock geology of Lough Corrib catchment is dominated by limestone formations in the east of the catchment; and sandstone and granite formations in the west of the catchment. This geology affects the groundwater aquifer as well as the soils and subsoils of the catchment. The karstified nature of the bedrock which underlies much of the Glencorrib GWS sub-catchment facilitates the regionally important aquifer and also the high and extreme vulnerability of groundwater to contamination by pollutants throughout much of the sub-catchment. Importantly, the geographic area through which groundwater moves through the karstified landscape is likely to be different to that delineated for surface water (the Glencorrib GWS sub-catchment). Subsequently, land use or human actions which take place locally but which are outside of the delineated Glencorrib GWS sub-catchment may still have the potential to impact on the Glencorrib GWS raw water supply. Increasing the understanding of groundwater influence at the Glencorrib GWS abstraction point is an important action for consideration.

Soils and subsoils types are varied throughout the Lough Corrib catchment, but are typically alkaline within the Glencorrib GWS sub-catchment, reflecting the limestone bedrock geology of the local area.

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. This, in association with the risk of nutrients and bacteria entering surface waters, means that care must be taken to ensure that domestic wastewater treatment systems located within the Glencorrib GWS sub-catchment are properly installed and maintained. The dwelling density in the sub-catchment is locally dense in places, and all dwellings are located within the three highest groundwater vulnerability classifications. High risk systems, along with cattle yards which are situated within areas of poor soil drainage and high groundwater vulnerability should be inspected as a priority to ensure that potential risk of contamination from these point sources is reduced. The management of waste from livestock within the Glencorrib GWS sub-catchment should also be strongly considered given the predominant pasture land cover within the sub-catchment, and the potential for both nutrients and microbial pathogens to swiftly enter both groundwater and surface water.

An assessment of water quality parameters in both the raw water and drinking water supplies is provided in Section 6.0.

6.0 Water Quality

Water quality has been assessed through data provided the EPA and Mayo County Council. Data presented mainly focuses on raw water but also includes some treated drinking water parameters such as Trihalomethanes. The EPA monitors water quality at multiple locations on the upper and lower basins of Lough Corrib as well as in Lough Mask (Figure 17). Within the upper basin of Lough Corrib, Site 2 is the EPA sampling location geographically closest to the Glencorrib GWS abstraction point (Figure 18), although the data for each of the sampling locations shown in Figure 18 are presented in this report to provide wider context of water quality within the upper basin of Lough Corrib.

Treated water data has been extracted from the national drinking water data sets available from the EPA and provided by the Local Authorities.

6.1 Water Quality Data

6.1.1 Colour

Natural colour reflects the presence of organic molecules originating from humic matter such as peat, leaves and branches. High colour levels may also be due in part to higher iron content, but it should be noted that the latter do no react with chlorine. A coloured water supply does not pose high health risks in itself but the coloured compounds 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. For these reasons, high levels of colour should be avoided where possible; however, colour can vary greatly as a parameter, depending on quantities of rain 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 maximum value of 20 mg/L PtCo (or Hazen) (true colour: PtCo and Hazen are equivalent units) for A1 waters (surface waters that only require simple physical treatment and disinfection to become drinking water).

True Colour was monitored by the EPA in the upper basin of Lough Corrib at a number of locations from August 2007 to March 2018 (Figure 19). Values ranged from being below the limit of detection (less than 2 Hazen/PtCo) at Site 6 in November 2007 (represented as a zero value in Figure 19) to a maximum of 54 Hazen/PtCo recorded at Site 2 in May 2018. Unusually, True Colour values did not exhibit any strong seasonal patterns. The Surface Water Regulations (1989) parametric value for Class A1 waters of 20 mg/L Hazen was frequently exceeded.

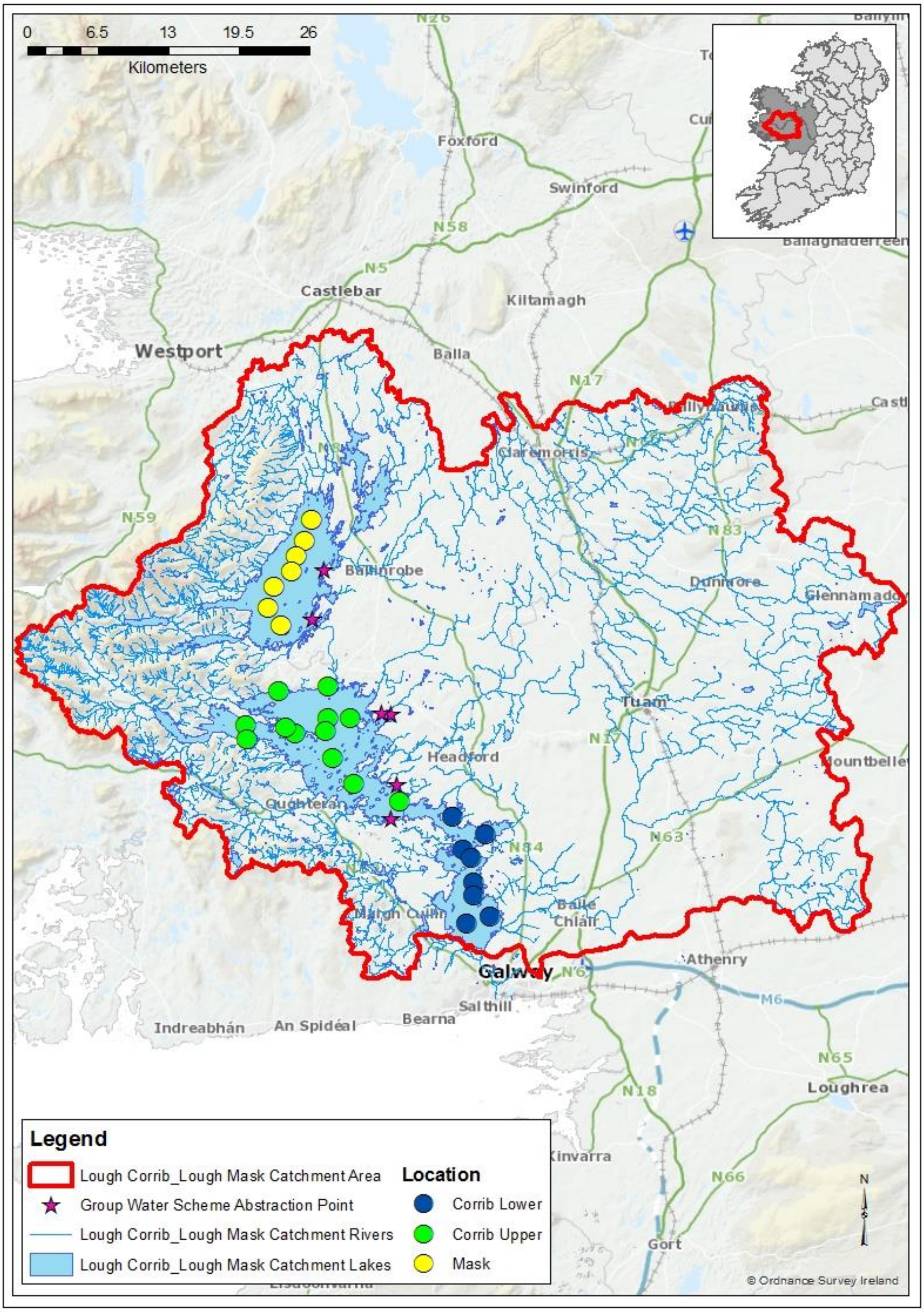

Figure 17: EPA water quality sampling locations for Lough Corrib and Lough Mask.

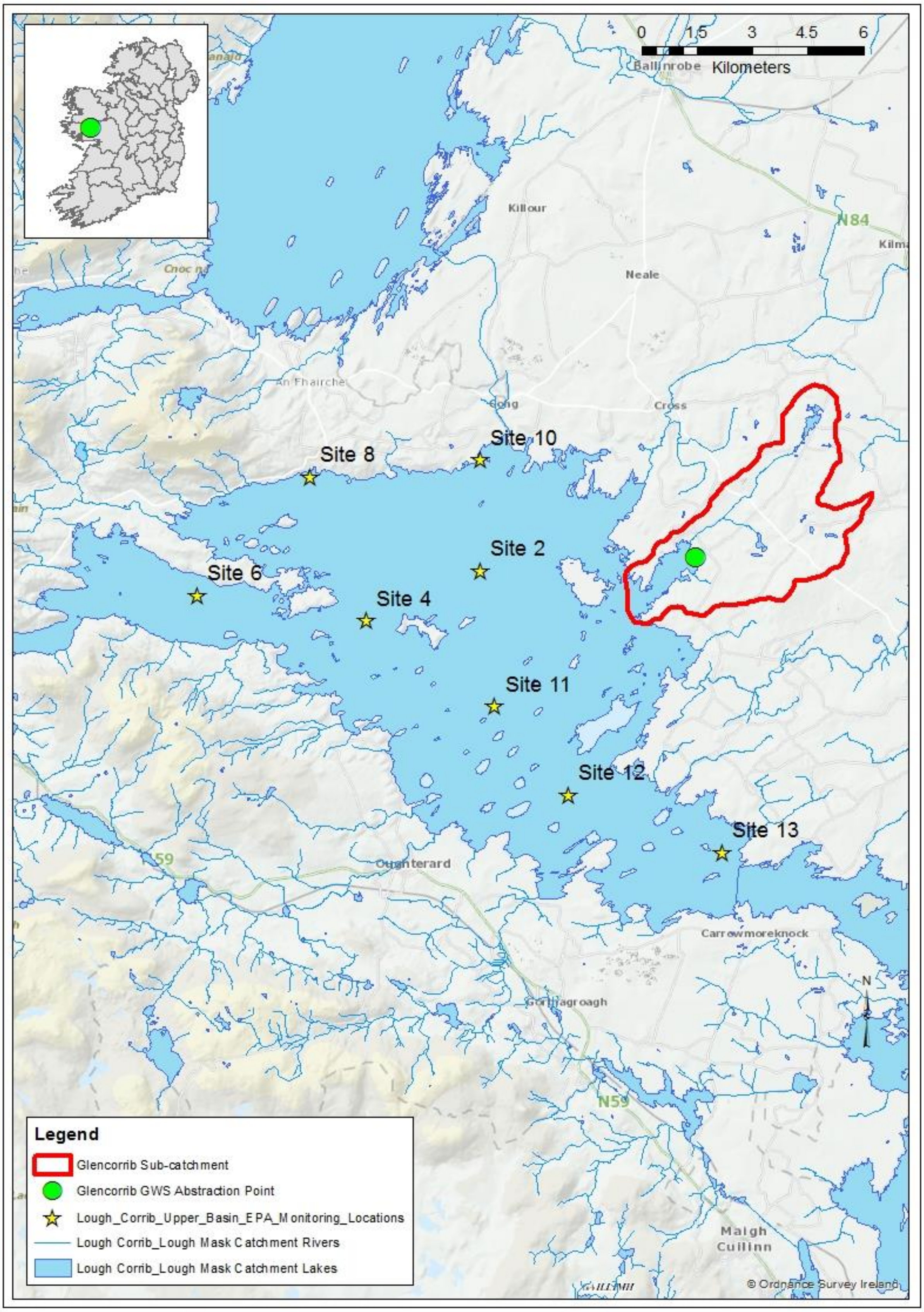

Figure 18: EPA water Quality sampling locations for the upper basin of Lough Corrib

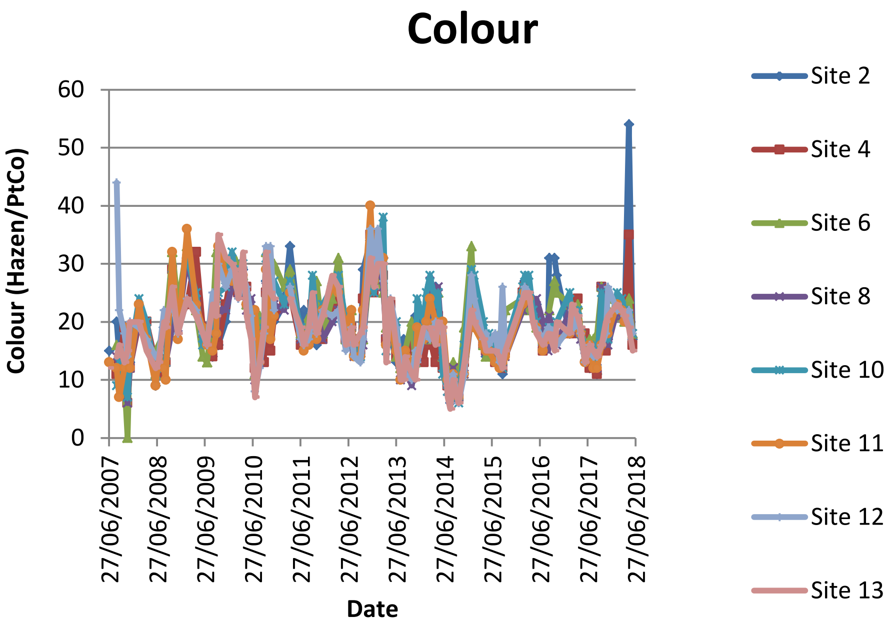

Figure 19: Raw water colour values for Lough Corrib for True Colour (EPA Water Quality Sampling Sites 2-13) from June 2007 to June 2018.

Despite the temporal variation in True Colour values throughout the upper basin of Lough Corrib, average (mean) values were similar across each of the EPA water quality sampling sites (Figure 20).

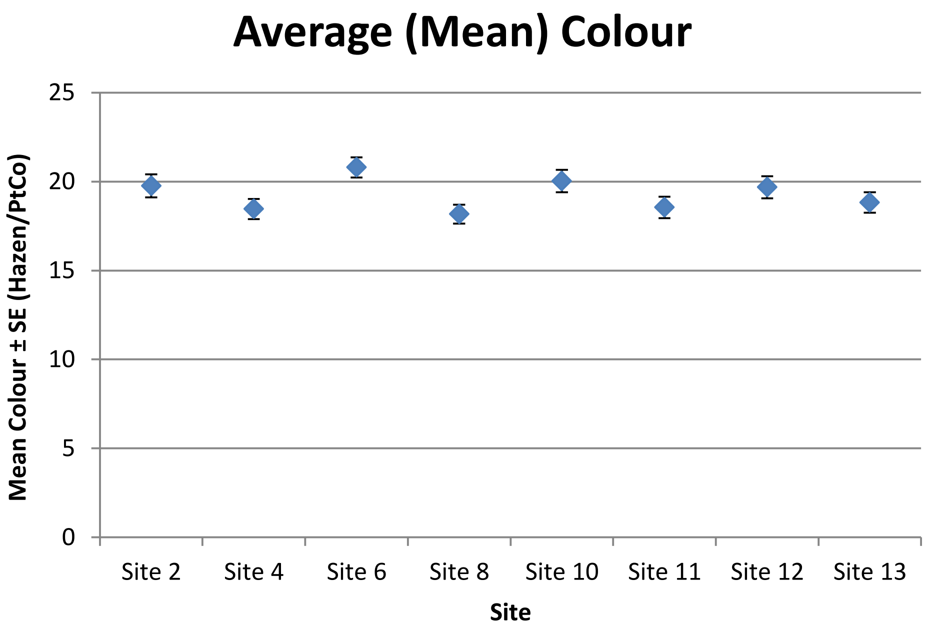

Figure 20: Average (mean ± standard error) raw water colour values for each of the monitoring locations. EPA water quality sampling sites 2-13 are for True Colour; Glencorrib MSR data are for Apparent Colour.

6.1.2 Total and Dissolved Organic Carbon

Natural Organic Matter (NOM) is a complex of organic matter 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 by-products such as Trihalomethanes as a result of the reaction of chlorine compounds with the NOM content of the raw water. Total Organic Carbon provides a measure of the NOM present in a water source, while Dissolved Organic Carbon (DOC) provided a measure of the dissolved fraction of this organic matter. These data can be used for an assessment parameter 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 mg/L (Chua, 1996).

DOC was monitored at all sampling locations in the upper basin of Lough in December 2012 and January 2013. Subsequently, DOC was only monitored at Site 2 until December 2013; and at Site 11 from July 2015 to May 2018 (Figure 21). Values at Site 2 were variable, ranging from a minimum of 4 mg/L in November 2013, to a maximum of 12 mg/L in June and July 2013. At Site 11, values were less variable, ranging from a minimum of 4 mg/L on three occasions, to a maximum of 6.5 mg/L in May 2018.

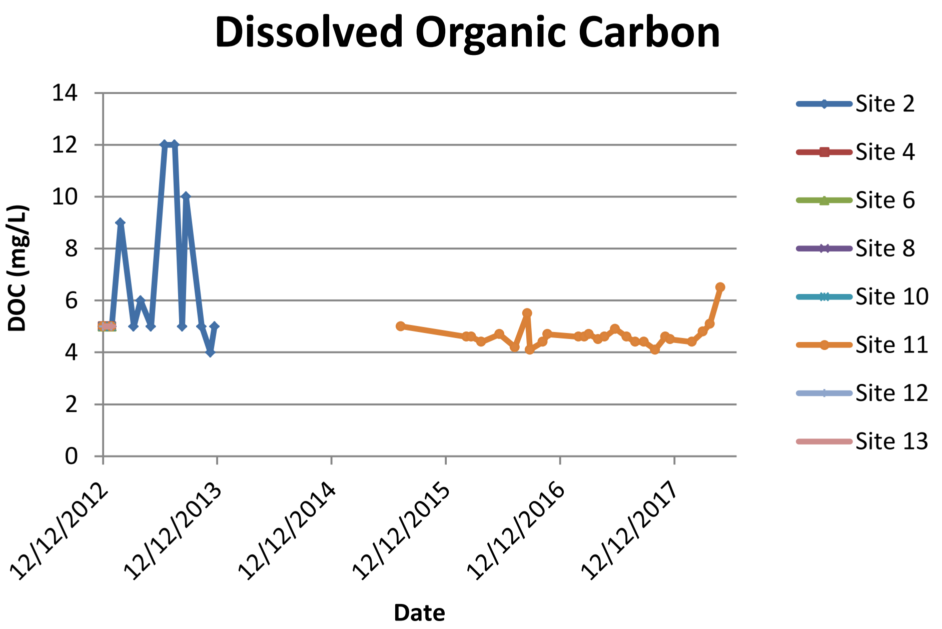

Figure 21: Raw water Dissolved Organic Carbon values at EPA sampling sites in the upper basin of Lough Corrib.

6.1.3 Trihalomethanes (THMs)

Total trihalomethanes (from treated water, measured at the tap) were monitored on five occasions between January 2014 and May 2018 (Figure 22). The Drinking Water Regulations (2007 and 2014) parametric limit of 100 µg /L were not exceeded on any occasion. THM concentrations in drinking water are typically highest between late summer and early winter when the possibility of THM formation is likely to be greatest due to often higher levels of DOC in the raw water. Yet, all of the THM monitoring was undertaken outside of this time period.

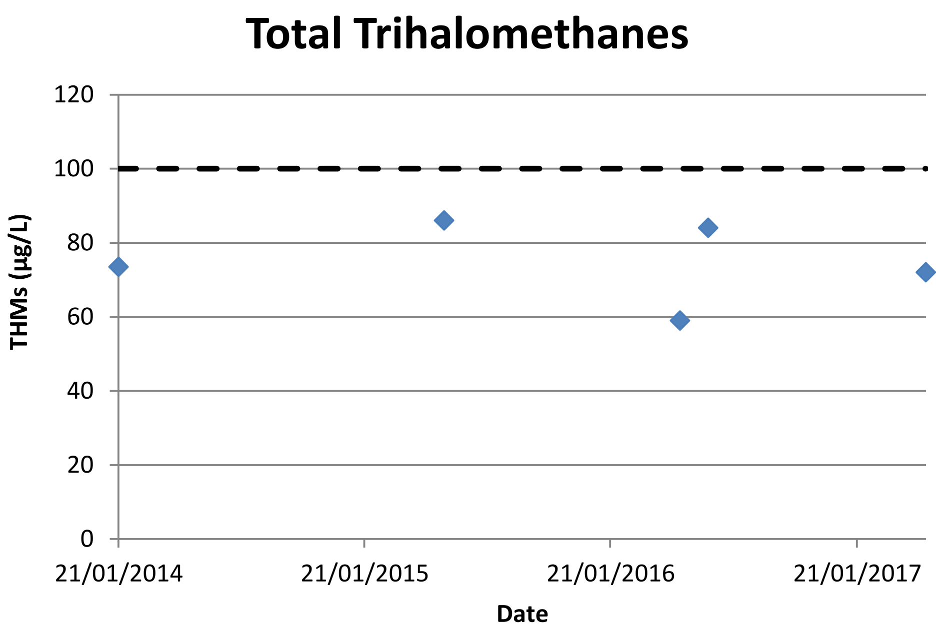

Figure 22: Total Trihalomethane data from the Glencorrib GWS treated water from January 2014 to May 2017.

6.1.4 Turbidity

Turbidity in water consists of very fine 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. In groundwater, turbidity can be an indicator that surface waters that potentially carry bacterial pathogens are entering the groundwater system. 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.

There is no defined limit for turbidity at the tap under the Drinking Water Regulations 2014, however the recommended limit for turbidity in drinking water leaving a surface water treatment plant is 1 NTU.

The EPA did not monitor turbidity in the raw water supply.

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. For Class A1 waters, the Surface Water Regulations (1989) recommend that iron concentrations do not exceed 200 µg/L.

Iron concentrations were monitored at EPA sampling Site 2 in November and December 2007, January 2010 and on a monthly basis in 2013. Values were typically below the limit of detection except on six occasions in 2013 when values were recorded between 11 and 34 µg/L. The Surface Water Regulations (1989) parametric limit was not exceeded on any occasion.

6.1.6 Manganese

Manganese (Mn) is found in soils and ground waters and is generally not considered harmful to humans unless ingested in significantly elevated concentrations over long periods of time. 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) recommend concentration of manganese in Class A1 waters as 50 µg/L.

Manganese concentrations were monitored at EPA sampling site 2 over the same timeframe as for Iron, above. Again, values were typically below the limit of detection, except for four occasions in 2013 when values of 10µg/L were recorded. The Surface Water Regulations (1989) parametric limit was not exceeded on any occasion.

6.1.7 pH

The pH 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 range of 5.5-8.5 for Class A1 waters. The Drinking Water Regulations (2007 and 2014) requires a pH range of 6.5-9.5 for treated water.

pH was monitored at the eight EPA sampling sites in the upper basin of Lough Corrib (Figure 23). pH values ranged from a minimum of pH 6.7 at Site 8 in February 2018, to a maximum of pH 8.6 at Sites 11 and 13 in June 2014. This maximum value exceeds the Surface Water Regulations (1989) recommended range for Class A1 waters.

Average (mean) pH values were similar across the EPA water quality sampling sites.

The pH values recorded typically reflect the alkaline nature of Lough Corrib which is indicative of the underlying karstic limestone geology which is present throughout much of the wider Lough Corrib catchment.

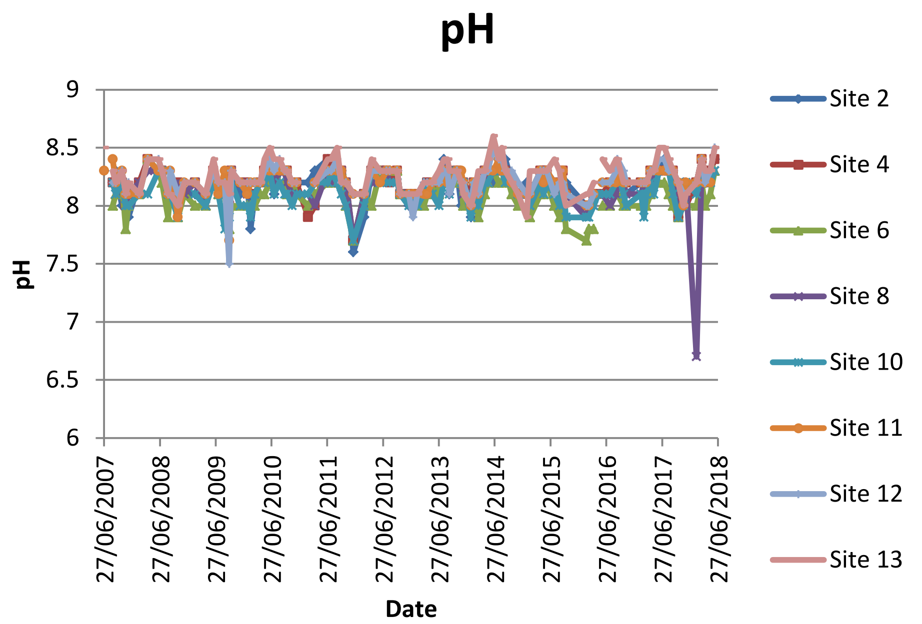

Figure 23: pH values at EPA sampling locations within the upper basin of Lough Corrib between June 2007 and June 2018.

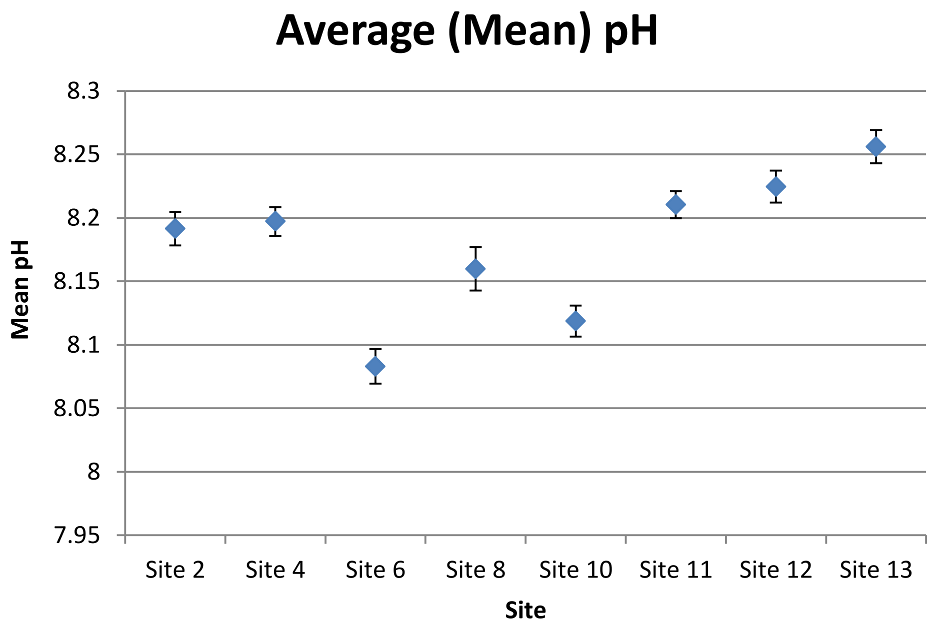

Figure 24: Average (mean ± standard error) pH values at EPA sampling locations in the upper basin of Lough Corrib.

6.1.8 Alkalinity

Alkalinity is a measure of 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, although primarily influenced by the soils and rocks over or through which waters flow, can be indicative of eutrophication and photosynthesis.

Total Alkalinity was monitored at each of the eight EPA sampling sites across the upper basin of Lough Corrib. Values were relatively consistent across most of the sampling sites, although Site 6 had typically lower Total Alkalinity values than the other sites (Figure 25), and this is reflected in the average value per site (Figure 26). Values ranged from a minimum of 36 mg/L $CaCO_3$ at Site 6 in April 2016 to a maximum of 234 mg/L $CaCO_3$ at Site 12 in September 2007.

These Total Alkalinity values would be indicative of the limestone bedrock geology present throughout much of the Lough Corrib catchment.

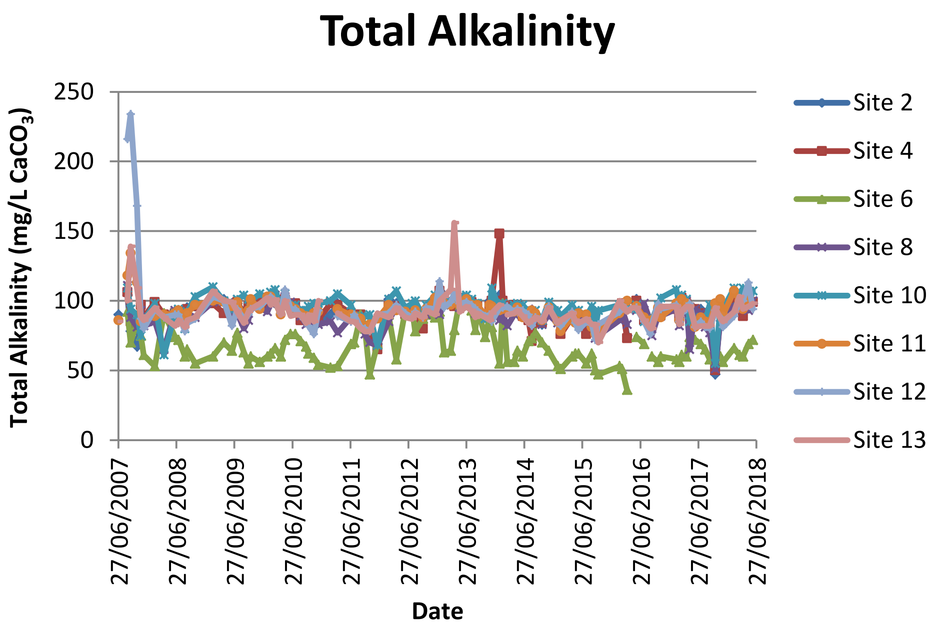

Figure 25: Total Alkalinity at each of the eight EPA sampling sites in the upper basin of Lough Corrib.

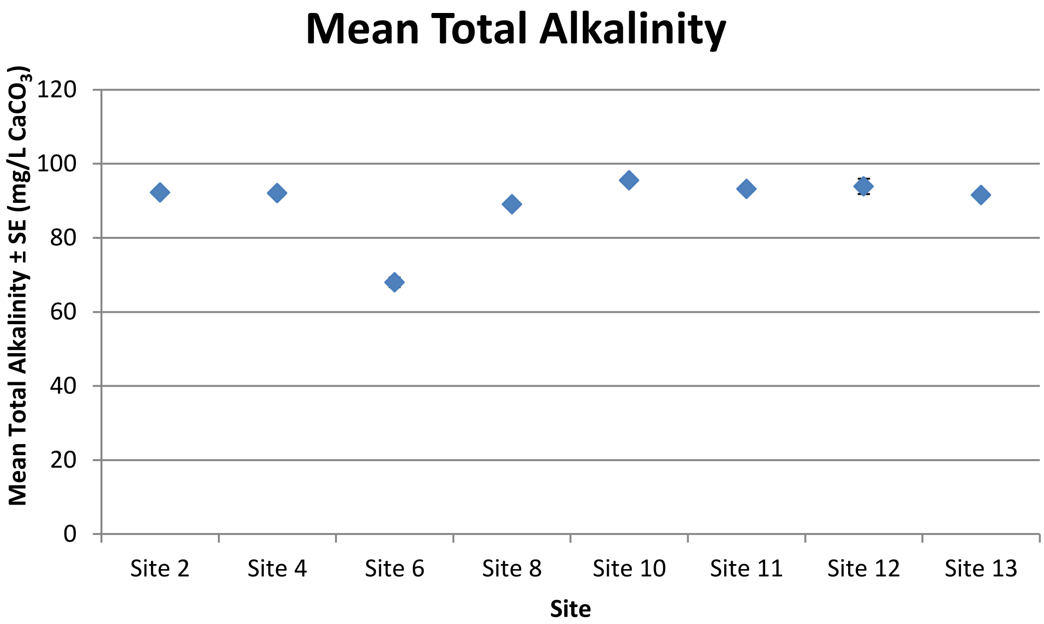

Figure 26: Average (mean) Total Alkalinity values in the upper basin of Lough Corrib for each of the eight EPA sampling sites.

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. Waterbodies 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 (P) 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) 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 scum's and a general deterioration in water quality.

Eutrophication is the largest threat to Irish surface 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 waters sourced from surface water bodies. There is currently no statutory limit for phosphorus in drinking waters, although the Surface Water Regulations (2009) outlined that orthophosphate (an inorganic form of phosphorus readily available for photosynthesis, with high orthophosphate concentrations often occurring in conjunction with algal blooms) concentrations in rivers should lie within the following boundaries: High status ≤0.025 mg/L P; and Good status ≤0.035 mg/L P.

Total Phosphorus (TP) was monitored at each of the eight EPA sampling sites in the upper basin of Lough Corrib (Figure 27). Values ranged from being below the limit of detection on a number of occasions at a number of sites (represented as zero values in Figure 27), to a maximum of 0.035 mg/L TP recorded at Site 8 in August 2007. Mean TP concentrations were highest at Sites 4 and 8 (Figure 28). While not at excessive levels, Total Phosphorus concentrations within the upper basin of Lough Corrib are high enough to support algal growth and potentially, in combination with other factors, support algal bloom events

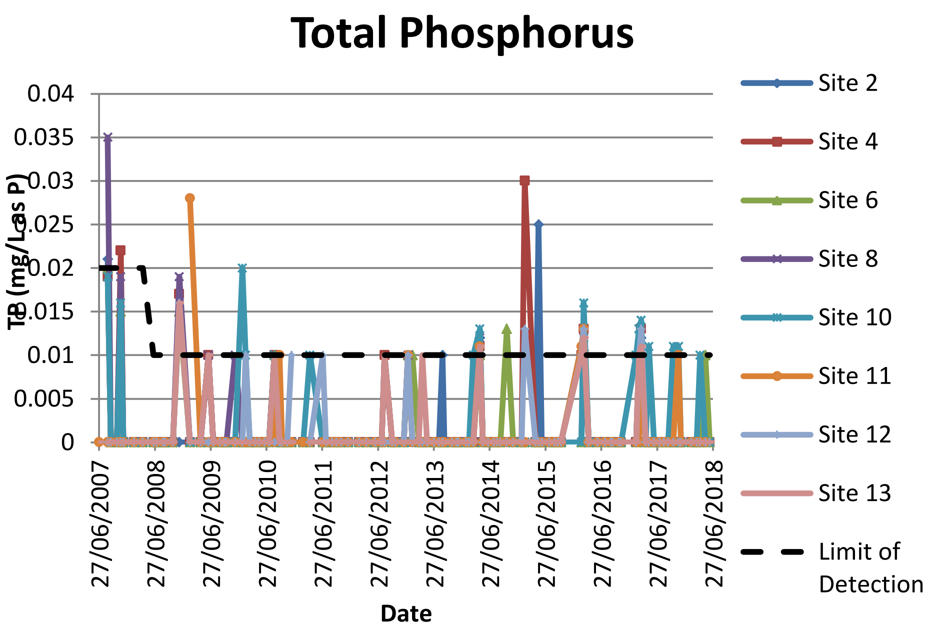

Figure 27: Total Phosphorus concentrations at each of eight EPA sampling sites in the upper basin of Lough Corrib.

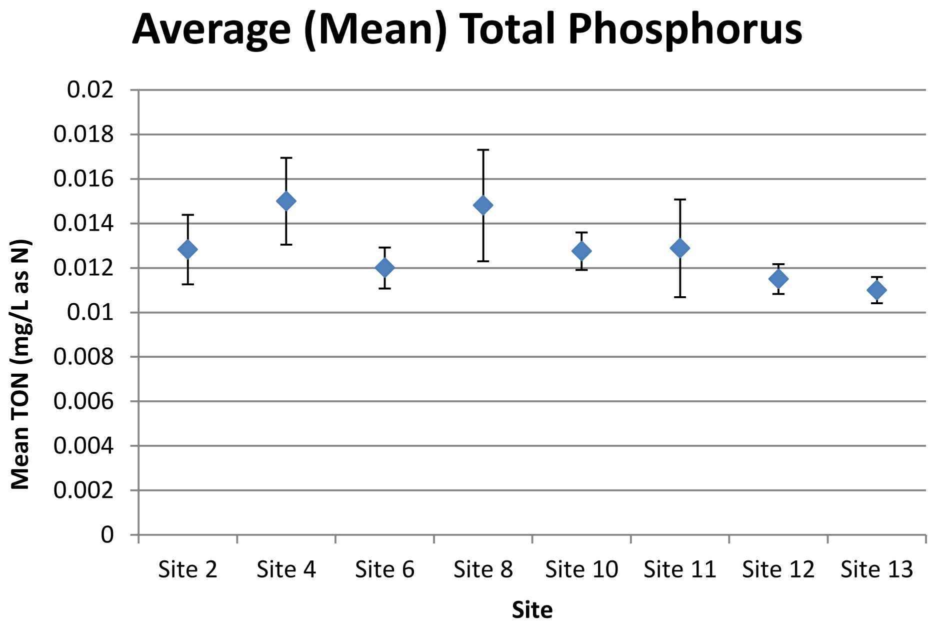

Figure 28: Average (mean ± standard error) Total Phosphorus concentrations for each of the eight EPA sampling sites in the upper basin of Lough Corrib.

Orthophosphate concentrations were also monitored at each of the eight EPA sampling sites in the upper basin of Lough Corrib (Figure 29). Concentrations were recorded above the limit of detection on only three occasions. The average for these occasions would place the upper basin of Lough Corrib within the High status for orthophosphate.

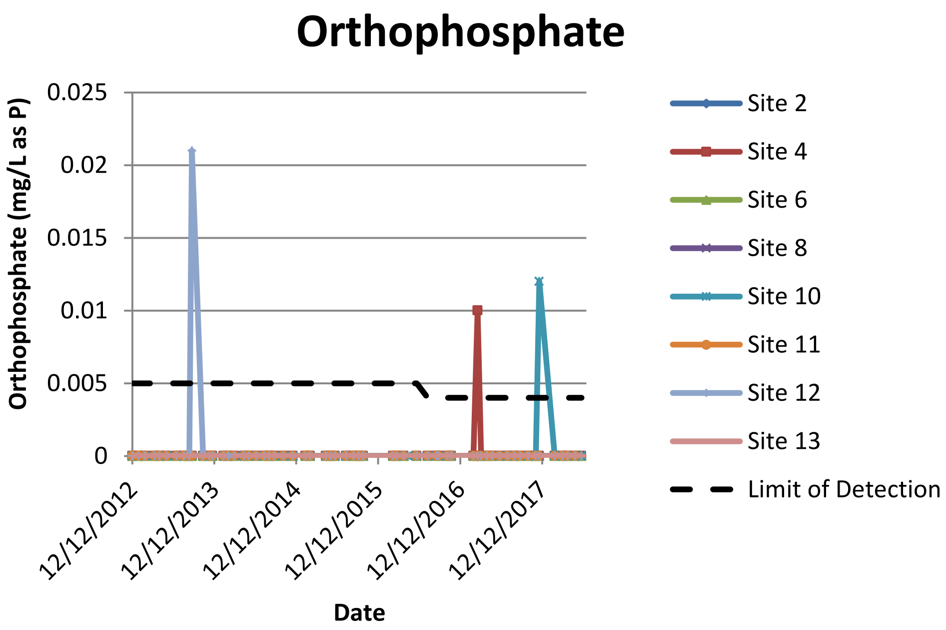

Figure 29: Orthophosphate concentrations at eight EPA sampling sites within the upper basin of Lough Corrib.

6.1.10 Chlorophyll and algae

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.

Chlorophyll was monitored at the eight EPA sampling sites in the upper basin of Lough Corrib (Figure 30). Seasonal variations of higher values in late summer and autumn and lower values through winter and spring were evident. Values ranged from being below the limit of detection (represented in Figure 30 as zero values) on multiple occasions at multiple sites; to a maximum of 8.2 mg/m^3 at Site 6 in October 2007. High chlorophyll concentrations were observed at multiple sites in late summer 2007 and late summer 2008, potentially indicative of a whole-of upper basin algal bloom. A high value at Site 13 in July 2017 may be more indicative of a localised algal bloom.

Mean chlorophyll concentrations were highest at Site 2 (Figure 31). Mean concentrations at Site 2, closest to the Glencorrib GWS abstraction point, was the highest across the upper basin of Lough Corrib.

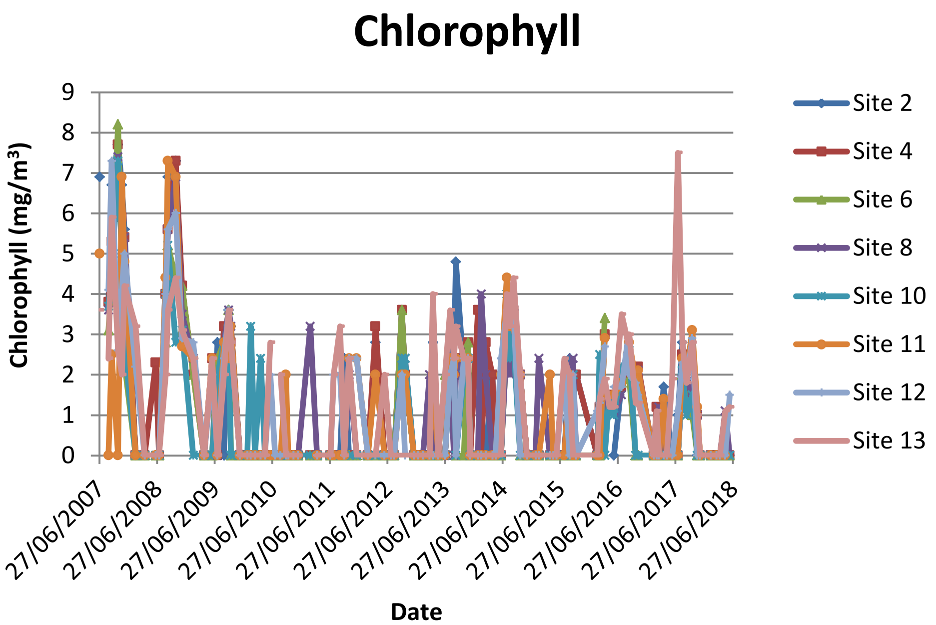

Figure 30: Chlorophyll *a* concentrations at the eight EPA sampling sites within the upper basin of Lough Corrib.

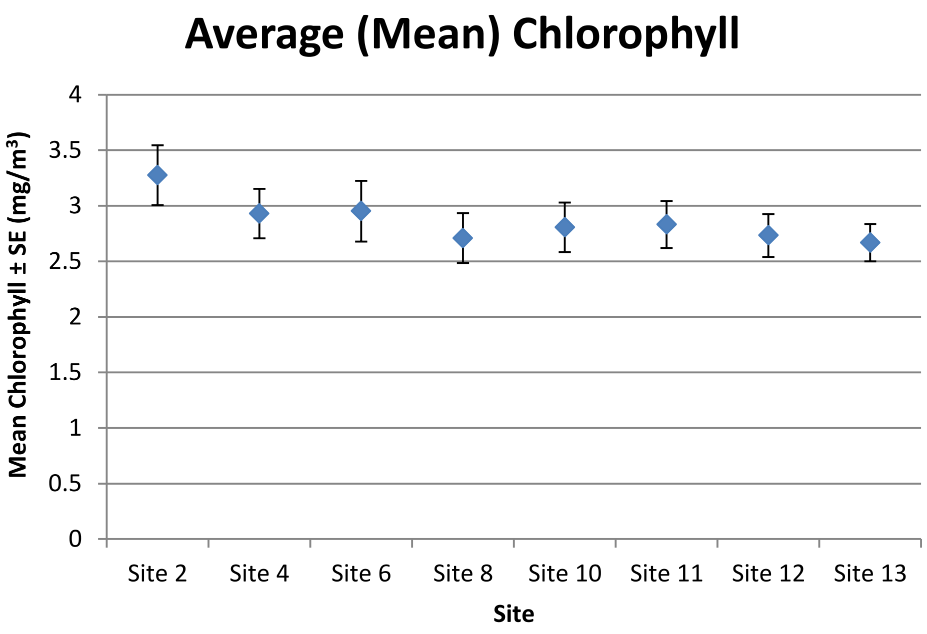

Figure 31: Average (mean ± standard error) Chlorophyll *a* concentrations at the eight EPA sampling sites within the upper basin of Lough Corrib.

6.1.11 Nitrogen

Nitrogen (N), 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. 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).

There are specific health implications regarding high nitrate and nitrite levels in drinking water. Methemoglobinemia, or blue baby syndrome, is a condition found especially in infants under 6 months and is a result of the infant's blood not carrying as much oxygen as it should be able to. This is caused by nitrates being converted by bacteria in the baby's stomach to nitrites which are then absorbed into the blood where it is converted to methemoglobin. This methemoglobin does not carry oxygen as efficiently as the usual haemoglobin. Severe cases can result in brain injury and death. Pregnant women and adults with reduced stomach acidity are also susceptible to nitrite-induced methemoglobinemia. 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 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.

Nitrate and Nitrite

Nitrite was monitored between January 2010 and June 2018, and concentrations were frequently below the limit of detection at all eight EPA sampling sites (represented in Figure 32 as zero values). The maximum nitrate concentration recorded was 0.017 mg/L as N at Site 6 in October 2015. Site 6 observed the highest mean Nitrite concentrations of all the EPA sampling sites (Figure 33).

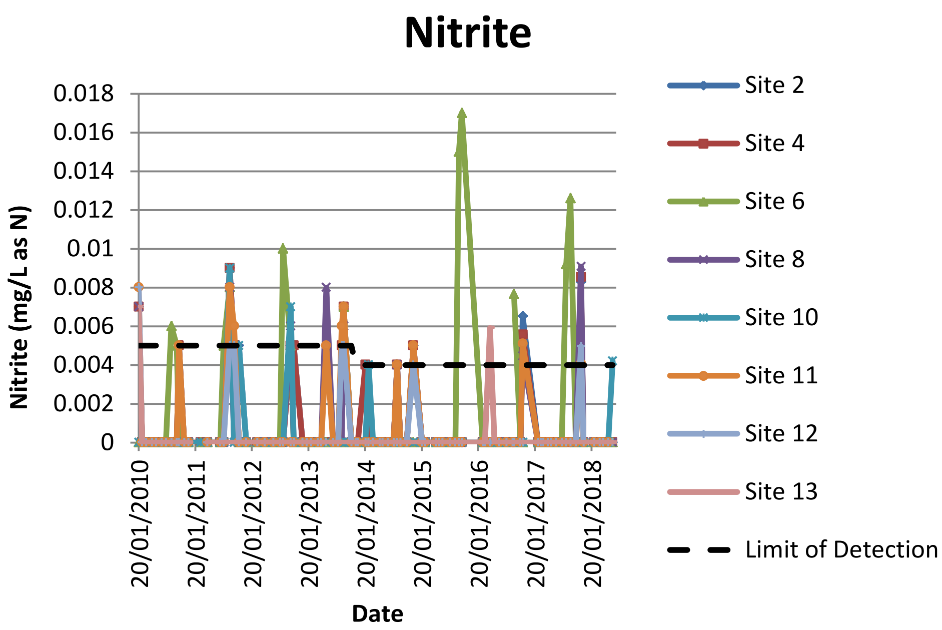

Figure 32: Nitrite concentrations at eight EPA sampling locations in the upper basin of Lough Corrib.

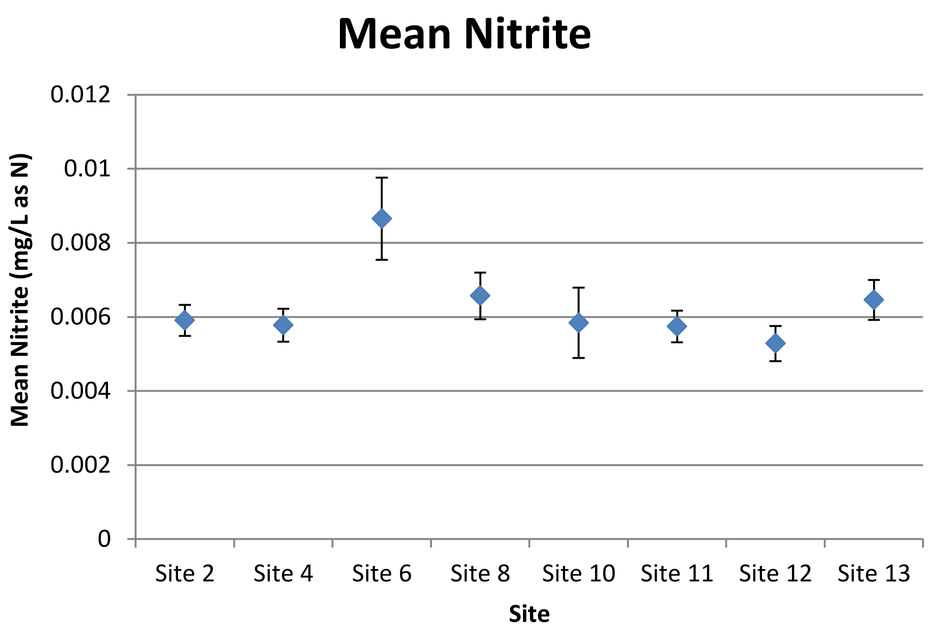

Figure 33: Average (mean ± standard error) Nitrite concentrations at eight EPA sampling locations in the upper basin of Lough Corrib.

Nitrate was monitored at seven of the eight EPA sampling sites in the upper basin of Lough Corrib from February 2016 to June 2018 (nitrate was not monitored at Site 10). Nitrate concentrations were often below the limit of detection at multiple sites (represented in Figure 34 as zero values).The maximum nitrate concentration recorded was 0.86 mg/L as N at Site 6 in February 2016. Mean nitrate concentrations were lowest at Sites 2, 12 and 13 and highest at Sites 4 and 8.

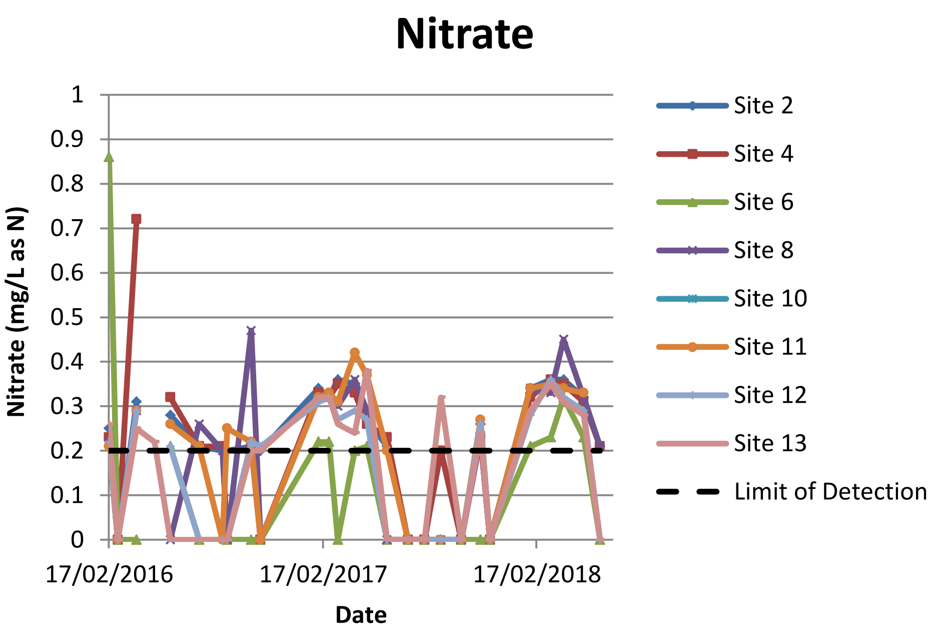

Figure 34: Nitrate concentrations at eight EPA sampling locations in the upper basin of Lough Corrib

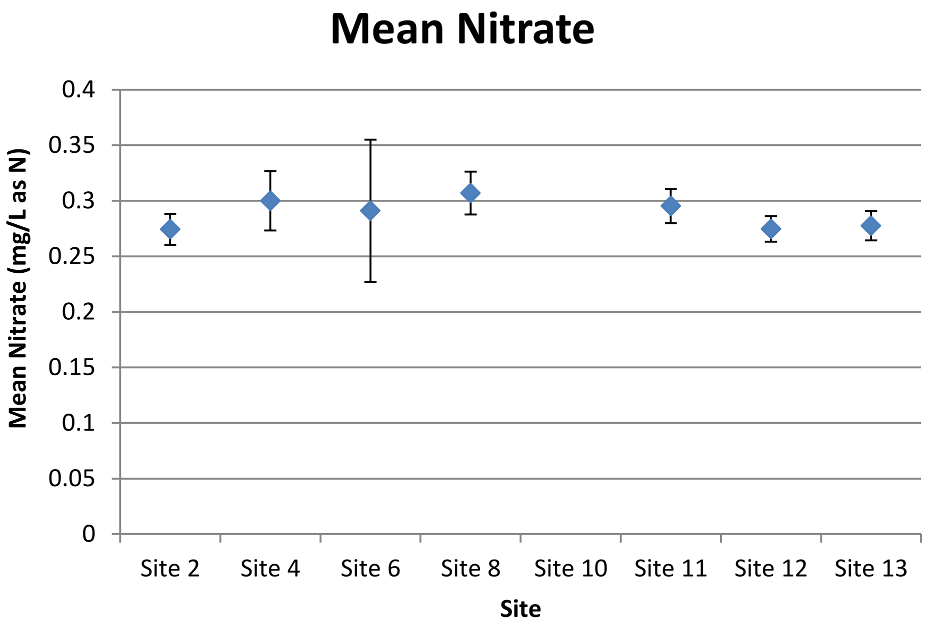

Figure 35: Average (mean ± standard error) Nitrite concentrations at eight EPA sampling locations in the upper basin of Lough Corrib

Total Oxidised Nitrogen (nitrate and nitrite combined) concentrations ranged from being below the limit of detection on a number of occasions (represented in Figure 36 as zero values) to a maximum of 1.8 mg/L recorded at Site 2 in February 2015. TON concentrations were often highest during winter and spring months. Mean TON concentrations were similar across most of the sampling sites, although concentrations were lowest at Site 6 (Figure 37).

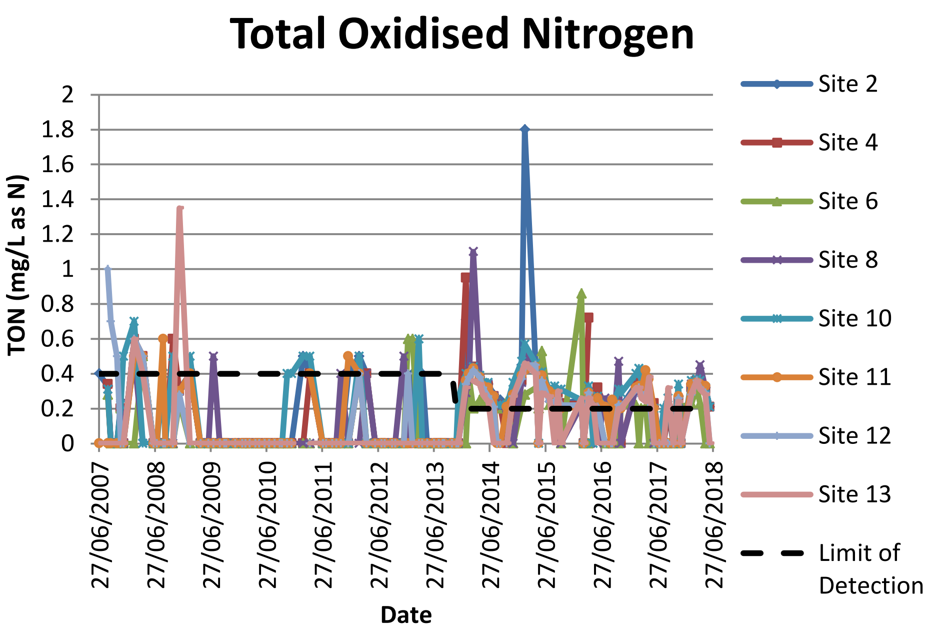

Figure 36: Total Oxidised Nitrogen concentrations across eight EPA sampling sites in the upper basin of Lough Corrib.

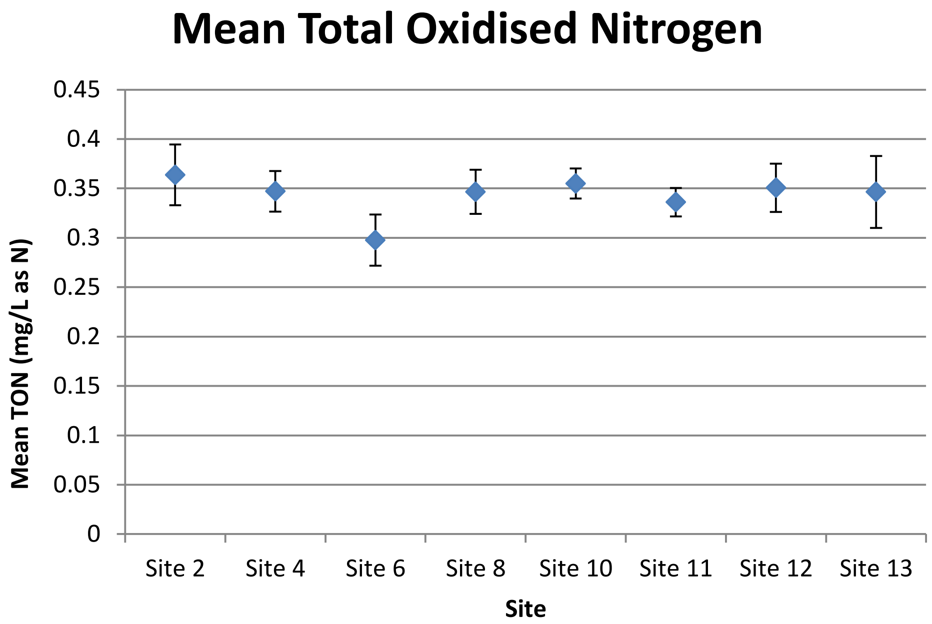

Figure 37: Average (mean ± standard error) Total Oxidised Nitrogen concentrations at each of eight EPA sampling sites in the upper basin of Lough Corrib.

Total Ammonia

Total Ammonia was monitored at each of the eight EPA sampling sites in the upper Lough Corrib basin (Figure 38). Values ranged from being below the limit of detection on multiple occasions (represented as zero values in Figure 38) to a maximum of 0.12 mg/L recorded at Site 8 in March 2017. Generally, Total Ammonia values were highest during autumn and winter months. Mean Total Ammonia concentrations varied between sites, with Sites 4 and 11 having the highest mean concentrations; and Sites 10, 12 and 13 having the lowest mean concentrations (Figure 39). Using the data for all of the sampling sites combined, the overall mean Total Ammonia concentration of 0.032 mg/L as N places the upper basin of Lough Corrib within the High status with regards to Total Ammonia under the Surface Water Regulations (2009).

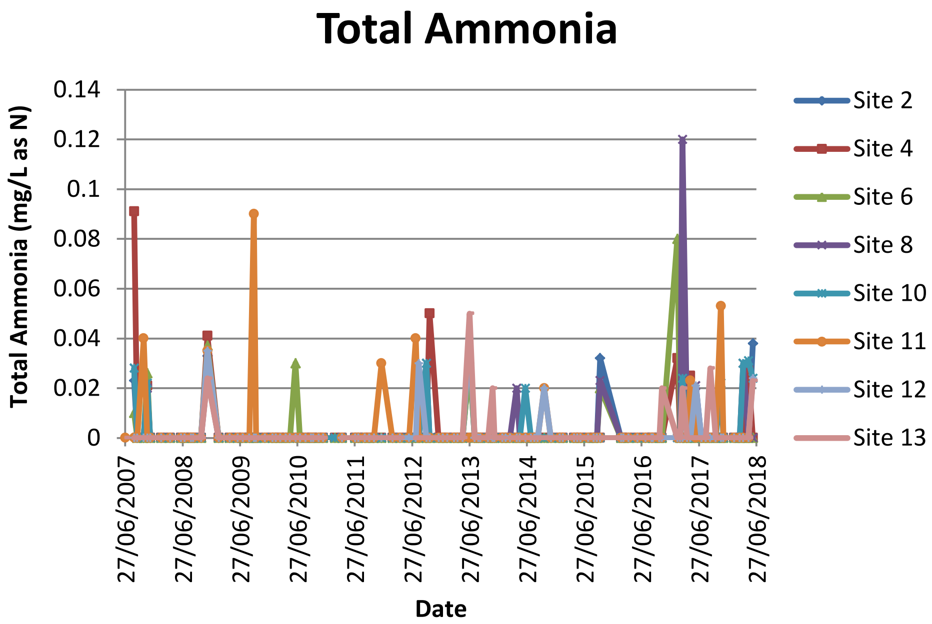

Figure 38: Total Ammonia concentrations at each of eight EPA sampling sites in the upper basin of Lough Corrib.

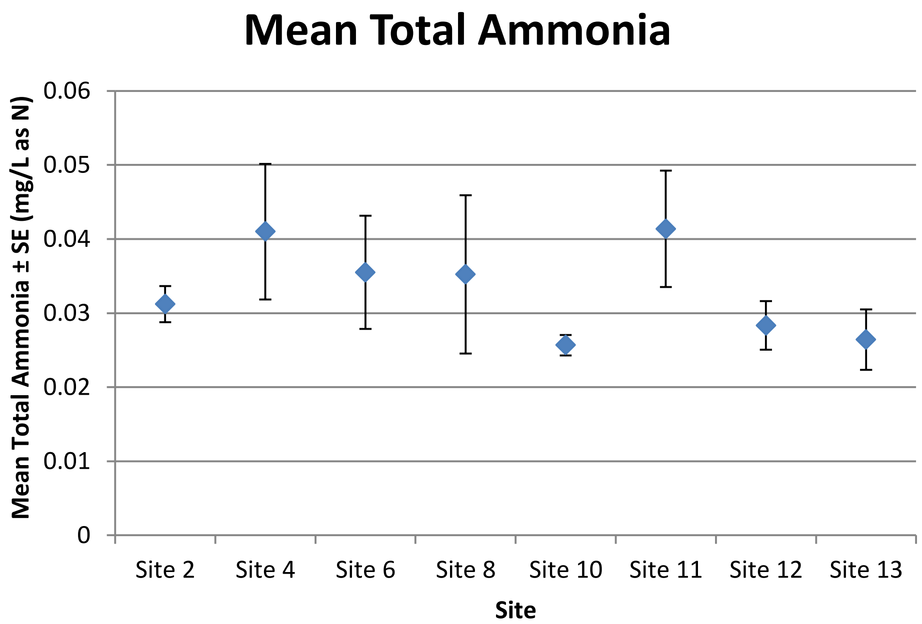

Figure 39: Average (mean ± standard error) Total Ammonia concentrations at each of eight EPA sampling sites in the upper basin of Lough Corrib.

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 was monitored at the eight EPA sampling sites within the upper basin of Lough Corrib (Figure 40). Conductivity values ranged from a minimum of 157 µS/cm at Site 6 in October 2011 to a maximum of 513 µS/cm recorded at Site 12 in August 2007. Average Conductivity values were similar across most sites, except for Site 6 which was lower than all other sites (Figure 41). Conductivity values were well below the Surface Water Regulations (1989) parametric limit for Class A1 waters.

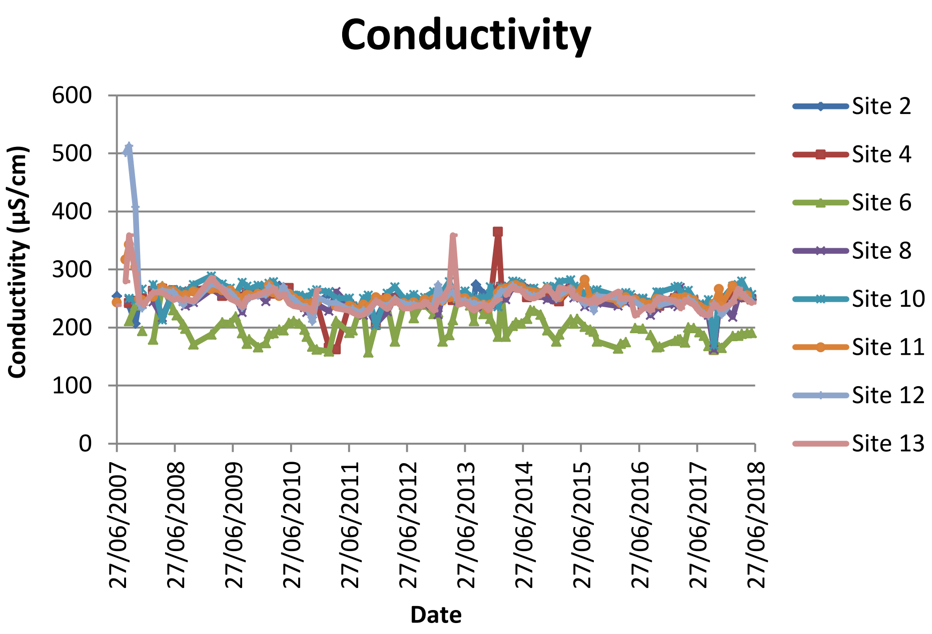

Figure 40: Conductivity at the eight EPA sampling sites within the upper basin of Lough Corrib.

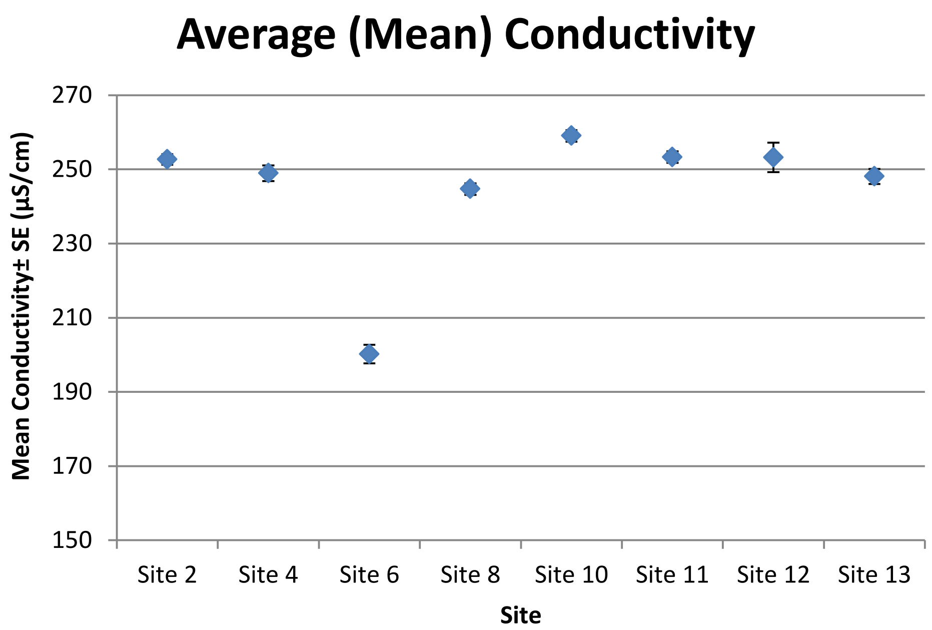

Figure 41: Average (mean ± standard error) Conductivity at the eight EPA sampling sites within the upper basin of Lough Corrib.

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 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.

Both DO saturation and DO concentration were monitored at each of the eight EPA sampling sites (Figure 42 and Figure 43). Dissolved Oxygen Saturation ranged from a minimum of 82 % at Site 2 in January 2010 to a maximum of 132 % recorded at Site 13 in June 2013 (Figure 43). Supersaturated DO conditions were frequently observed in summer months across all sampling sites, identifying likely frequent algal blooms occurring across the upper basin of Lough Corrib. The seasonality of Dissolved Oxygen Concentrations is clearly shown in Figure 43. Values for both Dissolved Oxygen Saturation and Concentration were similar for each site. The average (mean) values showed similar patterns for both DO Saturation and Concentration. Values were similar across Sites 2, 4, 6 and 8. Values were lowest at Site 10 and highest at Sites 11, 12 and 13 (Figure 44 and Figure 45).

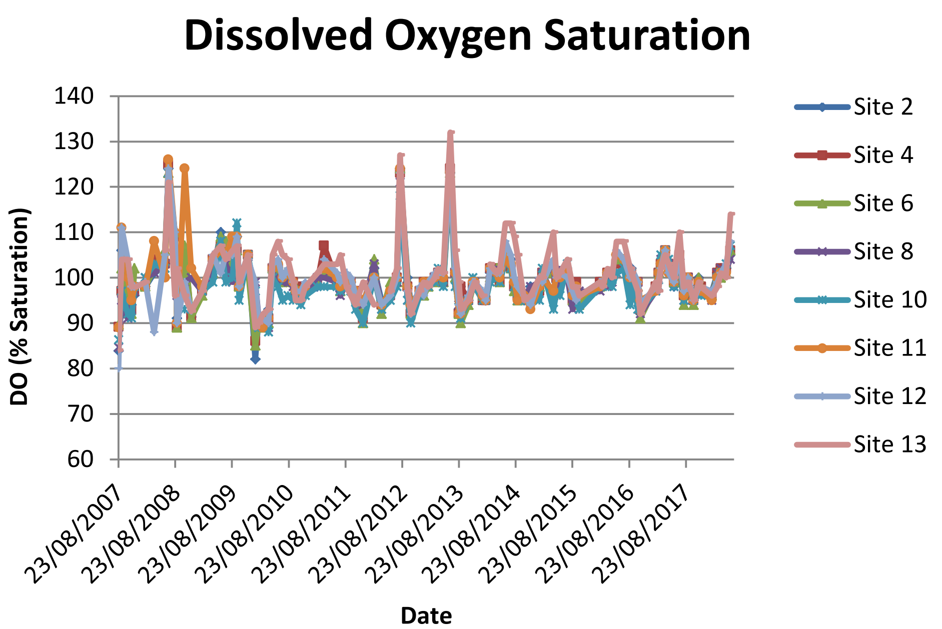

Figure 42: Dissolved Oxygen Saturation at each of the eight EPA sampling sites in the upper basin of Lough Corrib.

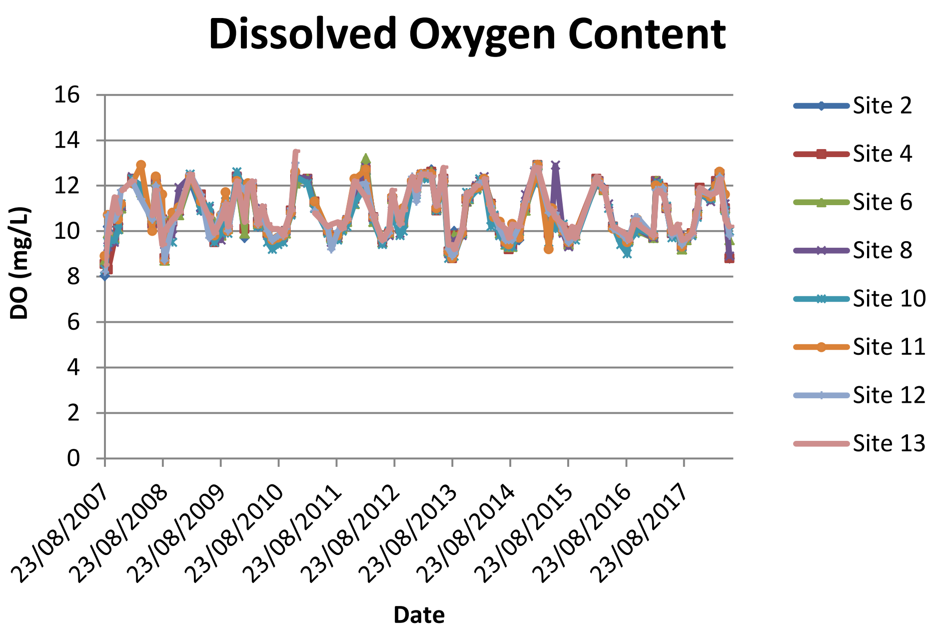

Figure 43: Dissolved Oxygen Concentration at each of the eight EPA sampling sites in the upper basin of Lough Corrib.

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) require the value for BOD in Class A1 waters to be below 5mg/L O_2.

Biological Oxygen Demand has not been monitored in the upper basin of Lough Corrib.

6.1.15 Coliforms

Faecal coliforms such as *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 100 ml, or 1,000 faecal coliforms per 100 ml. Following treatment, the Drinking Water Regulations (2007) state that Total coliforms values above 0 numbers per 100ml are unacceptable.

***Escherichia coli* (*E. coli*)**

Escherichia coli bacteria are present in high numbers in human and animal (including bird) faeces. They are generally not found in waters in the absence of faecal pollution, however, it would be rare to find surface waters that do not contain faecal coliforms. Groundwater's are significantly less susceptible to faecal coliform contamination than surface waters, and frequently do not contain bacteria.

E. coli has not been monitored in the upper basin of Lough Corrib. On no occasion was *E. coli* found to be present in any treated water sample data provided by Mayo County Council.

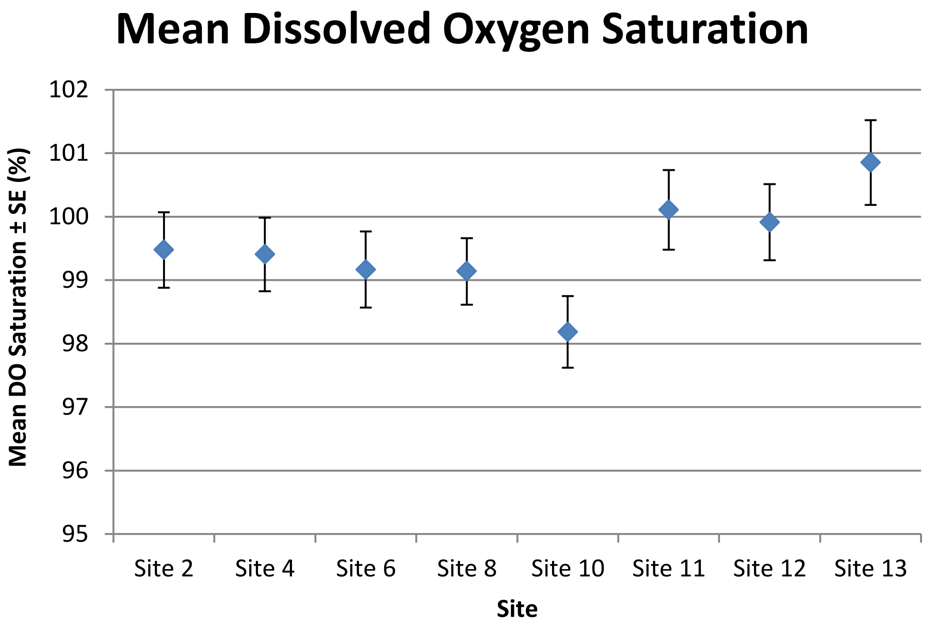

Figure 44: Average (mean ± standard error) Dissolved Oxygen Saturation at the eight EPA sampling sites in the upper basin of Lough Corrib.

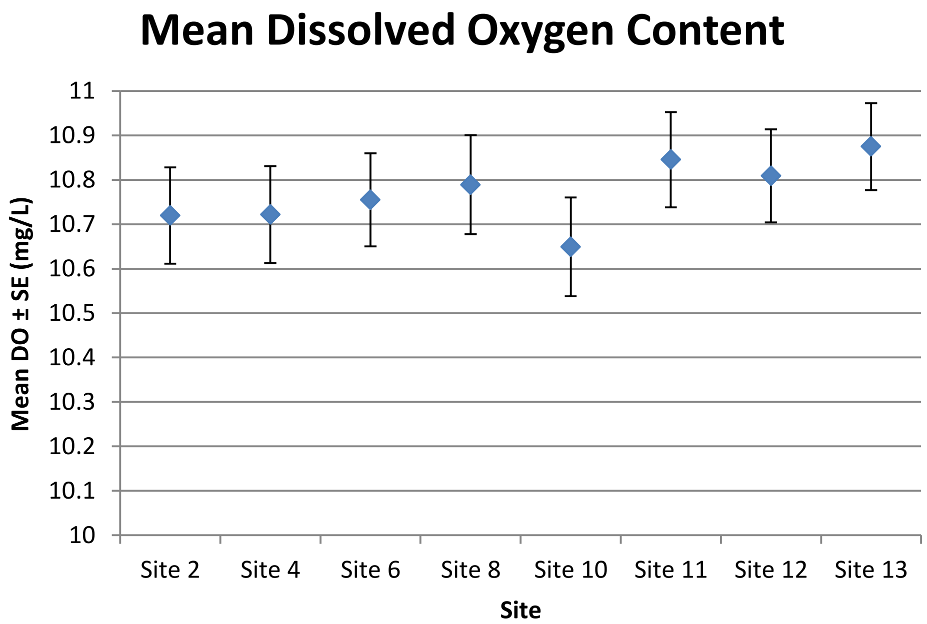

Figure 45: Average (mean ± standard error) Dissolved Oxygen Concentration at the eight EPA sampling sites in the upper basin of Lough Corrib.

Clostridium perfringens

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

C. perfringens has not been monitored in the upper basin of Lough Corrib.

On no occasion was *C. perfringens* found to be present in any treated water sample data provided by Mayo County Council.

Total Coliforms

Total Coliforms have not been monitored in the upper basin of Lough Corrib.

On no occasions were Total Coliforms found to be present in any treated water sample data provided by Mayo County Council.

6.2 EPA River and Stream Water Quality Monitoring

EPA river and stream water quality monitoring has been presented above for a number of parameters. A brief description of Q-values assessed by the EPA has is provided below.

6.2.1 Biological data

Q values

Clabby *et al.* (2006) stated 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 little macroinvertebrate diversity (with communities dominated by tolerant species) and poor water quality.

Macroinvertebrates have been monitored at 87 locations within the Lough Corrib catchment (Figure 46). For 61 of these locations, the Q value was determined to be High or Good. Twenty locations were classified as being of Moderate status; and 6 as Poor status. For the locations on rivers flowing into the upper basin of Lough Corrib, The majority were classified as High or Good status, with only one location classified as Moderate status.

No EPA Q monitoring locations are present within the Glencorrib GWS sub-catchment.

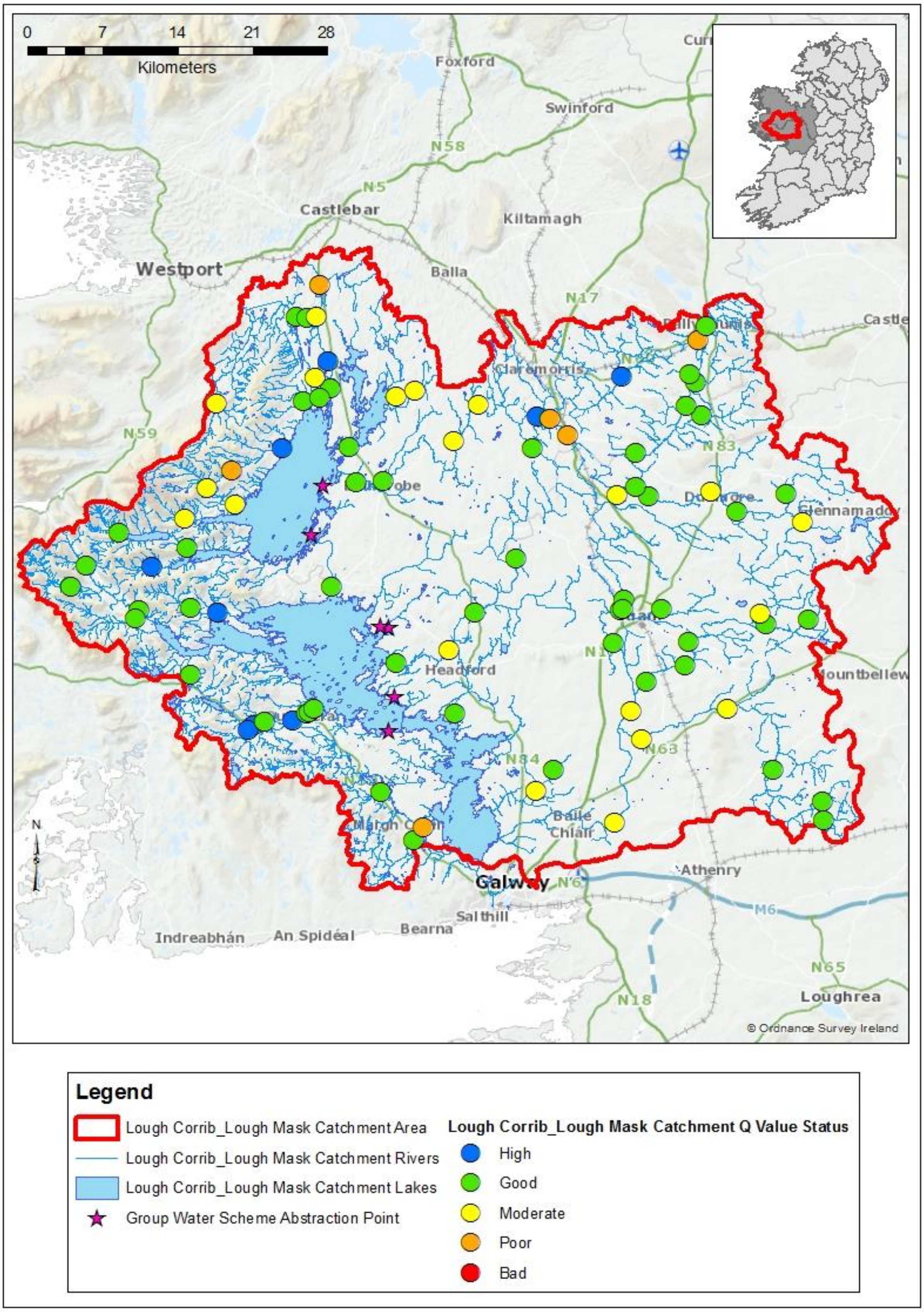

Figure 46: EPA Q monitoring stations within the Lough Corrib catchment.

6.2.2 WFD Status

Through monitoring actions undertaken throughout Ireland as part of the EU Water Framework Directive, all of Ireland's water bodies can be classified in terms of their ecological status. The website www.catchments.ie provides visual maps and data on river and stream water quality throughout Ireland via an interactive GIS viewer. Using this tool, it is possible to examine the current water body status for all rivers and streams within the Lough Corrib catchment, and the risk of these water bodies not achieving good ecological status. In addition, this data can be downloaded for use in GIS programmes from http://gis.epa.ie/.

The most recent ecological status of all monitored water bodies within the Lough Corrib catchment is shown in Figure 47. The water bodies entering the upper basin of Lough Corrib are classified as either having Good status, or are currently unassigned. The upper basin of Lough Corrib itself is classified as being of Good status. In comparison, the lower basin of Lough Corrib is classified as being of Moderate status. The status of the stream within the Glencorrib GWS sub-catchment is currently unassigned.

Part of the WFD assessments are to ascertain the risk of the water quality of water bodies deteriorating or achieving less than Good status in the future. These risk maps can be viewed on http://gis.epa.ie/ and a screen grab of such a map for the Lough Corrib region is shown in Figure 48. The upper basin of Lough Corrib is currently under review for its risk, while the lower basin is designated as being at risk. Most of the water bodies flowing in to the upper basin are designated as being not at risk, however there is one river, the Owenriff, which flows through Oughterard and enters the western region of the upper basin, which has been designated as being at risk.

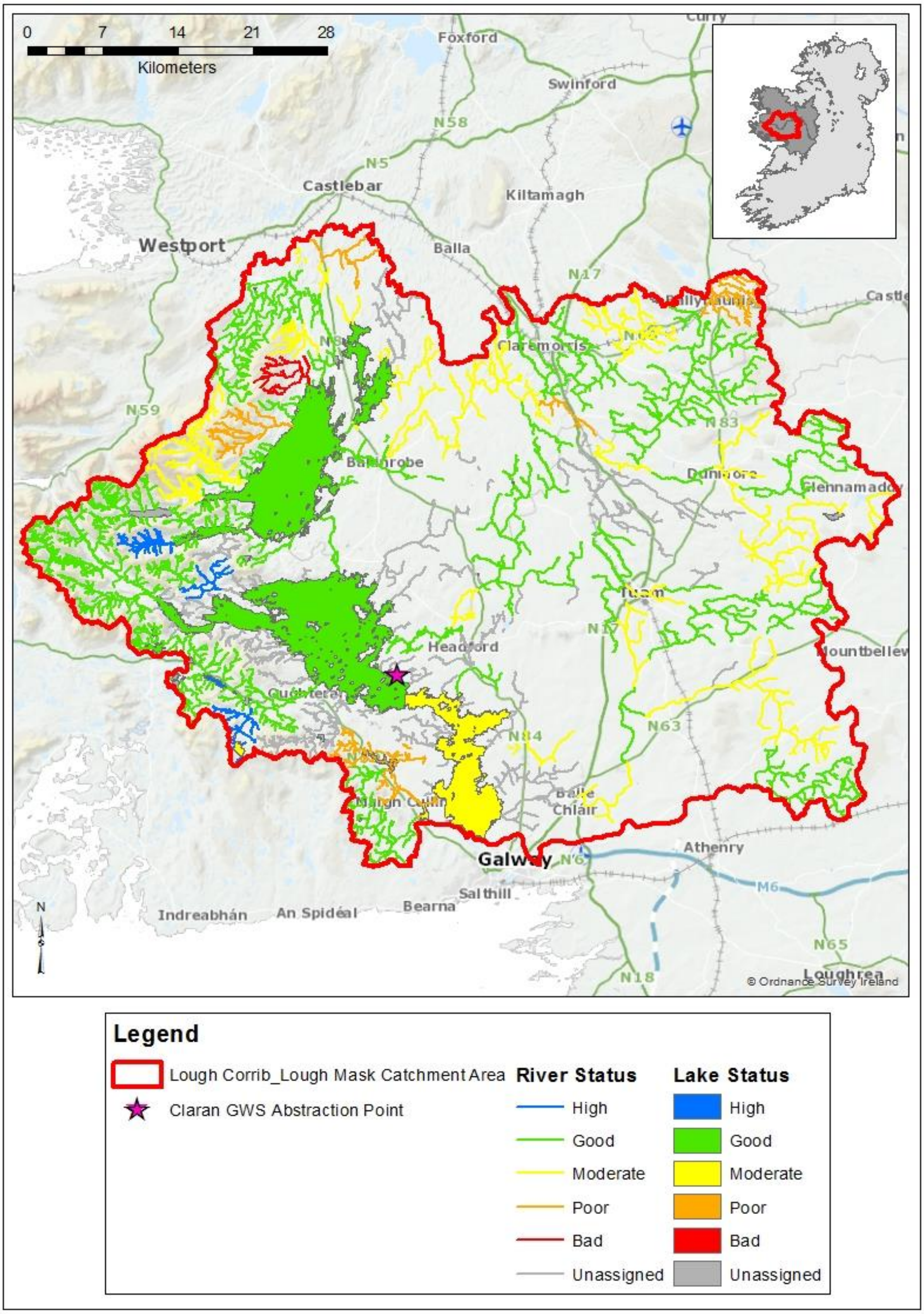

Figure 47: Ecological status of waterbodies within the Lough Corrib catchment (data available from http://gis.epa.ie/).

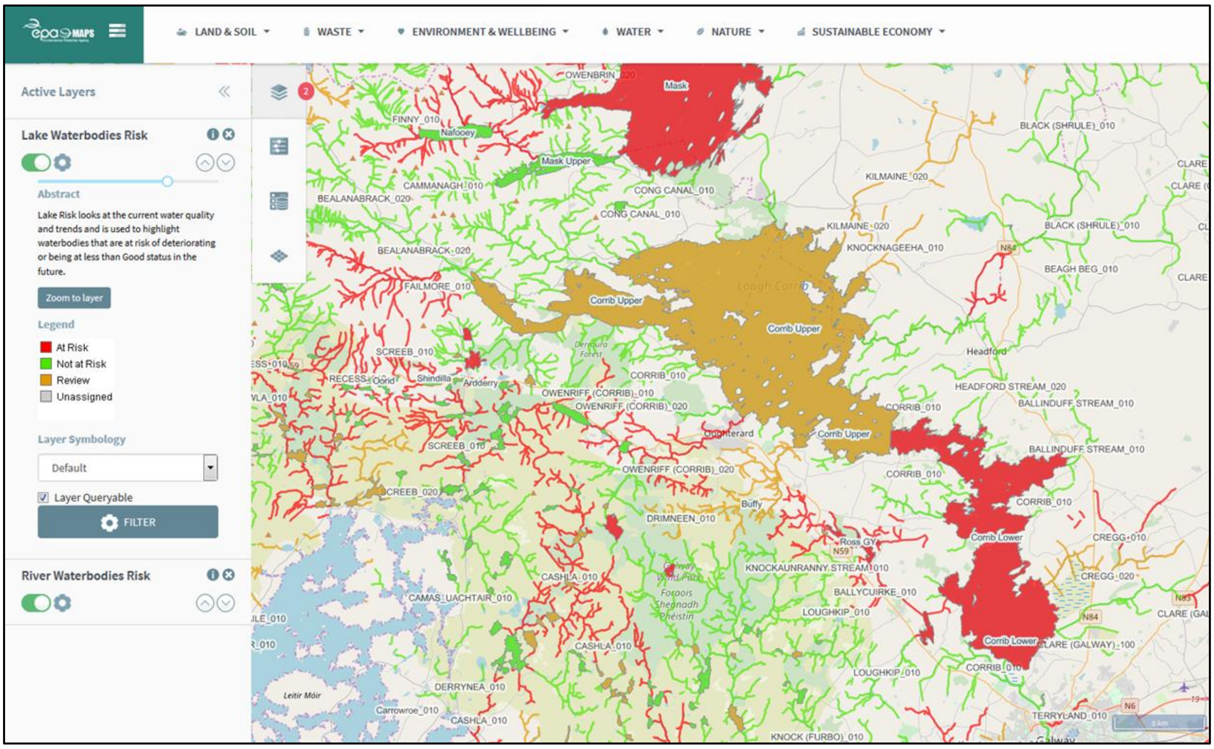

Figure 48: Water body risk of not achieving Good status. Screen grab from http://gis.epa.ie/

6.3 Overall Interpretation of Water Quality

The raw water quality data analysed throughout this report has been provided by the EPA from eight sampling sites throughout the upper basin of Lough Corrib. EPA sampling site 2 is the site closest to Glencorrib GWS abstraction point. Data provided by Mayo County Council for reporting treated drinking water quality has been used to assess certain parameters from 2014 onwards.

True colour values in the upper basin of Lough Corrib were often high, with the Surface Water Regulations (1989) parametric value for Class A1 waters being exceeded frequently. Dissolved Organic Carbon levels were shown to be occasionally high, but there is limited data available throughout the upper basin of Lough Corrib. As discussed in this report, high values of True Colour are not harmful in themselves, however they can be indicative of high DOC levels and subsequently during the treatment process, chlorine reacts with DOC to form Trihalomethanes (THMs). The higher the DOC levels and the higher the chlorine disinfection concentrations as well as the longer the residence time in storage reservoirs, the greater the likelihood of THMs forming. In the treated water supply, Trihalomethanes did not exceed the Drinking Water Regulations (2014) parametric value on any occasion. THM concentrations in drinking water are typically highest between late summer and early winter when the possibility of THM formation is likely to be greatest due to often higher levels of DOC in the raw water. Yet, all of the THM monitoring was undertaken outside of this time period and therefore it is possible that the Drinking Water Regulations (2014) were exceeded, given the high (but not excessive) THM concentrations present on occasion.

The pH values recorded across all sampling locations reflect the limestone nature of much of the underlying bedrock within the Lough Corrib catchment. This is also highlighted in the high alkalinity of the water. It is therefore likely that this hard water may impact on consumer appliances such as kettles and washing machines.

Total Phosphorus concentrations were observed to be occasionally high at a number of EPA sampling sites and have the potential to contribute to algal blooms within the upper basin of Lough Corrib. In addition, Total Oxidised Nitrogen concentrations are also high enough to support algal blooms. However, in general, nutrient levels throughout the upper basin of Lough Corrib are not excessive and this is highlighted by the relative infrequent algal blooms suggested by the Chlorophyll *a* and Dissolved Oxygen data.

During the site visit to Glencorrib GWS undertaken as part of this report, a number of head of cattle were observed freely accessing the water within 30 m of the Glencorrib GWS abstraction point (Figure 49). Given this livestock access so close to the abstraction point, combined with the potential for animal wastes to be spread on the land locally, the nearby location of a large slatted shed, and the potential for domestic waste water treatment systems within the Glencorrib sub-catchment to contaminate surface waters and groundwaters, microbial assessment of the raw water is required. This is likely undertaken through the Glencorrib GWS Monthly Status Reports provided by the GWS DBO contractor, but this data has not been made available for this report.

Figure 49: Cattle able to freely access Lough Corrib within 30m of the Glencorrib GWS abstraction point as observed during the site visit undertaken for this report.

The water bodies flowing in to the upper basin of Lough Corrib have generally been classified as being not at risk of deteriorating or achieving Good status in the future. However, the Owenriff river has been classified as being at risk, and the risk designation for the upper basin of Lough Corrib itself is currently under review. Therefore, there is potential for the water quality of the raw water abstracted by Glencorrib GWS to deteriorate into the future. This may be accentuated by the karstic limestone geology which underlies much of the east of the Lough Corrib catchment and indeed the Glencorrib GWS sub-catchment. The karstic geology means that there is reduced natural remediation of contaminants which can swiftly enter both surface waters and groundwaters which flow towards the Glencorrib GWS abstraction point.

Given the size of the wider Lough Corrib catchment, there are limited source protection measures that can be put in place without long-term integrated catchment management between a wide number of stakeholders. As Lough Corrib is of significant environmental importance as an SAC and SPA, as well as being a source of drinking water, such integrated, collaborative management will be essential to improve the water quality of the lake into the future.

Subsequently, the recommendations made in Section 7.0 are mindful of the wider, larger catchment-scale issues, but are focussed on the smaller geographical unit of the Glencorrib GWS sub-catchment that is shown in Figure 3. By focussing at this smaller geographical scale upon issues that are likely to be immediately affecting the water quality of the northern basin of Lough Corrib and the embayment from which Glencorrib GWS abstract their water, there are actions that can be undertaken that are more achievable and are likely to result in localised improvements in water quality rather than attempting to address the much larger catchment-scale issues that require significant resource investment.

7.0 Summary of key points

Following the assessment of physical components of the Lough Corrib catchment and the water quality of the upper basin of Lough Corrib, the following key points are made to highlight source protection and maintain high quality raw water supplies for the GWS.

Putting 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 Glencorrib GWS meetings (AGM, Committee meetings, etc.). This will ensure that important issues within the catchment/sub-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 Glencorrib GWS should encourage committee members and people with connections to the scheme to report potential pollution issues, particularly within the Glencorrib GWS sub-catchment. 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 or the EPA as required.

Developing a protocol for dealing with offenders
The committee should agree a protocol for dealing with potential pollution/contamination incidences. From the moment the staff receive knowledge of an incident, there should be a procedure in place to direct an appropriate response . 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.

Ensuring Trihalomethanes are monitored in late summer through to early winter
Concentrations of Trihalomethanes in treated water are typically highest during the period of late summer through to early winter, when concentrations are usually at their highest. For Glencorrib GWS, the Drinking Water Regulations (2014) parametric value for THMs was not exceeded but concentrations were occasionally high despite THM monitoring being undertaken outside of the late summer to early winter period. Therefore Glencorrib GWS should ensure that THMs are monitored on at least a monthly basis between the months of July and November in addition to periodically (e.g. once every two months) during the remainder of the year.

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.

Engaging the Geological Survey of Ireland.
The karstic nature of the underlying geology within the Glencorrib GWS sub-catchment identifies that there is significant potential for contaminants to be delivered to the Glencorrib GWS abstraction point via groundwater pathways that do not align with the surface water sub-catchment that has been delineated in this report. Therefore, to fully understand the potential contribution of groundwater to the GWS abstraction point, it is recommended that the GWS engage both the NFGWS and the Geological Survey of Ireland to discuss the potential for assessing the zone of contribution of groundwater to the abstraction point.

Agriculture and farmyard management
Given the high and extreme vulnerability of groundwater to pollution by nutrient and bacterial contaminants within the Glencorrib GWS sub-catchment (and potentially beyond, depending on groundwater pathways which are as-yet unknown), there is strong potential for swift delivery of contaminants to the Glencorrib GWS abstraction point by both surface water and groundwater pathways.

The primary sources of nutrient enrichment and microbial contamination of freshwater systems are diffuse agricultural pollution and point source pollution (such as 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 the embayment from which Glencorrib GWS abstracts its raw water can lead to potential contamination issues with regard to nutrient input and faecal coliforms. While a survey of fencing and livestock access was not undertaken as part of this report, livestock were observed directly accessing the embayment within 30m of the abstraction intake. Although it may not be feasible to fence all boundaries to water bodies within the Glencorrib GWS sub-catchment, limiting livestock access to water bodies, particularly close to the abstraction intake, could significantly reduce potential faecal contamination of the GWS water source and remove a potential source of direct nutrient input.

(b) Nutrient management
Given the dominance of pasture in the Glencorrib GWS sub-catchment, there are significant aspects of agricultural and farmyard management that have the potential to cause issues within the raw water supply. Some general recommendations are made below:

(a) Make scheme members 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 2017).

Some important points are listed below, including those relevant for karstified areas such as those present within the Glencorrib GWS sub-catchment:

- No chemical fertiliser applied within 2 m of surface waters;
- No organic fertiliser/soiled water spread within 20 m 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 200 m of the abstraction point (surface water, borehole, spring or well).
- For abstractions >10 m^3/d or >50 people, no spreading within 100 m of abstraction point (as above).
- No spreading organic fertilizer/manure within 15 m of exposed Cavernous or Karstified limestone features (such as swallow holes and collapse features).

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 meet with farmers to remind them of their legal obligations and the benefits to the scheme of complying within this code of good agricultural practice.

(b) Some areas within the Glencorrib GWS sub-catchment, have the potential to be spread with slurry or manure. Therefore soil nutrient analysis and nutrient management planning is required.

- Farmers should only apply organic and inorganic fertiliser on lands for which nutrient management plans have been completed;
- Nutrient management plans should be completed ever 4-5 years for all farms;
- Field slope should be considered when generating nutrient management places, not just soil nutrient status;
- Issues relating to soil nutrient status should be communicated with farmers both orally and in writing.

The Department of Agriculture, Food and the Marine (DAFM) have identified a ten-year vision for growth of their Irish agricultural economy for the period 2015-2025 through Food Wise 2025. Food Wise 2025 recognises that increasing production to achieve the above goals will create challenges in simultaneously meeting international environmental targets for air quality, biodiversity and water quality. It is important for Glencorrib GWS to consider that within the Glencorrib GWS sub-catchment (and within the as yet unidentified groundwater zone of contribution), an increase in agricultural production has the potential to impact on the quality of the raw water supply, depending on the scale of productivity increase, nutrient management, waste management and livestock access to water sources.

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). The majority of dwellings within the Glencorrib GWS sub-catchment are situated within areas of High or Extreme ground water vulnerability. Therefore, good OSWTS management is vital within the sub-catchment in order to reduce the potential for nutrient, faecal and other contaminants entering surface and groundwater 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/.

Glencorrib GWS should meet with residents within the sub-catchment and provide them 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 desludged 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 this is due to poor drainage then expert advice should be sought by contacting Mayo County Council.

The NFGWS, in collaboration with the EPA, recently completed a successful pilot project which encouraged community-scale desludging of wastewater treatment systems. By encouraging groups of residents to act together, price reductions for desludging were obtained. Glencorrib GWS should consider engaging with the NFGWS to discuss the successful process for such community-scale management of wastewater treatment systems within the sub-catchment.

Engage with Funshinna Cross GWS

Funshinna Cross Group Water Scheme also abstracts raw water from Ballynally Bay. Therefore, they share the same sub-catchment as Glencorrib GWS and sub-catchment-scale recommendations made in this report are applicable to both Funshinna Cross GWS and Glencorrib GWS. Subsequently, any implementation of sub-catchment-scale management actions, or engagement of local communities could be undertaken in partnership to reduce potential duplication of actions.

Wider catchment-scale issues.

As a result of Water Framework Directive monitoring, the upper basin of Lough Corrib has been classified as being of Good overall status, but its risk of deteriorating from this status is currently under review. The catchment area of Lough Corrib is very large and therefore any actions aimed at improving water quality at the wider Lough Corrib catchment scale requires an integrated approach involving multiple stakeholders. In addition, a number of GWS abstract their raw water from Lough Corrib, Lough Mask and Lough Carra. Consideration should be given by all such GWS to collectively engage Galway and Mayo County Councils to discuss larger scale catchment management actions that can be undertaken to improve raw water quality across the catchment, providing benefits for all GWS present within the Lough Corrib catchment.

7.1 Further Work

A number of issues have been identified within the wider Lough Corrib catchment and the Glencorrib GWS sub-catchment. Subsequent to the summary of key points made in Section 7.0, the following further work is advised.

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 Glencorrib GWS sub-catchment and the wider Lough Corrib 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. Modify Trihalomethane sampling

THM monitoring frequently took place outside of the period when Dissolved Organic Carbon values are typically highest (and subsequently the probability of THM formation is greatest). Glencorrib GWS should ensure that THM monitoring is undertaken on at least a monthly basis between July and November, and periodically (e.g. every two months) for the remainder of the year.

3. Engage the National Federation of Group Water Schemes and Geological Survey of Ireland

The karstic nature of the underlying geology of the Glencorrib GWS sub-catchment indicates strong potential for groundwater influencing the water quality of Lough Corrib and for contaminants to swiftly enter the groundwater. The geographical area from which groundwater may be delivered to the Glencorrib GWS abstraction point is likely to be different to that of the surface water catchment delineated in this report. Therefore, Glencorrib GWS should engage both the National Federation of Group Water Schemes and the Geological Survey of Ireland to attempt to fully understand the potential contribution of groundwater to the GWS abstraction point.

4. Engage with Glencorrib sub-catchment residents with regard to on-site waste water treatment system (septic tank) maintenance

Residents within the Glencorrib GWS sub-catchment should be engaged to ensure septic tanks are maintained and serviced regularly in order to reduce the potential for nutrient, microbiological and other contaminants entering surface water and groundwater bodies.

Following engagement with the Geological Survey of Ireland (see above), any septic tanks located outside of the Glencorrib GWS sub-catchment delineated in this report, but within any delineated groundwater zone of contribution, should also be maintained and serviced regularly.

The NFGWS has recently completed a pilot septic tank engagement project in collaboration with the EPA, and Glencorrib GWS should contact the NFGWS to discuss septic tank management and engagement mechanisms.

5. Fencing land with livestock access to local water bodies

Restricting direct livestock access to the embayment from which Glencorrib GWS abstracts its raw water will assist in reducing potential nutrient and faecal contamination of the raw water source.

This action, in combination with improving septic tank maintenance, will help to improve water quality for the GWS and potentially reduce treatment costs in the longer term. Engagement with local landowners will be necessary, and Glencorrib GWS could consider:

- Sharing the costs of any fencing installed close to the abstraction point
- The provision of water for livestock that have been restricted from accessing water through fencing.

6. Initiate a communications drive

Glencorrib GWS should consider undertaking a communications initiative to remind scheme members and residents within the GWS sub-catchment 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. The picturesque location of the treatment works 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 GWS and the source protection measures required to help improve the environmental status of the sub-catchment area whilst also providing cost-savings in the water treatment process.

7. Engage Funshinna Cross GWS

Funshinna Cross Group Water Scheme also abstracts raw water from Ballynally Bay. Therefore, they share the same sub-catchment as Glencorrib GWS and sub-catchment-scale recommendations made in this report are applicable to both Funshinna Cross GWS and Glencorrib GWS. Subsequently, any implementation of sub-catchment-scale management actions, or engagement of local communities could be undertaken in partnership to reduce potential duplication of actions.

8. Engage Mayo County Council regarding wider catchment-scale issues

Larger scale water quality issues within the wider Lough Corrib catchment can only be addressed through an integrated approach to catchment management. As a number of Group Water Schemes abstract from Lough Corrib, Lough Mask and Lough Carra, consideration should be given to collectively engaging Galway and Mayo County Councils with the aim at assisting in management actions for improving the water quality within the wider Lough Corrib catchment, providing benefits for all GWS within the catchment as well as local communities.

8.0 References

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