# Preliminary Report on Source Protection

## Kilmovee Urlaur Group Water Scheme

## County Mayo

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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 Kilmovee Urlaur 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).

Kilmovee Urlaur Group Water Scheme (GWS) extracts its water from the east side of Urlaur Lough ($53^0$ 50’ 48”N, $8^0$ 44’13”W), located approximately 11 km south of Ballaghadeareen, Co Mayo. Urlaur Lough has two primary inflowing streams from Lough Nanoge and Lough Roe respectively and there is an additional inflowing stream located to the south west of the catchment. The only outflow from Urlaur Lough is located to the south east of the catchment, which flows into Lung River. Urlaur Lough, Lough Nanoge and Lough Roe are protected as a Special Area of Conservation (SAC) as examples of hard water lakes, a habitat listed on Annex I of the E.U. Habitats Directive. The Urlaur Lough SAC, contain a range of habitats and a diversity of plant species, as well as providing breeding and feeding grounds for a range of wildfowl species. The surface area of Urlaur Lough is 1.15 $km^2$; it is 3.1 km long from north to south, with an average width of 0.34 km. Urlaur Lough has a maximum depth of 11 m and a mean depth of 4 m. The catchment area of Urlaur Lough is 13.6 $km^2$ and the lake has an elevation of approximately 81 m. The lake is categorised as typology class 10 (as designated by the EPA for the Water Framework Directive), i.e. shallow (<4m), greater than 50 ha and high alkalinity (>100mg/l $CaCO_3$). Urlaur Lough was identified in the Shannon Upper Water Management Unit Action Plan as being of ‘good’ status in 2009. The EPA Water Framework Directive, Lake Waterbody status 2010-2015 classification for Urlaur Lough was ‘Bad’ and at risk of not achieving good status in the future.

The predominant land use in the catchment is agriculture with much of the catchment classified by CORINE land cover system as pasture and peat bogs. There are small areas of coniferous forests and transitional woodland scrub located in the south of the catchment. The bedrock underlying the catchment is made up of Boyle Sandstone Formation and two limestone formations, Kilbryan Limestone Formation and Oakport Limestone Formation. The aquifers present in the catchment are classified as a Locally Important Aquifer- Bedrock which is moderately productive only in local zones and Regionally Important Aquifer – karstified (conduit). Subsoils within the catchment are dominated by cutover raised peat, till derived from sandstones, till derived from limestone and gravel derived from Limestone. There are also veins of Esker comprised of gravel of basic reaction found in the centre of the catchment. Much of the soil in the Kilmovee Urlaur GWS catchment is cutover/cutaway peat and acid deep well/poorly drained mineral soils, with smaller areas of Basic shallow well/poorly drained mineral and Basic Deep well/poorly drained mineral located in the south and south west of the catchment respectively. The ground water vulnerability is a mixture of High, Moderate and Low vulnerability, with a very small area of Extreme and E vulnerability located to the south west Kilmovee Urlaur GWS catchment. This association of poorly draining soils and high groundwater vulnerability may contribute to the high risk of nutrients and bacteria contaminating surface waters within the catchment through either surface water or groundwater pathways. This means that care must be taken to ensure that domestic wastewater treatment systems located in the vicinity of the Kilmovee Urlaur GWS abstraction point are properly installed and maintained.

A range of water quality parameters have been monitored throughout the Kilmovee Urlaur GWS catchment by AECOM and more recently by Glan Agua (on behalf of the GWS), Mayo County Council and the EPA. Water colour exceeded the parametric value of the Surface Water Regulations (1989) for 95 % of sampling occasions. Water colour is likely to be influenced by levels of Total Organic Carbon.

Given the high values of colour present in the raw water throughout the GWS catchment, the likelihood of Trihalomethanes (THM, a bi-product of the chlorination treatment process) being produced during the treatment process is high. The Drinking Water Regulations (2014) parametric value of 100 THM µg/L has been exceeded in Kilmovee Urlaur GWS for 70 % of sampling occasions. This may cause a risk to the consumers of Kilmovee Urlaur GWS, particularly as THM monitoring is frequently undertaken outside periods when true colour is likely to be highest (from late summer through to early winter) and therefore the probability of the formation of THMs during the treatment process is likely to be greatest. THM samples are taken (from October 2005 until - February 2016) by Mayo County Council and reported in the annual EPA Drinking Water Reports.

Microbiological contamination (levels of Faecal and Total Coliforms) within the raw water supply is not reported by AECOM or Glan Agua. Microbiological contamination within the treated water supply measured at the tap by Mayo County Council indicate spikes in total coliforms on occasions, although the results from the MSR from AECOM and Glan Agua indicate that the microbial contamination is being successfully removed by standard treatment processes. The microbiological contamination in the treated water supply should not exceed the required limit of 0 under the Drinking Water Regulations (2014). The Kilmovee Urlaur GWS is pending an upgrade to a Dissolved Air Flotation (DAF) water treatment plant. At present there is no UV treatment undertaken by Kilmovee Urlaur GWS which can reduce the risk of *Cryptosporidium* contamination of the treated water. A *Cryptosporidium* risk assessment is recommended, given the predominantly Karstic landscape and the landuse in the catchment.

Diffuse pollution from agriculture, particularly as the majority of the catchment land cover is classified as pasture, is likely to be the primary source of nutrients entering the surface waters of the catchment, with contributions also likely from point sources such as domestic wastewater treatment systems.

During the initial site visit to Kilmovee Urlaur GWS in July 2016, a number of important issues were identified that, if addressed through engagement with Mayo County Council and Glan Agua the DBO contractor, could lead to an improvement in the raw and treated water quality for Kilmovee Urlaur GWS. A number of key issues that should be addressed are recommended in Section 7.0 in order to improve source protection and maintain high quality water supplies from the primary water sources. The most urgent recommendations 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 Kilmovee Urlaur GWS 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. Filling water quality monitoring gaps.**

In assessing the water quality monitoring data it is evident that Total Organic Carbon (TOC) (in the raw water) and THM (in the treated water) should be monitored simultaneously. Monitoring TOC gives an indication of the level of organic matter in the raw water supply that can react with chlorine during the treatment process to produce THM. It is recommended that THM and TOC monitoring is focused over the period from late summer through to early winter as this is when colour values are highest, with additional occasional THM and TOC monitoring undertaken simultaneously throughout the rest of the calendar year. The monitoring of THMs should occur on water after chlorination (the formation of THM occurs within the first ten hours post-chlorination), in/near the GWS storage reservoir and at a representative consumer tap.

**3. Microbiological data collation and assessment**

No raw water microbiological data (*E. coli, C. perfringens* and Total Coliforms) were available for this report. If such data exists then it should be collated and analysed to understand levels of microbiological contamination of the raw water supply. If no such data exits then *E. coli, C. perfringens* and Total Coliforms should be monitored within the raw water supply on a monthly basis.

4. **Engage with Mayo County Council and Glan Agua regarding the management and mitigating measures of THMs within the distribution network.**

The excessive concentrations of THMs of treated waters at the tap are of concern. As discussed above, it is recommended that THM monitoring is focussed during the period of late summer through to early winter, with additional occasional THM monitoring undertaken throughout the rest of the calendar year. The proposed upgrade of the Kilmovee Urlaur water treatment plant to Dissolved Air Floatation (DAF) treatment process (undertaken on raw water prior to chlorination) should help to reduce the water colour and potential formation of THM within the network. Additional mitigation options that aim to reduce THM concentrations in the treated water supply should be discussed with both Glan Agua and Mayo County Council.

- An assessment of the chlorination procedures within the GWS distribution network is essential in order to help reduce the formation of THM while maintaining sufficient chlorine residual levels post reservoirs to eliminate the potential for microbial contamination along the distribution network.
- Assess aging water within the GWS reservoir and distribution network.

**5. Engage with Mayo County Council and Glan Agua Group regarding site security**

Immediate attention is required to ensure on site security. It is recommended that palisade fencing replaces the existing dilapidated timber fencing currently surrounding the Kilmovee water treatment plant and grounds.

**6. Engage with Mayo County Council and Glan Agua regarding water treatment plant operations.**

- An assessment of the current depth of the intake pipe from Urlaur Lough into the water treatment plant. It is also recommended that the intake pipe is maintained and cleaned regularly.
- An annual analysis of treated water at the Kilmovee Urlaur was sampled and reported by AECOM (parameters monitored included Copper, Sodium, Chloride, Nitrite, TOC, Pesticides herbicides, Pesticides (ocp) Chromium, Boron, Lead, THM, Iron, Mercury). It would be important to establish if this sampling regime will continue under the new DBO contractor, Glan Agua. Monitoring of iron and manganese on the raw water supply in addition to routinely measured pH, colour and turbidity.
- Apparent water colour measurements are available from AECOM and Glan Agua on raw and treated water in the water treatment plant. A regular measure of True water colour would enable comparisons of raw water values with that of Surface Water Regulations (1989) which is based upon true water colour (parametric value of 20 mg/L PtCo for True Colour for Class A1 waters).
- It is also recommended that a *Cryptosporidium* risk assessment is recommended, given the predominantly Karstic geology and the land-use in the catchment.

**7. Engage with GWS members with regard to on-site waste treatment systems (septic tanks) maintenance.**

Group water scheme members within areas of High ground water vulnerability should be engaged to ensure good septic tanks are maintained and serviced regularly in order to reduce the potential for nutrient and other contaminants entering the surface and ground water bodies.

**8. Engage with Geological Survey Ireland (GSI) regarding groundwater zone of contribution.**

This report this report is solely representative of surface water inputs. With the karstic nature of the catchment geology, there is the strong likelihood of the delivery of groundwater into the lake from areas outside of this surface water catchment. Therefore it is recommended for the GWS to contact GSI with regards to delineating the groundwater zone of contribution for Urlaur Lough.

**9. Soil nutrient analysis**

Given the EPA Water Framework Directive, Lake Waterbody status 2010-2015 classification for Urlaur Lough of 'Bad' and at risk of not achieving good status in the future the implementation of soil nutrient analysis for lands bordering Urlaur Lough would be valuable. Soils with high nutrient status are most likely to result in losses to nearby waterways. Knowledge of soil nutrient status would allow farmers to match fertiliser application to their needs and to save money by not applying fertiliser to fields that do not require it. This analysis would be beneficial to both the GWS and the farmers and therefore the costs could be shared also helping to maintain the good ecological status of Urlaur Lough.

**10. Fencing of land with livestock access to Urlaur Lough**

Restricting direct livestock access to water bodies in the vicinity of Urlaur Lough will assist in reducing potential nutrient and faecal contamination of the raw water source. This action, in combination with the monitoring of faecal coliforms in the raw water, will help to identify further source protection measure required to improve water quality for the GWS and potentially reduce treatment costs in the longer term.

**11. Initiate a communications drive**

Kilmovee Urlaur GWS should undertake a communications initiative to remind scheme members of their legal obligations with regards to nutrient enrichment practices, to recommend Good Agricultural Practices and to highlight the importance of wastewater treatment system management. Highlighting the importance of Scheme members' actions in regards to improving raw water quality could also raise awareness for facilitating improvements in environmental status of all the water bodies within the Kilmovee Urlaur GWS catchment. The location of the treatment works on the edge of Urlaur Lough presents an opportunity for a community open day when members of the local community and GWS members can learn more about the source of their drinking water, be informed about the treatment process, the work that is required to ensure good quality water reaches their taps and the source protection measures that need to be implemented to ensure good raw water quality.

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

# 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 Kilmovee Urlaur Group Water Scheme (GWS) catchment and explains how this is relevant to water quality. The potential impact of land use is discussed and available raw water quality data is evaluated. Finally, major concerns relating to source protection are highlighted and recommendations are made as how best to manage these concerns in the future.

# 2.0 Methods

## 2.1 Catchment delineation and description

The outline of the catchment was defined using the available contours on the Map Genie ArcGIS basemaps available from Ordinance Survey Ireland (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 Kilmovee Urlaur 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 for Kilmovee Urlaur GWS were collected from a number of sources: Monthly raw and treated water monitoring data from December 2008 until December 2016 was collected by AECOM and Glan Agua and are presented in this report. Drinking water monitoring by Mayo County Council and the Environmental Protection Agency (EPA) post treatment at the consumer taps from four sampling locations in the Kilmovee Urlaur GWS catchment from April 2005 until February 2016 is presented in this report.

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

# 3.0 Overview of Urlaur Lough and the Water Framework Directive

Under the Water Framework Directive (WFD, 2000/60/EC), the island of Ireland is divided into eight River Basin Districts (RBDs), two of which are international with boundaries shared by the Republic of Ireland and Northern Ireland. The Kilmovee Urlaur GWS catchment lies within the Shannon International River Basin District. Each RBD is subdivided into Water Management Units, and Urlaur Lough and its catchment are included within Upper Shannon Water Management Unit. An action plan for the Water Management Unit is available from http://www.westernrbd.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 Upper Shannon Water Management Unit (WMU). Rivers within the Upper Shannon WMU varied in status but were classed as High (2) or Moderate (18), 27 rivers at a Poor classification and 2 rivers with a Bad status. There are 39 lakes situated within the WMU and the status is High (2), with 21 at Moderate status classification, 2 have a classification of poor and 1 lake is unassigned.

The Upper Shannon WMU Action Plan attributes 92 % of the Total Phosphorus load as diffuse, with agriculture representing the largest source of diffuse nutrients (73 %), followed by un-sewered properties (8 %), forestry (7 %), wastewater treatment plants (5 %). A total of 14,587 on site water treatment systems (OSWTS) or septic tanks are located within the WMU, with 13,007 OSWTS lying in areas of very high or extreme risk. A summary of the WFD classification for Urlaur Lough is given in

Table 2 and each of the elements monitored through the EPA Water Framework Directive Lakes Water Quality Monitoring Programme (Upper Shannon Water Management Unit Action Plan, 2009). The overall Ecological Status is classified as 'Good'. No status is given in the WMU Action Plan for Chlorophyll, Fish, Morphology, Nutrient Enrichment and Physico-chemical.

**Table 2:** Water Framework Directive assigned status for each monitored element for Urlaur Lough (Adapted from the Upper Shannon Water Management Unit Action Plan, 2009).

| Name of water body | Biological Elements | | | Supporting Elements | | | Status | |
|---|---|---|---|---|---|---|---|---|
| | Macrophytes | Chlorophyll | Fish | Morphology | Nutrient Enrichment | Physicochemical | Ecological Status | Chemical Status |
| Urlaur Lough | Good | No status given | No status given | No status given | No status given | No status given | Good | No status given |

## 4.0 Physical Site Description

### 4.1 Catchment location and outline

Kilmovee Urlaur Group Water Scheme is a large scheme serving a population of approximately 1900 and is located in County Mayo, approximately 11 km south of Ballyhaunis, Co Mayo. The scheme extracts its water from the south of Urlaur Lough (Figure 1) beside Kilmovee Urlaur water treatment plant and reservoir. Urlaur Lough has a catchment area of 13.6 km$^2$ (Figure 2) and within the catchment there two are inflowing lakes into Urlaur Lough, Lough Roe and Lough Nanoge. The EPA Water Framework lake waterbody status 2010-2015 for Lough Roe and Lough Nanoge is unassigned and the lake waterbody status for Urlaur Lough is 'Bad' (http://gis.epa.ie/Envision). There is one main out flowing river from Urlaur Lough, which joins the Lung River before joining Lough Gara. Pressures within the catchment are primarily agricultural; particularly surrounding Urlaur Lough. Other pressures within the Kilmovee Urlaur catchment may include domestic wastewater treatment systems in areas High groundwater vulnerability.

Urlaur Lough has a surface area of 1.15 km$^2$, with a mean depth of 4 m and a maximum depth of 11 m. Water is abstract from Lough Urlaur (10 m from the water treatment plant) from the intake pipe at a depth of approximately 1.5 m. The lake is categorised as typology type 10 (as designated by the EPA for the purposes of the Water Framework Directive), i.e. shallow (<4 m), less than 50 ha and high alkalinity (>100 mg/l $CaCO_3$). Urlaur Lough is an Annex I list of the EU Habitats Directive as a hard water marl lake. The aquatic flora of the lake is dominated by stoneworts (*Chara* spp.) (NPWS, 1999). Urlaur Lough provides an important local angling amenity and is known to contain a moderate stock of pike, perch and eels (IFT, unpublished data). In the past, the lake was stocked

with bream in 1961 which failed to establish (IFT, unpublished data).

**Figure 1:** Site Location: Urlaur Lough.

## 4.2 Bedrock geology

The bedrock underlying the Kilmovee Urlaur GWS catchment consists of three main geological formations, Boyle Sandstone, Kilbryan Limestone and Oakport Limstone formation which lie east to west across the catchment (Figure 3). The Boyle Sandstone formation is composed of fine grain of sand, mineral and rock. Sandstone rock formation usually allows percolation of water, making them ideal for aquifers which have a greater capacity to filter out pollutants from the surface in comparison to Limestone. Limestone is a sedimentary rock (comprised of fine grains/fragments of mineral and rocks) 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.

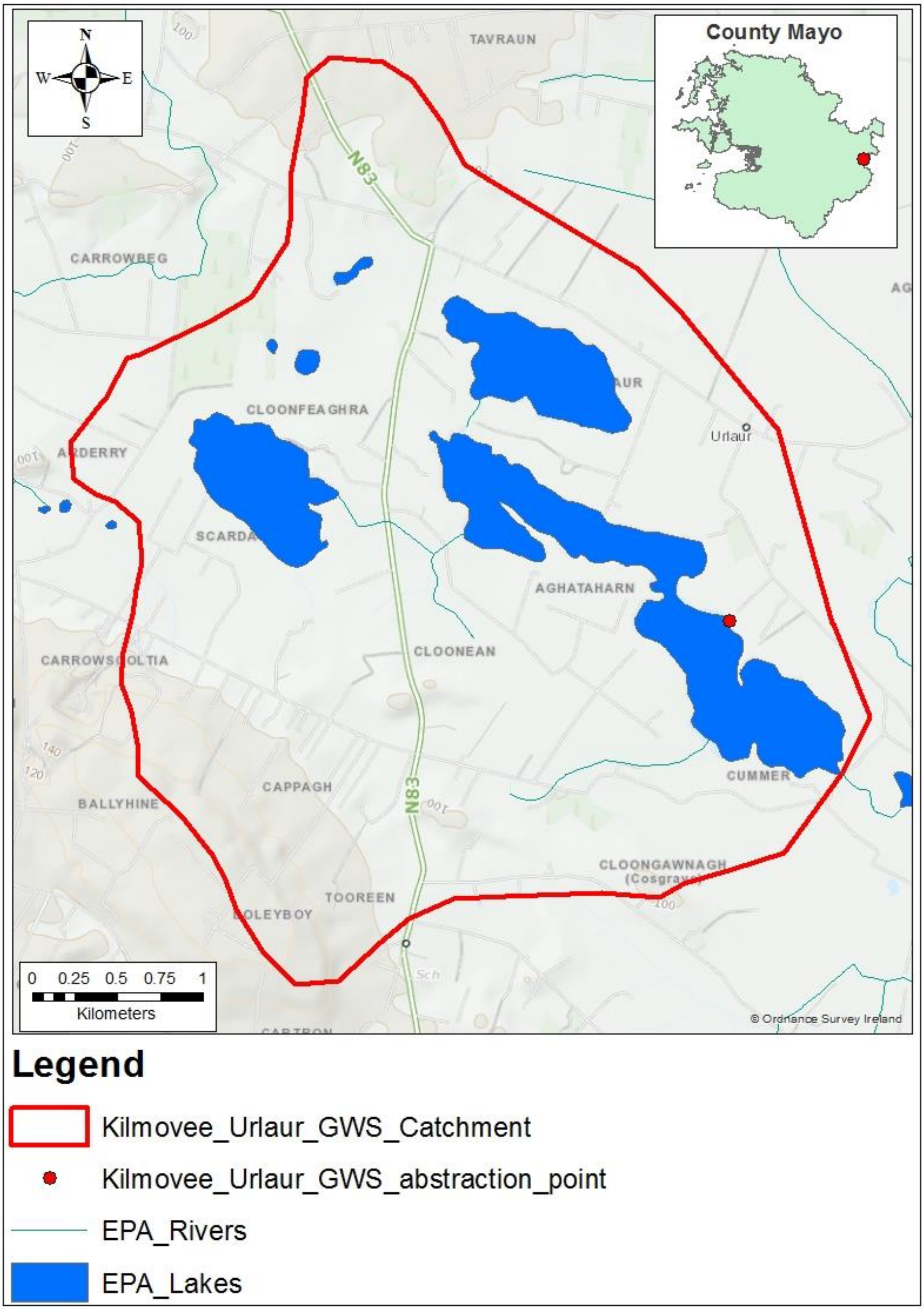


**Figure 2:** Catchment area and location of Kilmovee Urlaur GWS abstraction point and water treatment plant.

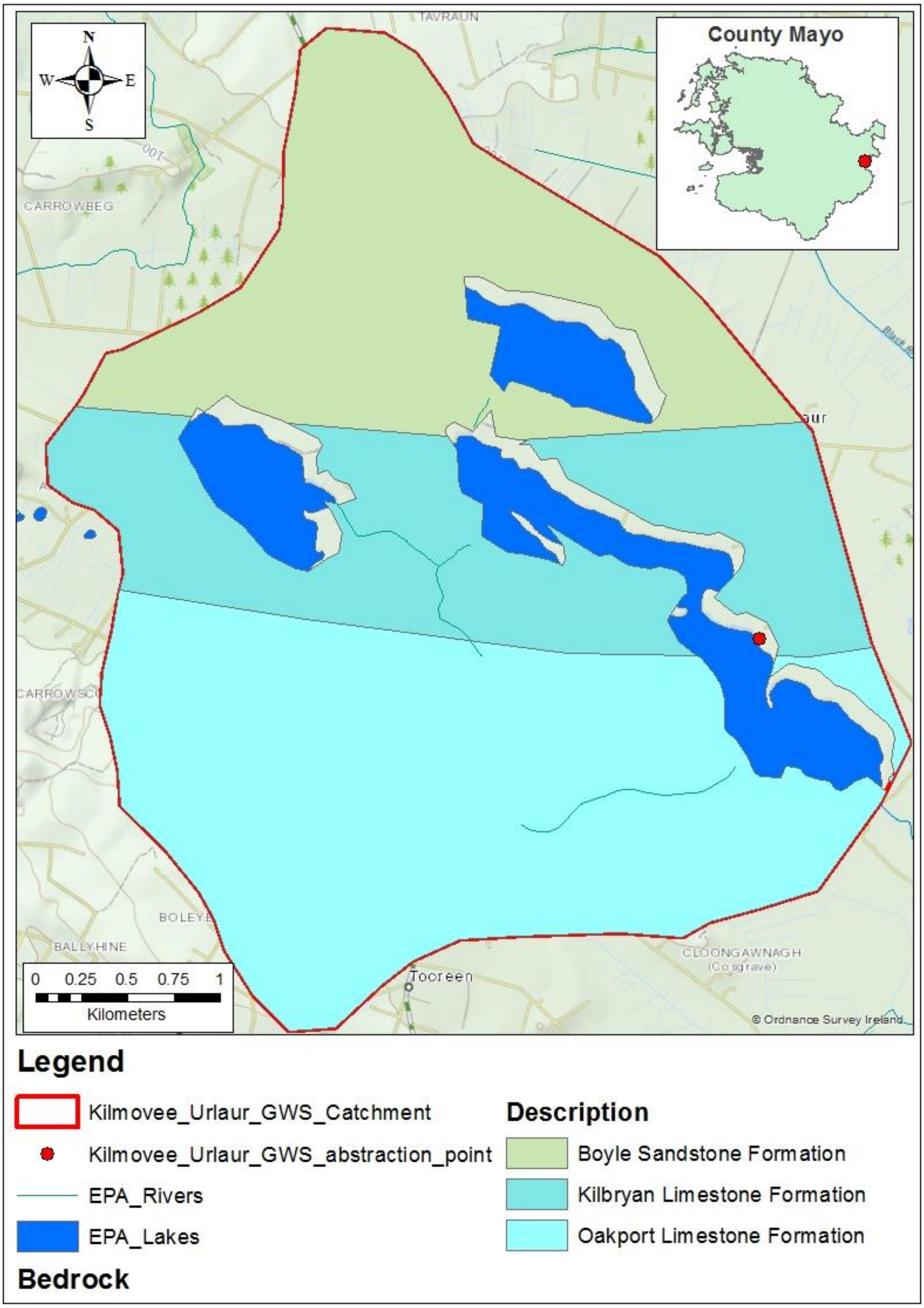


**Figure 3**: Bedrock geology within the Kilmovee Urlaur GWS catchment.

## 4.3 Bedrock aquifers

An aquifer is an underground body of permeable rock or sand/gravel that yields water in sufficient quantities for use. The different bedrock type found within the Kilmovee Urlaur GWS catchment (described in Section 4.2) give rise to various aquifer types (Figure 4). The dominant aquifer classification for the Kilmovee Urlaur GWS catchment in the central and northern end of the catchment is 'Locally Important Aquifer – Bedrock which is Moderately Productive only in local zones'. The underlying aquifer in the southern end of the catchment consists of a 'Regionally Important Aquifer – Karstified (conduit).These productive aquifers correspond with the karstic limestone areas identified in the bedrock of the catchment (Figure 3). The karsitifed aquifer present around the lower end of Urlaur Lough is likely to contain large stores of groundwater, and springs and swallow holes typical of a karstified environment are present within the locality.
However, 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.

## 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.

The groundwater vulnerability of the Kilmovee Urlaur GWS catchment is mixture of High, Moderate and Low ground water vulnerability, with a small pocket of E (Rock at/near surface or karst). An area of Extreme ground water vulnerability is present in the south west of the catchment (Figure 5), and is associated with small areas of High ground water vulnerability surrounding Urlaur Lough, particularly to the south west of the lake, with a large area of High ground water vulnerability located in the south of the GWS catchment.

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

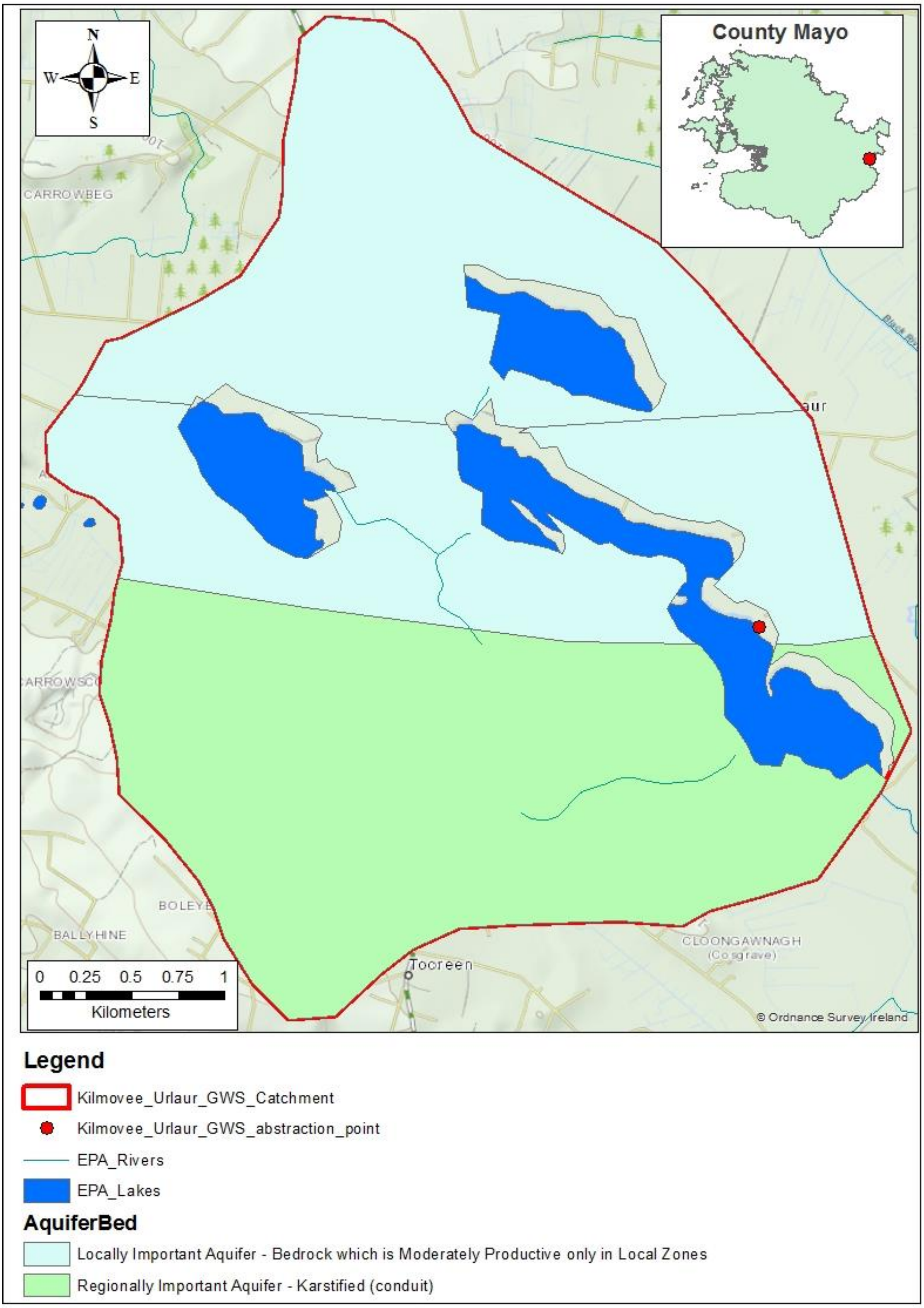


**Figure 4:** Aquifer types present within the Kilmovee Urlaur GWS catchment.

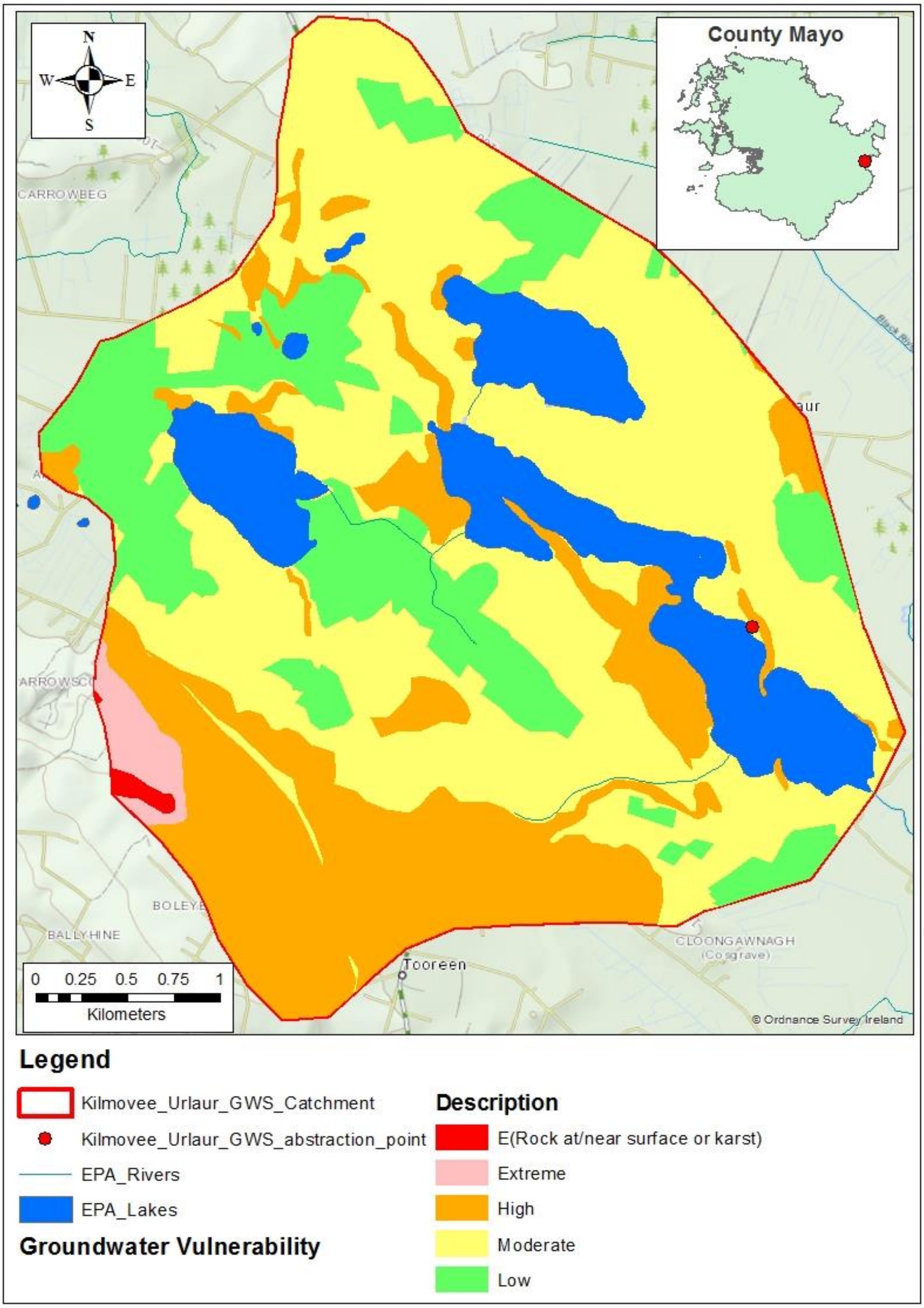


**Figure 5:** Groundwater vulnerability within the Kilmovee Urlaur GWS catchment.

## 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.

There are seven subsoil types present within Kilmovee Urlaur GWS catchment (Figure 6). There are large areas of Cutaway raised peat and Till derived from Devonian Sandstone scattered throughout the catchment. The subsoil in the north of the GWS catchment is comprised of Till derived from Devonian and Carboniferous Sandstone. Large areas of Till derived from Limestone and Gravel derived from Limestone are located in the south west and south of the GWS catchment respectively. Also veins of Esker comprised of gravel of basic reaction run down the centre of the catchment and in close proximity of Urlaur Lough, Lough Nanoge and Lough Roe.

## 4.6 Soils

The Kilmovee Urlaur GWS catchment soils are dominated by Cutover/Cutaway Peat in the west and Acid Deep well/poorly drained mineral soil in the north and south east of Urlaur Lough and the GWS catchment (Figure 7). There is a large area of Basic Deep well/poorly drained mineral and Basic Shallow well/poorly drained mineral located in the south west and south of the Kilmovee Urlaur GWS catchment. The shallow, well drained soils are associated with subsoils classified as having bedrock at or near the surface (Figure 6).

## 4.7 Slope and run-off

The slope of the land leading to a water body is an important determinant of the rate at which water and pollutants move into the lake by overland 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 topography of the Kilmovee Urlaur GWS catchment ranges from an elevation of 100 m around Urlaur Lough to 140 m to the south west of the GWS catchment. 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 Kilmovee Urlaur GWS catchment along with those immediately surrounding the Urlaur Loughs basin 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.

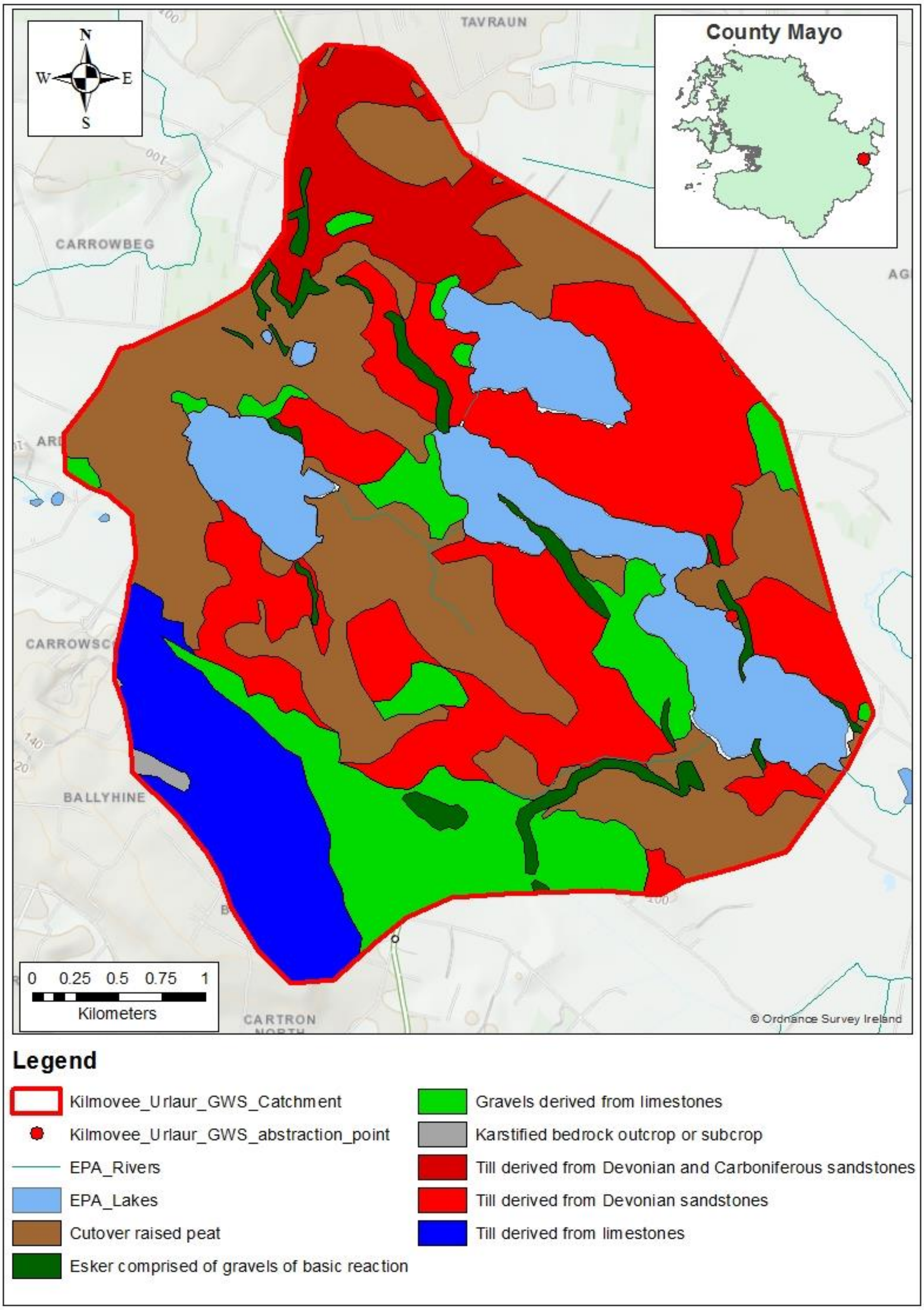


**Figure 6:** Subsoil deposits within the Kilmovee Urlaur GWS catchment.

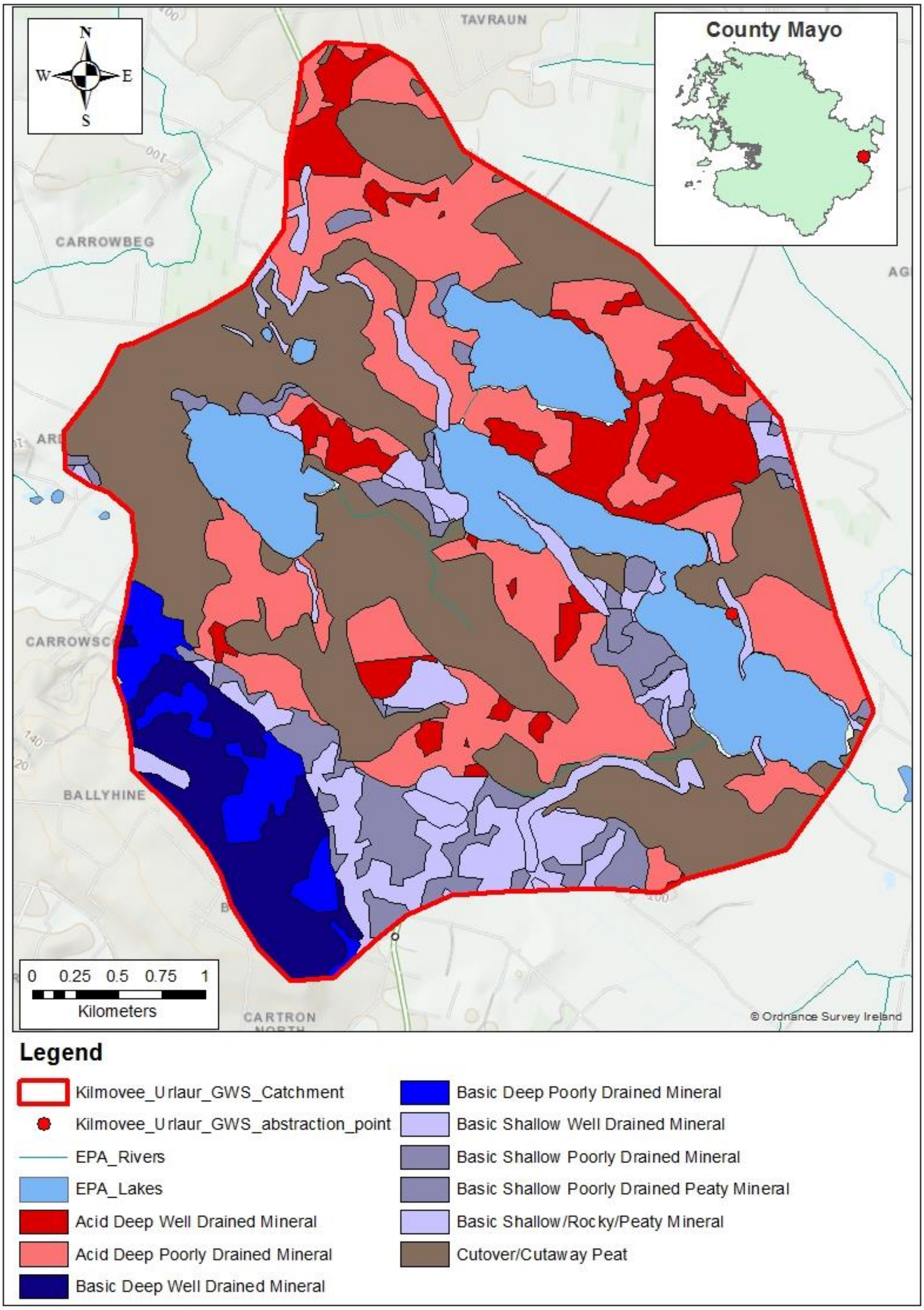


**Figure 7:** Soil types present within the Kilmovee Urlaur GWS catchment.

# 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. Figure 8 shows the CORINE land cover within the Kilmovee Urlaur GWS catchment.

Land cover within the Kilmovee Urlaur GWS catchment is predominantly agricultural with land classified as pastures (Figure 8). Land classified as pasture surrounds Urlaur Lough, with the exception of a small area of peat bog located in the east of the catchment and Urlaur Lough, just above the abstraction point. There are a number of areas of peat bog scattered throughout the catchment and pockets of coniferous forests and transitional woodland scrub located in the north of the catchment. Along the west of the GWS catchment, near Carrowscoltia, there is a small area of land (47 ha) designed as a mineral abstraction site.

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 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.

Coniferous forestry is present in small areas in the north of the catchment, within close proximity of Lough Roe and Lough Nanoge. Therefore, there is the potential for these forests to impact on water quality within Urlaur Lough. However, given the respective sizes of the catchment and the forestry, the impact of the forestry on raw water quality at the Scheme's abstraction point is likely to be limited.

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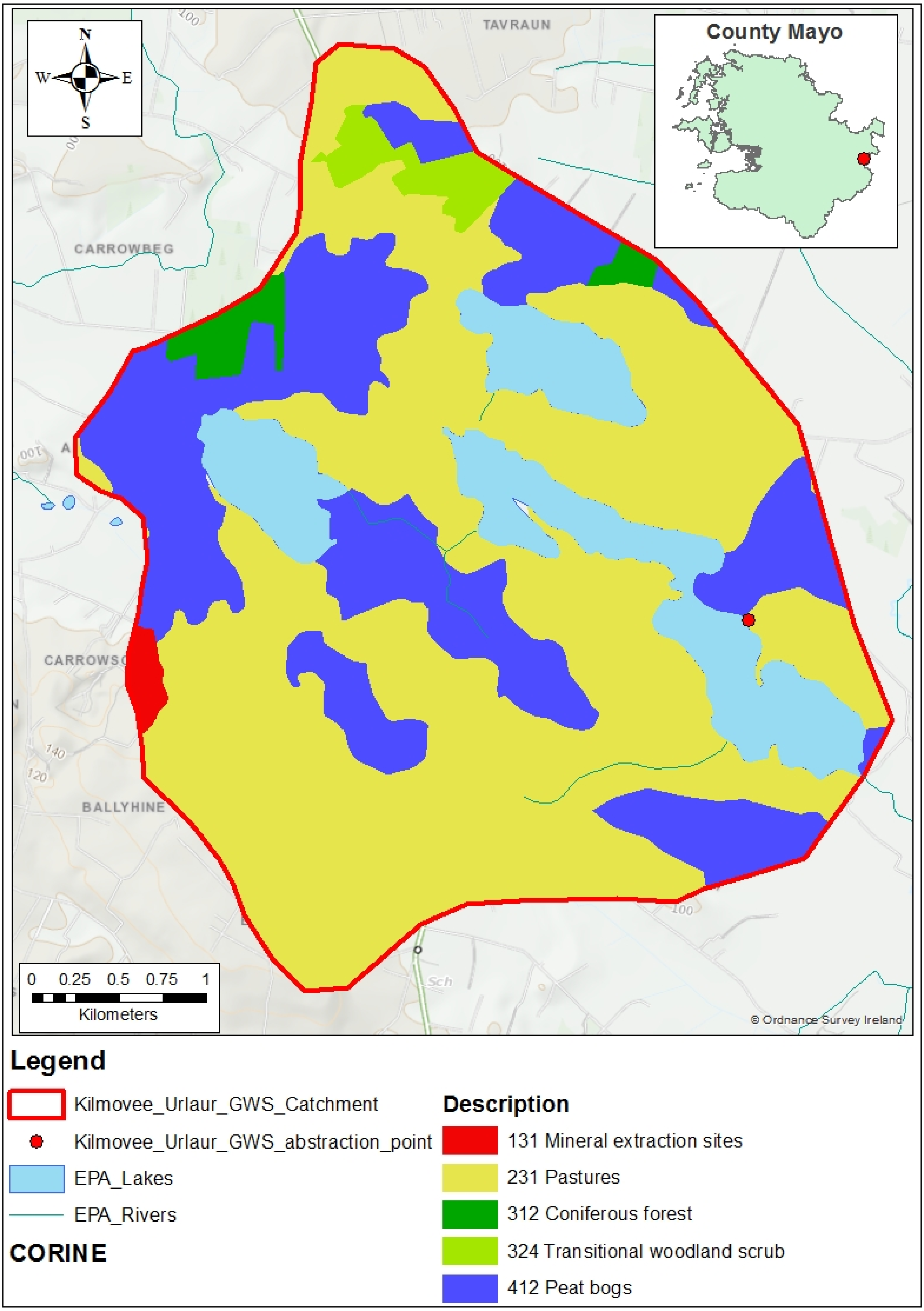



**Figure 8:** CORINE Land Cover classification within the Kilmovee Urlaur GWS catchment.

## 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 no IPPC licences within the Kilmovee Urlaur GWS catchment.

## 5.4 Rural housing and on-site wastewater treatment plants

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

The location of dwellings in the Kilmovee Urlaur GWS catchment was estimated by viewing the Ordnance Survey map and aerial photography of the area (Figure 9). Whilst dwellings cannot be differentiated from other buildings, some insight into the location of dwellings and associated on-site wastewater treatment plants (usually septic tanks) was gained. The location of dwellings in the Kilmovee Urlaur GWS catchment in relation to groundwater vulnerability is presented in Figure 10.

There is data available that identifies the likely risk of contaminants from such treatment systems entering the water bodies within the Kilmovee Urlaur GWS catchment. In association with the Geological Survey of Ireland, the EPA have undertaken an assessment of domestic wastewater risk, giving a relative ranking that nutrients and bacteria from domestic wastewater treatment systems will contaminate surface waters via either surface water or groundwater pathways (EPA, 2013a and b). There are three domestic wastewater risk classifications within the Kilmovee Urlaur GWS catchment area and these are best viewed online via the EPA's geoportal: http://gis.epa.ie/Envision. There is a classification of 'Zone 1A: Low risk in a non sensitive area' for the majority of the GWS catchment. There is an area north and west of Lough Nanoge and in the central region of Urlaur Lough that is classified as 'Zone 2A: Moderate risk in a non sensitive area'. On the eastern side of Lough Nanoge, there is an area classified as 'Zone 3A: High risk in a non sensitive area. It should be noted that there are limitations in related to population densities and scale associated to these maps.

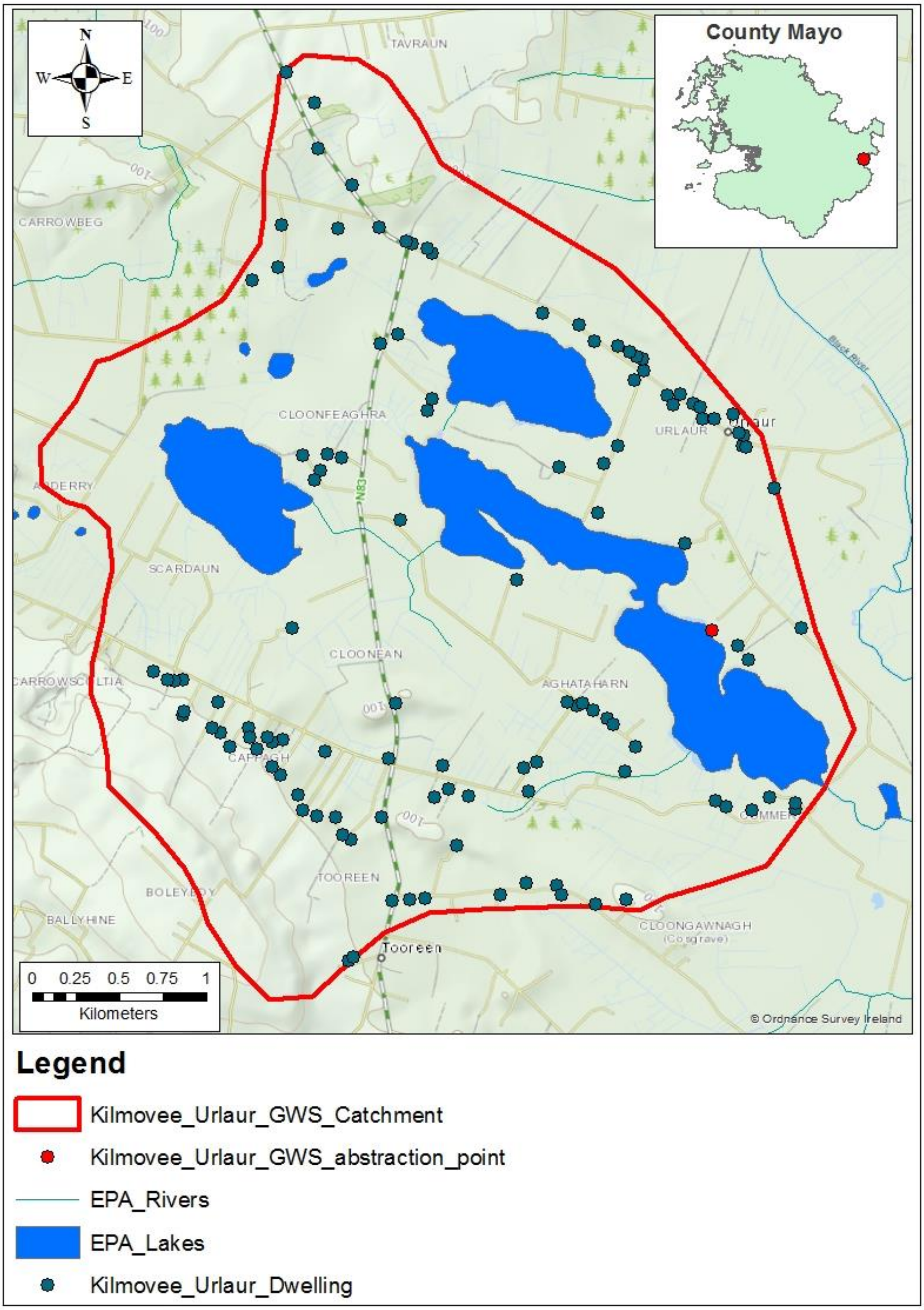



**Figure 9:** Estimated location of dwellings (dots) following examination of Ordnance Survey maps and aerial photographs of the Kilmovee Urlaur GWS catchment.

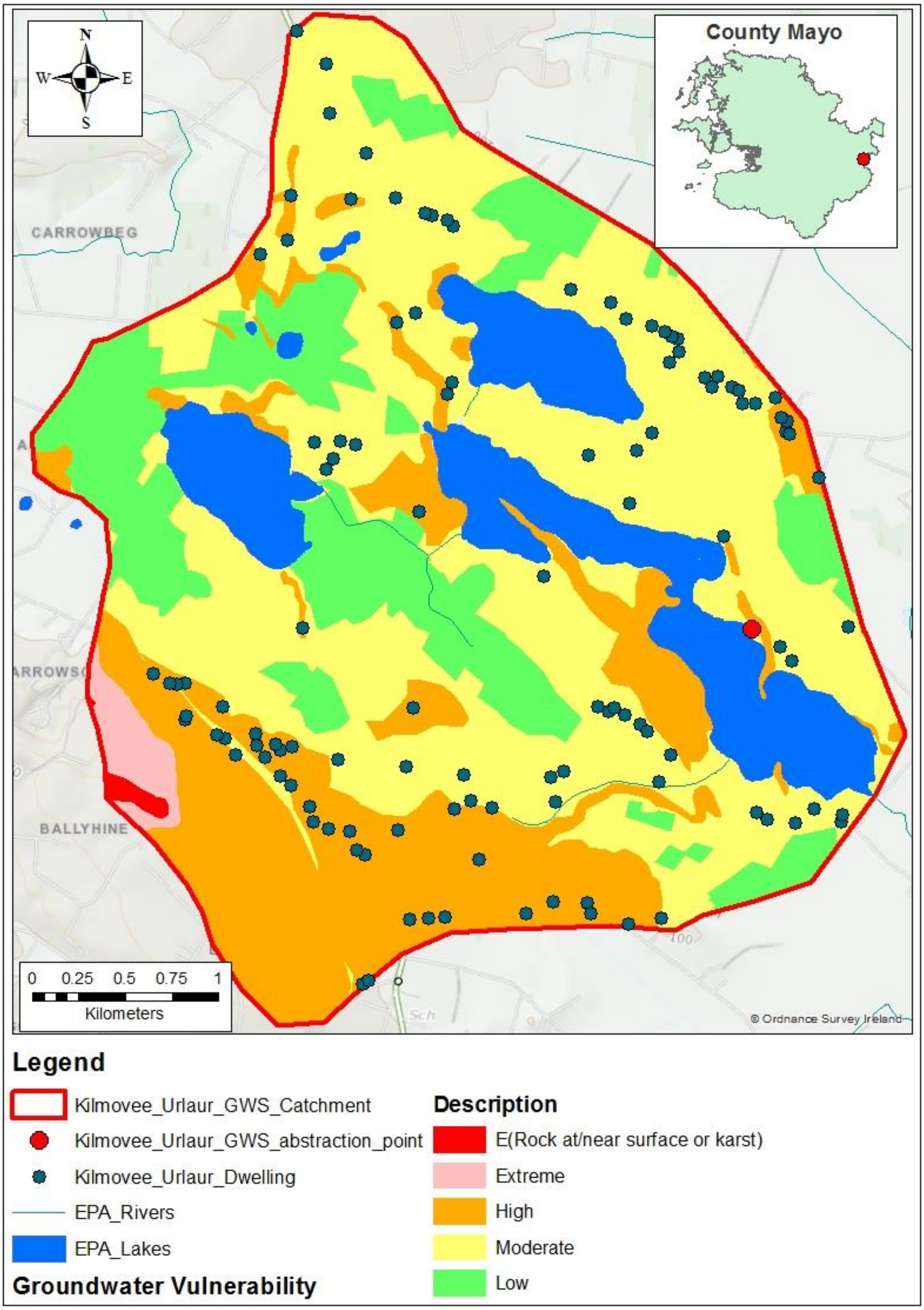



**Figure 10:** Estimated location of dwellings (dots) in relation to classifications of groundwater vulnerability in the Kilmovee Urlaur GWS catchment.

## 5.5 Overall interpretation of catchment land use

The Kilmovee Urlaur GWS catchment area of 13.6 $km^2$ and is located approximately 11 km south of Ballyhaunis, Co Mayo. Kilmovee Urlaur GWS extract water from the east of Urlaur Lough. The lake is categorised as typology type 10, which is shallow (<4 m), less than 50 ha and high alkalinity (>100 mg/l $CaCO_3$). The maximum depth of Urlaur Lough is 11 m, with a mean depth of 4 m. Pressures within the catchment are primarily agricultural, with much of the catchment classes by CORINE land cover as pasture.

The soil in the catchment is a mixture of Basic deep/shallow, poorly/well drained mineral and Acid deep well/poorly drained mineral, with a large area of cutover/cutaway peat in the centre of the catchment and surrounding Urlaur Lough. The groundwater vulnerability within the catchment is a mixture of High, Moderate and Low, with a small pocket of Extreme ground water vulnerability located to the west of the catchment.

The aquifer classification for the Kilmovee Urlaur GWS catchment is 'Locally Important Aquifer – bedrock which is moderately productive only in local zones' and 'Regionally Important karstified (conduit)' corresponding with karstic limestone identified in the bedrock of the catchment. 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 in the vicinity of the Kilmovee Urlaur GWS abstraction point are properly installed and maintained. The dwelling density in the catchment is high and there are a number of dwellings in areas of High groundwater vulnerability. High risk systems, along with cattle yards which are situated within areas of poor soil drainage, high groundwater vulnerability should be inspected as a priority to ensure that potential risk of contamination from these point sources is reduced.

Urlaur Lough has been classified as having 'Good' overall ecological status in the Upper Shannon Management Unit Action Plan 2009. However, risks of nutrient addition through livestock access to the lake and from local on site wastewater treatment systems may still impact the nutrient status of Urlaur Lough. The presence of springs in the lake may also facilitate the delivery of nutrients and other contaminants into the raw water supply, possibly from outside of the surface water catchment areas delineated in this report. Under the EPA Water Framework Directive Lake Waterbody status 2010-2015, Urlaur Lough has a classification of 'Bad' and at risk of not achieving good status in the future. An assessment of water quality parameters is provided in Section 6.0.

# 6.0 Raw Water Quality

Water quality has been assessed at a number of locations throughout the Kilmovee Urlaur GWS catchment by Mayo County Council, the EPA and AECOM (April 2008 until April 2016) and Glan Agua (May 2016 to present) (on behalf of Kilmovee Urlaur Lake GWS). Where possible, water quality data collected from the abstraction point by AECOM or Glan Agua has been analysed and presented along with data from treated water, collected from monitoring locations throughout the catchment.

## 6.1 Raw Water Quality

### 6.1.1 Colour

Natural colour reflects the presence of organic molecules originating from humic matter such as peat, leaves and branches. A coloured water supply does not pose high health risks in itself but 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/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).

It should be noted that the water colour data from the water treatment plant provided by AECOM and Glan Agua is Apparent (unfiltered) water colour measured from April 2008 to December 2016. Water colour at the tap was measured as True (filtered) water colour by Mayo County Council from April 2005 until December 2013 and Apparent (unfiltered) water colour from January 2014 to February 2016. For water colour measurements, due to filtering, true colour values are lower than apparent colour values. Both datasets are presented here but it is important to mention that only True water colour measurements can be compared with the Surface Water Regulations (1989) (which are for true colour).

Measurements of raw apparent water colour from Urlaur Lough were measured at the water treatment plant by AECOM and Glan Agua from April 2008 until December 2016 (Figure 11). Water colour values for raw water ranged from a minimum of 2 mg/L PtCo in August 2009 to a maximum of 199 mg/L PtCo in October 2013, with an average of 56.5 mg/L PtCo recorded over the sampling period. Although no comparison can be made between the apparent (unfiltered) water colour measured on raw water from Urlaur Lough and the Surface Water Regulations (1989) which is based upon true water colour (parametric value of 20 mg/L PtCo which is based on for True Colour for Class A1), it is important to note the extreme high apparent water colour levels measured within the Kilmovee Urlaur GWS. Water colour values were much reduced in the treated water, with the treated apparent water colour ranging from a minimum of 2 mg/L PtCo in June 2016 to a maximum of 52.3 mg/L PtCo in February 2016, with an average of 16 mg/L PtCo.

Mayo County Council and the EPA measured True water colour from April 2005 until December 2013 and measured apparent water colour from January 2014 until March 2017 at the tap from a number of locations within in Kilmovee Urlaur GWS network (Figure 12). The true water colour measured at the tap showed a range of water colour from a minimum of 2 mg/L PtCo in August 2011 to a maximum of 42 mg/L PtCo in January 2007, with an average of 16.8 mg/L PtCo recorded at the tap from April 2005 until December 2013. The apparent water colour measured at the tap showed a range of water colour from a minimum of 2 mg/L PtCo in July 2014 to a maximum of 26.6 mg/L PtCo in February 2016, with an average of 15.7 mg/L PtCo recorded from January 2014 until March 2017. There is a general trend of increasing colour in treated water at the tap from 2008 onwards.

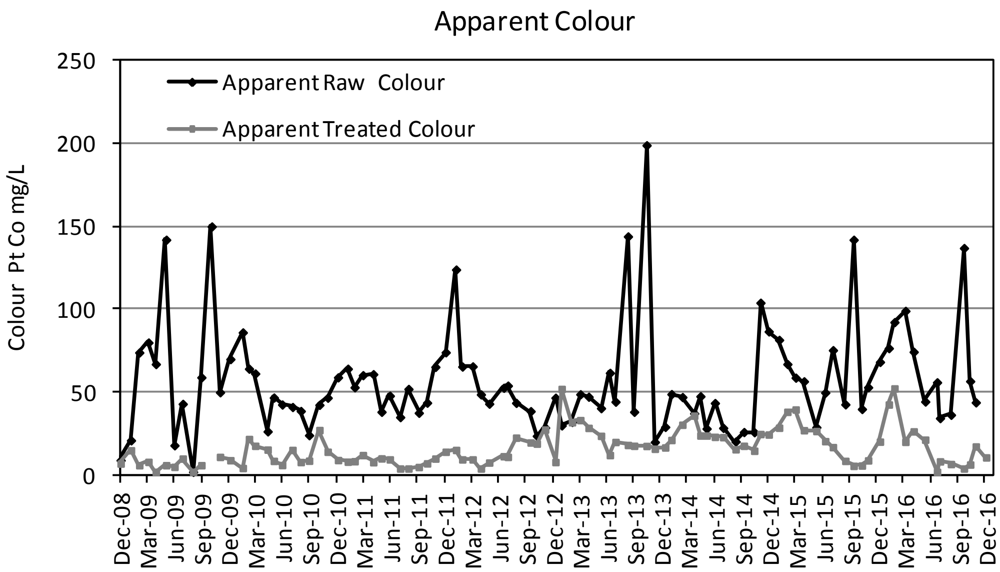



Figure 11: Raw and treated apparent water colour from Kilmovee Urlaur GWS water treatment plant from December 2008 until December 2016. Source data: AECOM and Glan Agua.

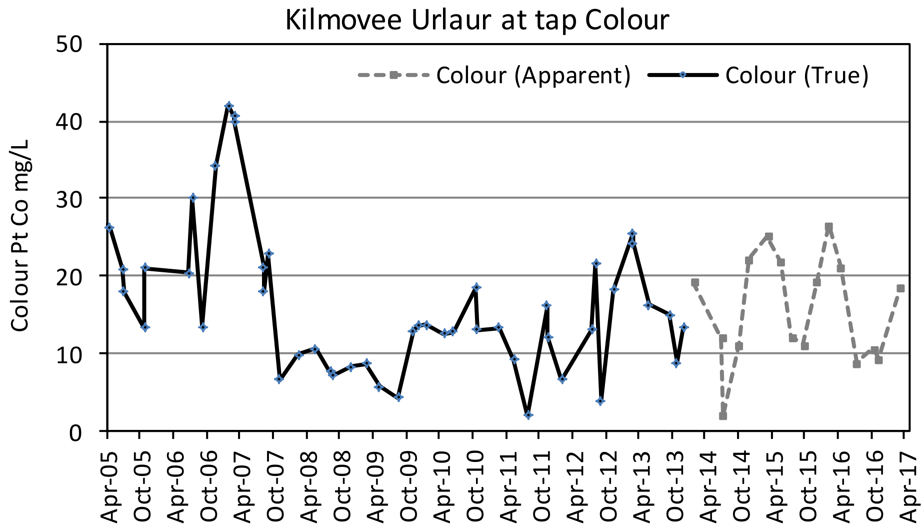
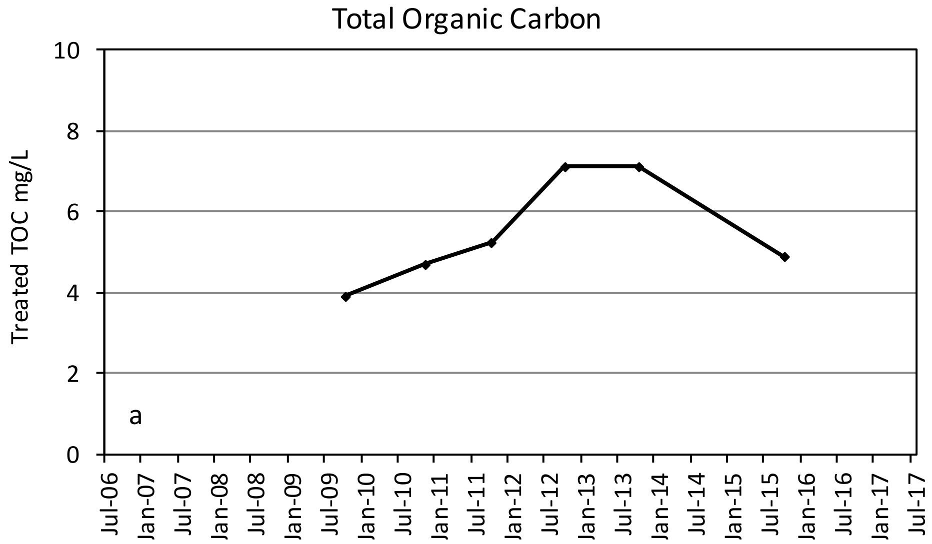



Figure 12: Treated water colour measurements from Mayo County Council and the EPA March 2005 until March 2017.

### 6.1.1.1 Total 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 an estimate of the NOM present in a water source and can be used as an assessment of water quality during the treatment process for drinking water. TOC levels within raw water samples from 12 Irish water treatment works were found to range between 3.5 – 14 mg/L (Chua, 1996).

TOC data were provided by AECOM from treated water at the Kilmovee Urlaur water treatment plant from October 2009 until October 2015 (Figure 13a). Values ranged from a minimum of 3.9 mg/L in October 2009 and a maximum of 7.1 mg/L in October 2012, with an average of 5.4 mg/L recorded over the six sampling occasions. Mayo County Council measured TOC at the tap from the treated water between July 2006 and April 2016 (Figure 13b). Values ranged from a minimum of 4.9 mg/L in August 2008 and a maximum of 8.6 mg/L in July 2016, with an average of 6.6 mg/L recorded over the eleven sampling occasions.



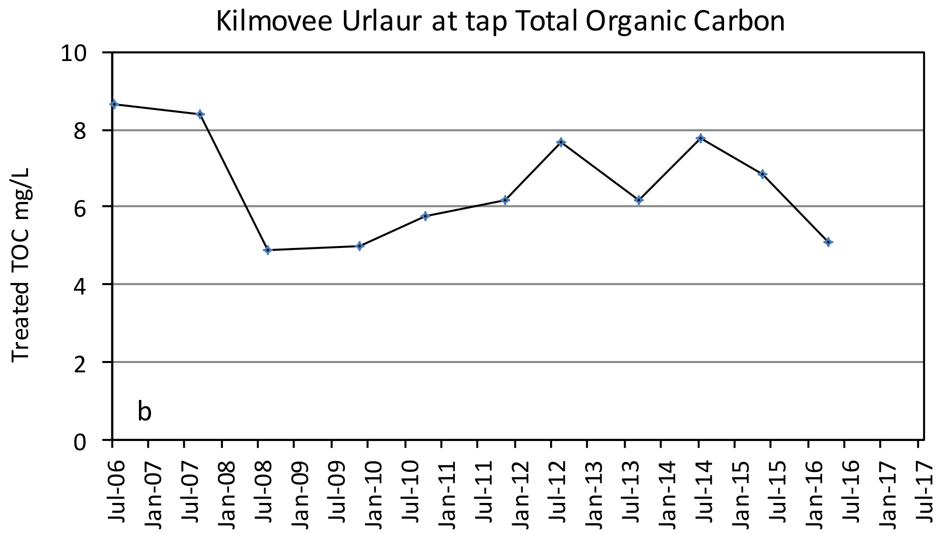



Figure 13**:** a) Total Organic Carbon from treated water at the Kilmovee Urlaur water treatment plant (data source AECOM) and b) Total Organic Carbon from treated water in the network from July 2006 until April 2016 (Data source Mayo County Council).

### 6.1.1.2 Trihalomethane

Trihalomethane data were provided by Mayo County Council on twenty four sampling occasions between October 2005 and April 2016 (Figure 14). Values ranged from a minimum of 10 µg THM/L in August 2011 and a maximum of 212 µg THM/L on February 2016, with an average of 120 µg THM/L recorded over the sampling occasions. The Drinking Water Regulations (2007 and 2014, parametric limit of 100 µg THM/L) were exceeded consistently from February 2013 until February 2016 at the Kilmovee Urlaur water treatment plant, where failures were observed on 71 % of sampling occasions. These results indicate a significant issue with high THM values following the treatment process. It should be noted that timing of THM sampling occasions should be focused on periods between late summer and early winter when the possibility of THM formation is likely to be greatest. Within the Kilmovee Urlaur GWS catchment, there were no THM measurements taken during the autumn period since 2014 to April 2016. There is an increase in THMs from 2008, with the exception of three sampling occasions (October 2010, May and August 2011), which follows the trend also noted of the increase in water colour.

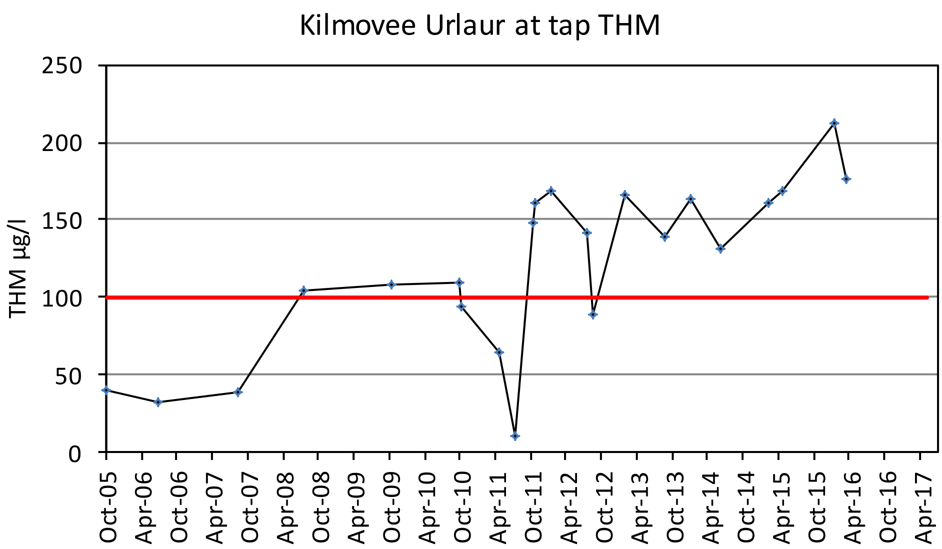



Figure 14: Total Trihalomethanes from treated water in the network from October 2005 until April 2016. Red line indicated the Drinking Water Regulations (2014) limit of 100 µg THM/L). Data source: Mayo County Council.

Trihalomethane data were provided by AECOM from treated water at the Kilmovee Urlaur water treatment plant from October 2009 until October 2015 (Figure 15). Values ranged from a minimum of 26.8 µg THM/L in November 2010 and a maximum of 164 µg THM/L in October 2015, with an average of 89.1 µg THM/L recorded over the eight sampling occasions. The Drinking Water

Regulations (2007 and 2014, limit of 100 µg THM/L) were exceeded on two sampling occasions (October 13 and October 2015).

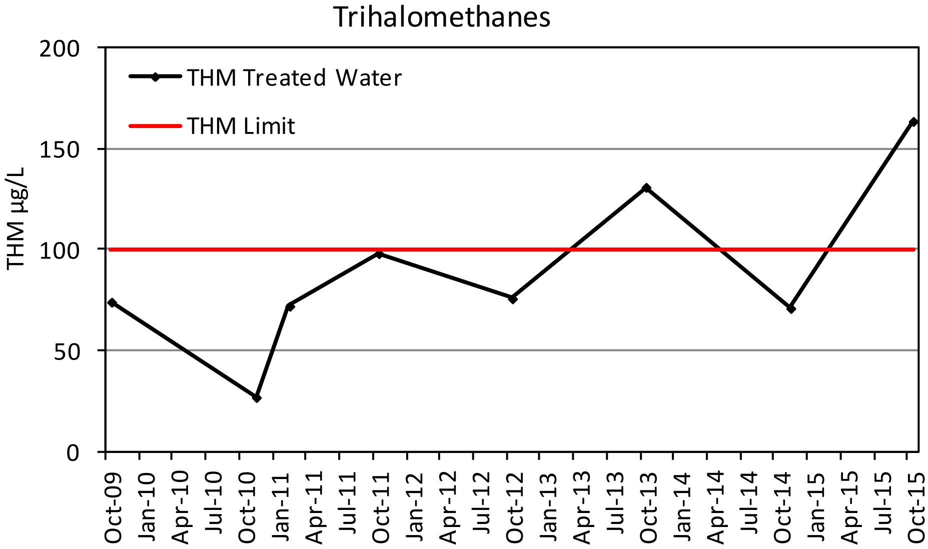



Figure 15: Total Trihalomethanes from Kilmovee Urlaur treated water from October 2009 until February 2016 at the water treatment plant. Red line indicated the Drinking Water Regulation limit of 100 µg THM/L). Date source: AECOM.

### 6.1.2 Turbidity

Turbidity in water consists of very finely divided particles that are too small to be removed through filtration. Their origin may include clay particles, algae, silt, sewage solids and organic or biological sludges. High levels of turbidity in the raw water supply can interfere with the ability of the treatment plant to provide safe drinking water. 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.

Turbidity was monitored at the Kilmovee Urlaur treatment plant on raw and treated water by AECOM and more recently by Glan Agua on behalf of Kilmovee Urlaur GWS from December 2008 until December 2016 (Figure 16). The turbidity of raw water ranged from a minimum of 0.2 NTU on a number of sampling occasions to a maximum of 21 NTU in October 2013, with an average of 2.5 NTU. The turbidity of treated water ranged from a minimum of 0.1 NTU in March and August 2009 to a maximum of 8.1 NTU in May, August and November 2010, with an average of 1.4 NTU measured over the sampling period.

Turbidity was also measured by Mayo County Council from April 2005 until March 2017 on the treated water at the tap from a number of locations in Kilmovee Urlaur GWS network (Figure 17). Results showed the range of turbidity from a minimum of 0.02 NTU in March 2011 and to a maximum of 6.9 NTU in March 2007, with a average measurement of 0.7 NTU recorded for the sampling period.

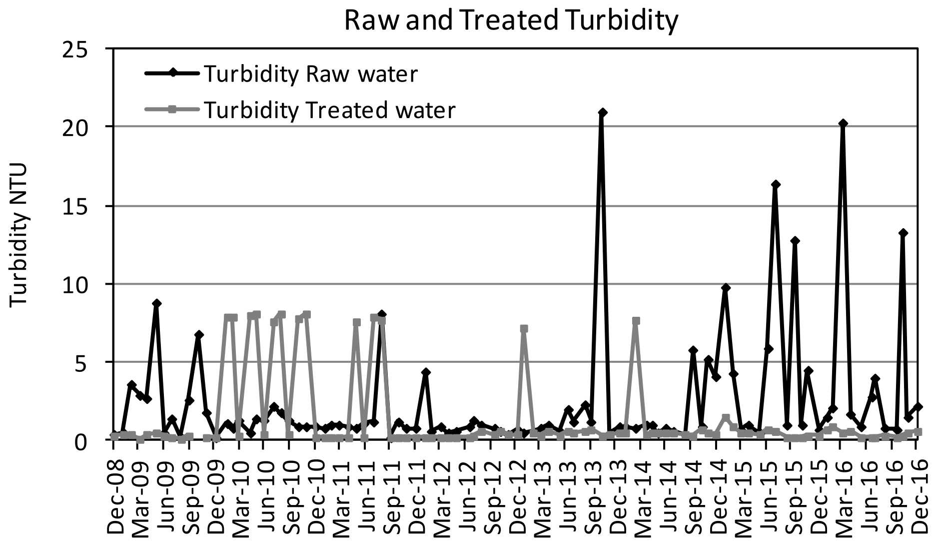



Figure 16: Raw and treated water turbidity from Kilmovee Urlaur water treatment plant from December 2008 until December 2016. Data source: AECOM and Glan Agua.

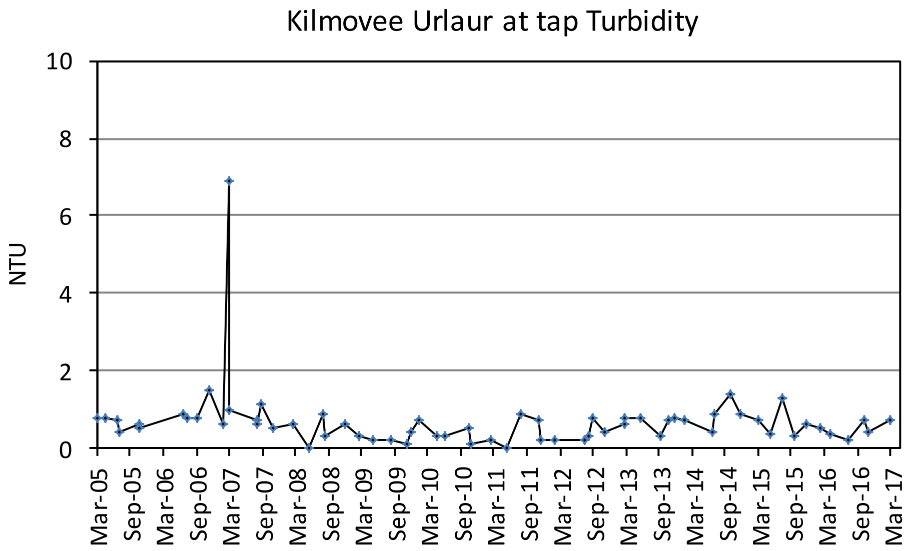



Figure 17: Treated water Turbidity at the tap from March 2005 until March 2017. Data source: Mayo County Council.

### 6.1.3 Iron

Iron (Fe) is present in rocks and soil in an insoluble form but can become soluble when water passes through ground formations containing iron. Large amounts of iron in water are not usually harmful to consumers, but can be aesthetically unpleasing as a result of causing changes in colour or turbidity. This can lead to staining of laundry, discoloration of vegetables following cooking and taste problems. The Surface Water Regulations (1989) recommend concentration of iron in Class A1 waters as 200 µg/L.

Treated water iron concentrations were measured at the Kilmovee Urlaur water treatment plant from December 2008 until December 2016 (Figure 18). Values ranged from a minimum of 10 µg/L on a number of sampling occasions to a maximum of 139 µg/L in March 2014, with an average value of 25 µg/L recorded over the sampling period. The Drinking Water Regulations (2014) set a limit of iron in drinking water of 200 µg/L, which was not exceeded at the Kilmovee Urlaur water treatment plant on any occasion over the sampling period.

Mayo County Council monitored the iron concentration of treated water at the tap from a number of locations from Kilmovee Urlaur GWS network from April 2005 until March 2017 (Figure 19). Values ranged from a minimum of 5 µg/L on a number of sampling occasions to a maximum of 108 µg/L in November 2006, with an average value of 42 µg/L recorded over the sampling period. The Drinking Water Regulations (2014) set a limit of iron in drinking water of 200 µg/L and this was not exceeded in the Kilmovee Urlaur GWS over the sampling period.

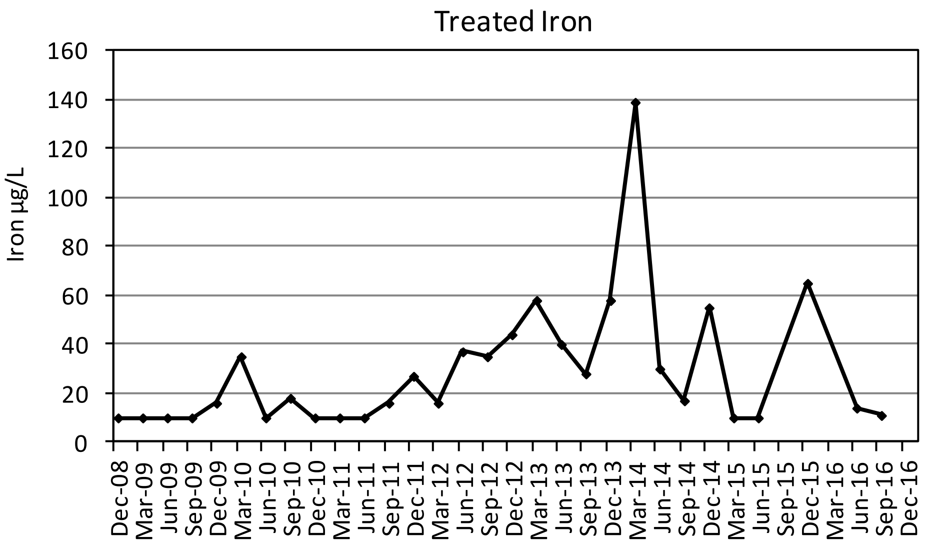



Figure 18: Treated water iron from Kilmovee Urlaur water treatment plant from December 2008 until December 2016. Data source: AECOM and Glan Agua.

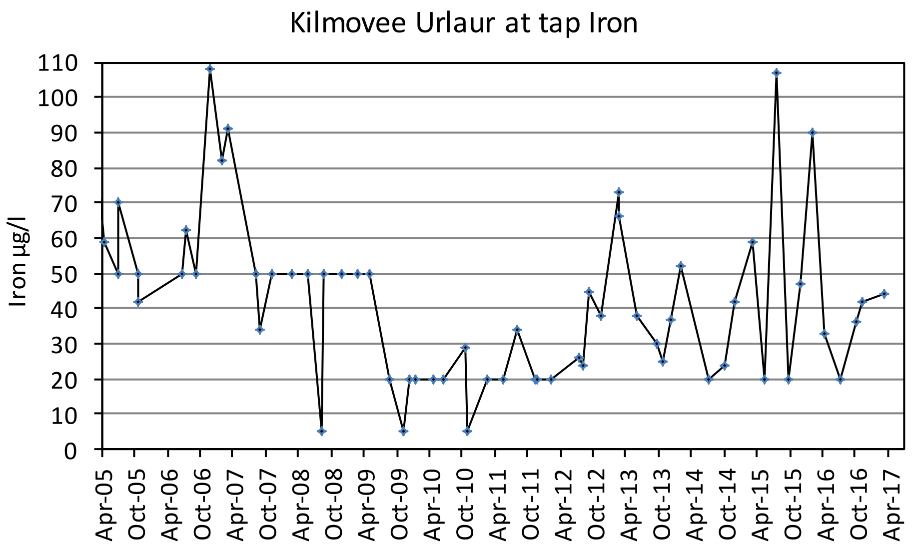


**Figure 19:** Treated water Iron concentrations in the network from April 2005 until March 2017. Data source: Mayo County Council.

**6.1.4 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) parametric value for manganese in Class A1 waters is 50 µg/L.

Manganese was monitored on treated water at the Kilmovee Urlaur water treatment plant from April 2008 until September 2016 (Figure 20). Treated water manganese values ranged from a minimum of 5 µg/L on a number of sampling occasions and a maximum of 19 µg/L in March 2012, with an average value of 5.8 µg/L recorded for the sampling period. Values were consistently below the limit of 50 µg/L outlined by the Drinking Water Regulation (2014).

Manganese was monitored by Mayo County Council in the treated water within Kilmovee Urlaur GWS network from April 2005 until March 2017 (Figure 21). Manganese concentration ranged from a minimum of 1 µg/L on a number of sampling occasions to a maximum of 60 µg/L in July 2006, with an average value of 18.6 µg/L recorded for the sampling period. The Drinking Water Regulations (2014) set a limit of 50 µg/L of manganese in drinking water, and this was exceeded on one occasion over the monitoring period (July 2006).

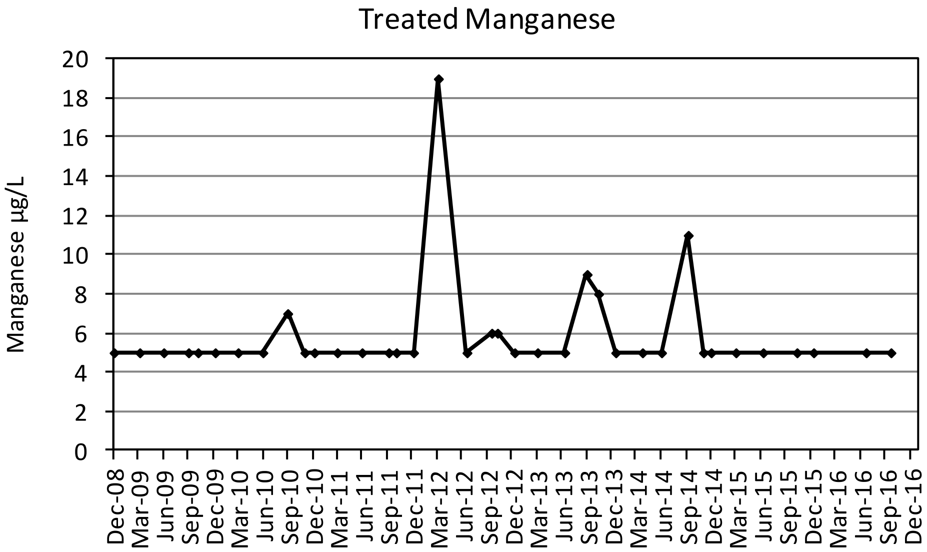



**Figure 20:** Treated water manganese concentrations at the Kilmovee Urlaur water treatment plant from December 2008 until December 2016. Data source: AECOM and Glan Agua.

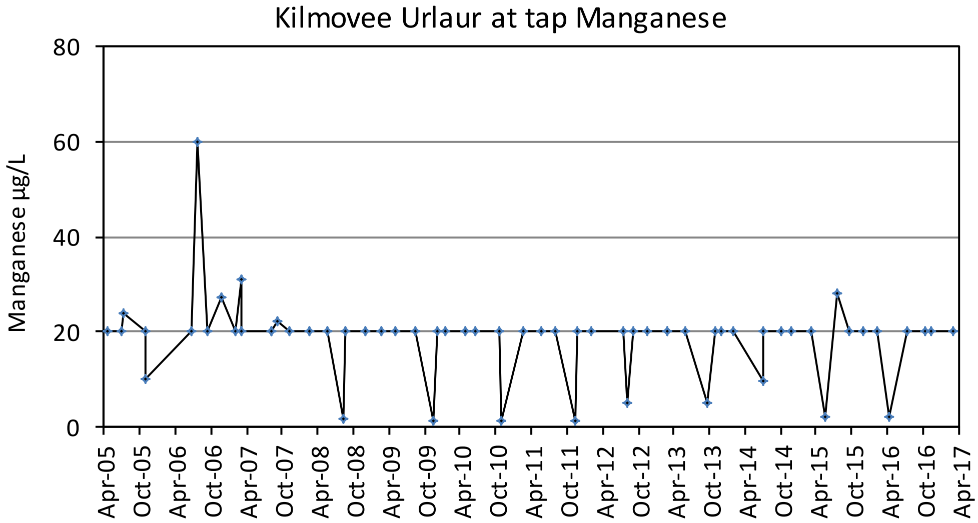



Figure 21: Manganese concentrations on treated water in the Kilmovee Urlaur GWS network from April 2005 until March 2017. Data source: Mayo County Council.

**6.1.5 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 on raw and treated water has been monitored at the Kilmovee Urlaur water treatment plant on behalf of Kilmovee Urlaur GWS from December 2008 until December 2016 (Figure 22). The pH values of raw water ranged from a minimum of pH 6.8 in October 2010 to a maximum of pH 8.3 on a number of sampling occasions. Values for raw water pH were consistently within the range outlined by the Surface Water Regulations (1989) for Class A1 waters. The pH values of treated water ranged from a minimum of pH 7 in August 2013 and a maximum of pH 8.4 in April 2013. Treated water pH was within the range of the Drinking Water Regulations on all sampling occasions.

Mayo County Council and the EPA have monitored pH in the treated water a number of sites within the Kilmovee Urlaur GWS network between April 2005 and March 2017. The pH values were within the range of the Drinking Water Regulations 2014 on all sampling occasions.

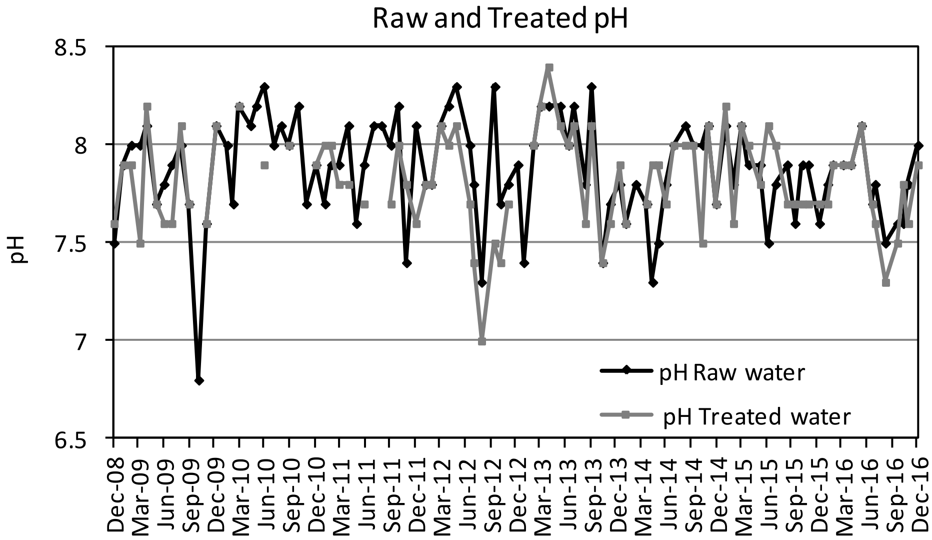



**Figure 22:** Raw and treated water pH levels at Kilmovee Urlaur water treatment plant from April 2008 until December 2016. Data source: AECOM and Glan Agua.

**6.1.6 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.

Alkalinity was measured at a number of locations in Urlaur Lough by Mayo County Council from April 2012 to October 2016 (Figure 23). From Urlaur Lough site 1, values ranged from a minimum of 85 mg/L $CaCO_3$ in August 2010 and August 2016 to a maximum of 132 mg/L $CaCO_3$ in April 2016, with an average value of 107 mg/L for the sampling period. Urlaur Lough is categorised as typology type 10 (as designated by the EPA for the purposes of the Water Framework Directive), i.e. shallow (<4 m), less than 50 ha and 'High alkalinity' (>100 mg/l $CaCO_3$).

Alkalinity was not monitored by AECOM or Glan Agua at the Kilmovee Urlaur water treatment plant.

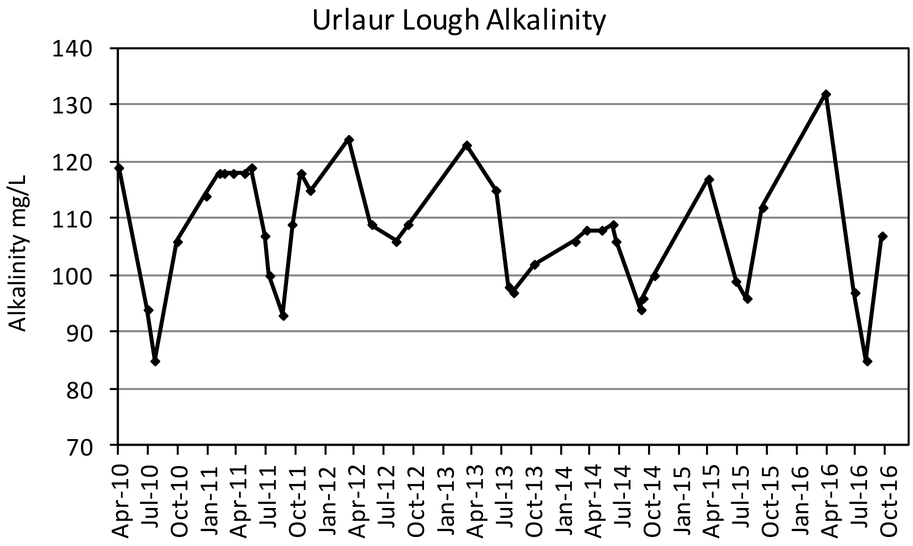



Figure 23: Alkalinity concentrations of Urlaur Lough from April 2010 until October 2016. Data source: Mayo County Council and EPA.

**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.

**6.1.7 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.

Total Phosphorus (TP) has not been monitored by AECOM or Glan Agua on raw or treated water at the water treatment plant or at the tap within the Kilmovee Urlaur GWS network by Mayo County Council.

Total Phosphorus (TP) has been monitored in Urlaur Lough by Mayo Council Council from April 2010 until October 2016 (Figure 24). The concentrations of TP in Urlaur Lough ranged from a minimum of 0.005 mg/L on a number of sampling occasions to a maximum of 0.02 mg/L in September 2011 and June 2012.

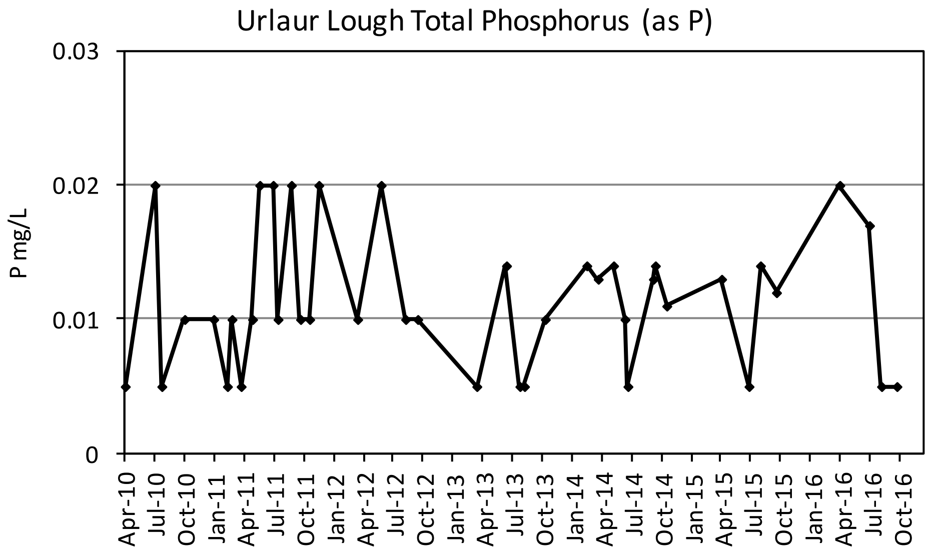



Figure 24: Total Phosphorus concentrations in Urlaur Lough from April 2010 to October 2016. Data source: Mayo County Council and EPA.

**6.1.8 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.

Total Chlorophyll *a* has been monitored in Urlaur Lough by Mayo County Council from April 2010 until October 2016 (Figure 25). The chlorophyll concentrations in Urlaur Lough ranged from 1 mg/m$^3$ July 2010 and August 2012 to a maximum of 13 mg/m$^3$ in April 2014. Chlorophyll *a* concentrations in Urlaur Lough show a strong seasonality with highest values typically during summer and early autumn and lowest concentrations during winter early spring months.

The Surface Water Regulations (2009) do not include parametric values for Chlorophyll concentrations for Lake Type 10 (the classification given to Urlaur Lough: shallow (<4 m), less than 50 ha and 'High alkalinity' (>100 mg/l $CaCO_3$). The reference and boundary Chlorophyll concentrations for Lake Type 10 are 3.5 mg/m$^3$, 6.4 mg/m$^3$ for High/Good conditions and 10.9 mg/m$^3$ for Good/Moderate conditions. The average Chlorophyll a concentration for Urlaur Lough from April 2010 until October 2016 was 4.8 mg/m$^3$ and therefore it is likely that Urlaur Lough was High/Good condition for chlorophyll for the monitoring period.

Algal species (in terms of algal counts) have typically not been monitored within the Kilmovee Urlaur GWS catchment. AECOM monitored algae on Kilmovee Urlaur raw water on the 6th April 2011. Data from the AECOM monthly status reports suggests that the algae species present in the water sample included "Diatoms *Asterionella Formosa,* Cryptophyte *Cryptophyte sp*. Chrysophtes *Dinobryon divergens* (vc), Chlorophytes *Cosmarium sp*, *Tetraedon minimum, Scenedesmus sp*". There was no algae counts data given although it was noted that the 'cell number were low in all cases'.

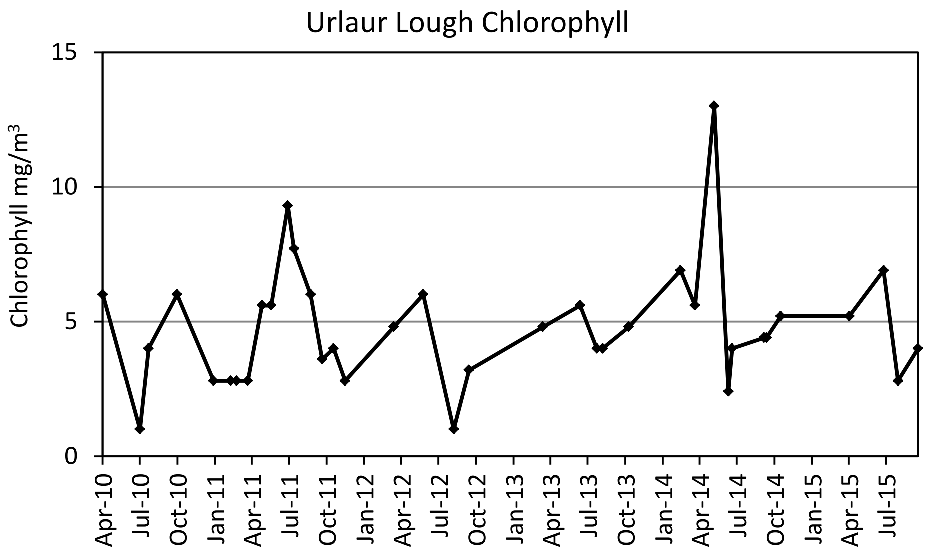



Figure 25: Chlorophyll concentration of Urlaur Lough from April 2010 until October 2016. Source Mayo County Council and EPA.

**6.1.9 Transparency**

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

Transparency was routinely monitored in Urlaur Lough by Mayo County Council from April 2010 until October 2016 (Figure 26). The Transparency at site 1, ranged from 1.1 m in April 2011 and April 2014, to a maximum of 4 m in July 2013, with an average transparency of 2.1 m over the sampling period. There is no apparent seasonality in the dataset.

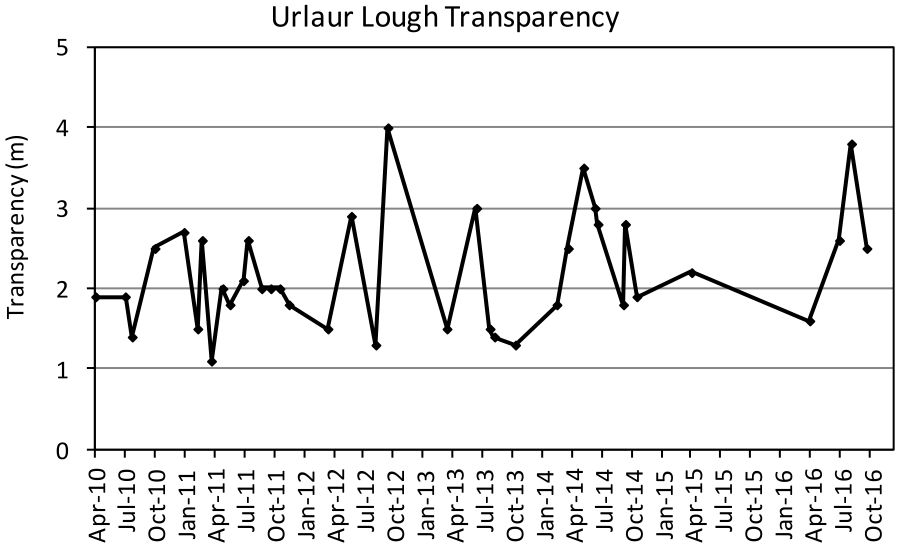



Figure 26: Transparency for Urlaur Lough from April 2010 to October 2016. Source Mayo County Council and EPA.

**6.1.10 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 and 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.

***Total Oxidised Nitrogen (TON)***

Nitrate has been monitored in the treated water on behalf of Kilmovee Urlaur at the water treatment plant by AECOM. Nitrate was monitored on treated water from December 2008 until December 2015 (Figure 27). The maximum nitrate concentration measured in treated water was 0.02 mg $NO_3$-N/L in December 2012, with an average of 0.017 mg $NO_3$-N/L. These values are well below the 50 mg $NO_3$-N/L parametric value stated in the Drinking Water Regulations (2014).

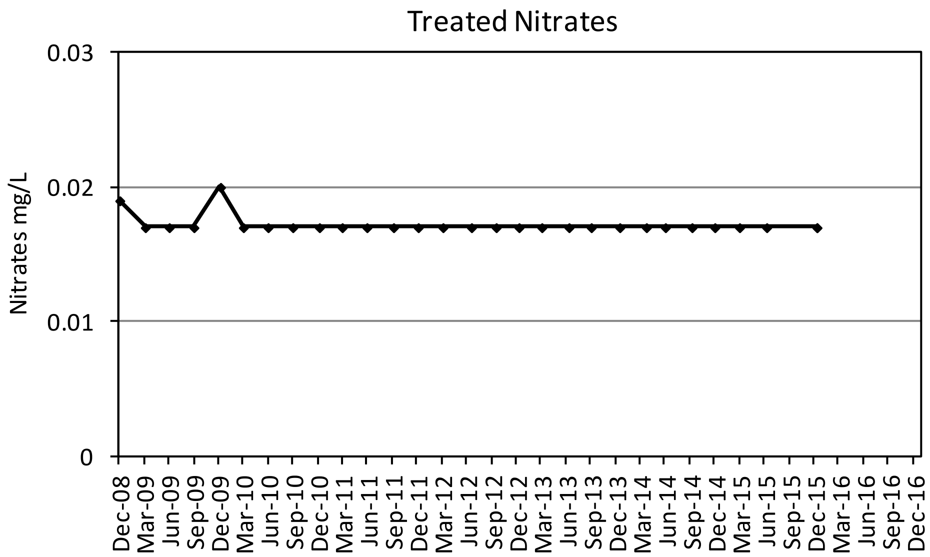



Figure 27: Treated water nitrate concentrations at Kilmovee Urlaur water treatment plant from December 2008 until December 2015. Data source: AECOM.

Mayo County Council monitored concentrations of Nitrates and Nitrite on the treated water from a number of locations in Kilmovee Urlaur GWS network from April 2005 until March 2017 (Figure 28 a and b). The maximum nitrate concentration measured was 7 mg $NO_3$-N/L on July 2006, with an average concentration of 2 mg $NO_3$-N/L recorded within the catchment. These values are well below the 50 mg $NO_3$-N /L parametric value for nitrates stated in the Drinking Water Regulations (2014). The maximum nitrite concentration measured in treated water was 0.04 mg $NO_2$-N /L on a number of sampling occasions with an average of 0.02 mg $NO_2$-N/L. These values are well below the 0.5 mg/L parametric value stated in the Drinking Water Regulations (2014). It should be noted that there was no monitoring of nitrates or nitrites in the raw water supply.

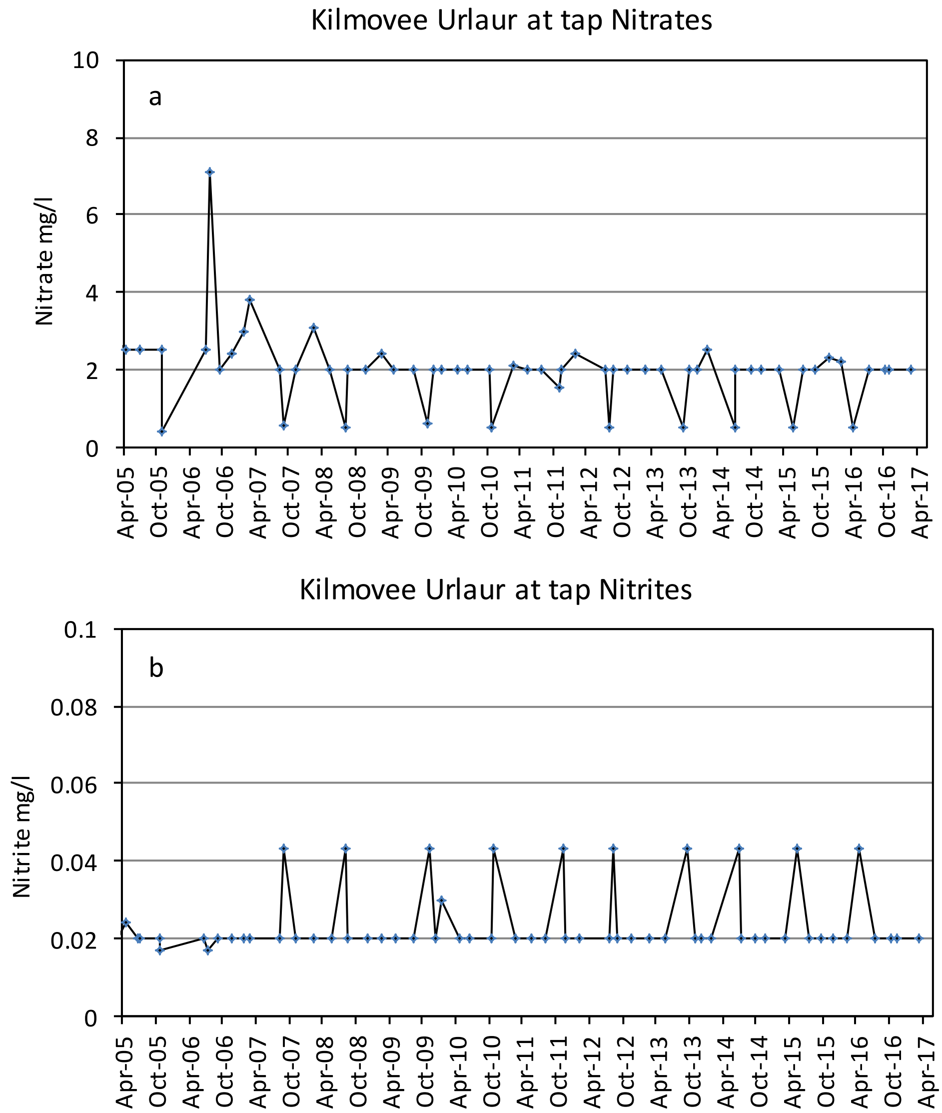
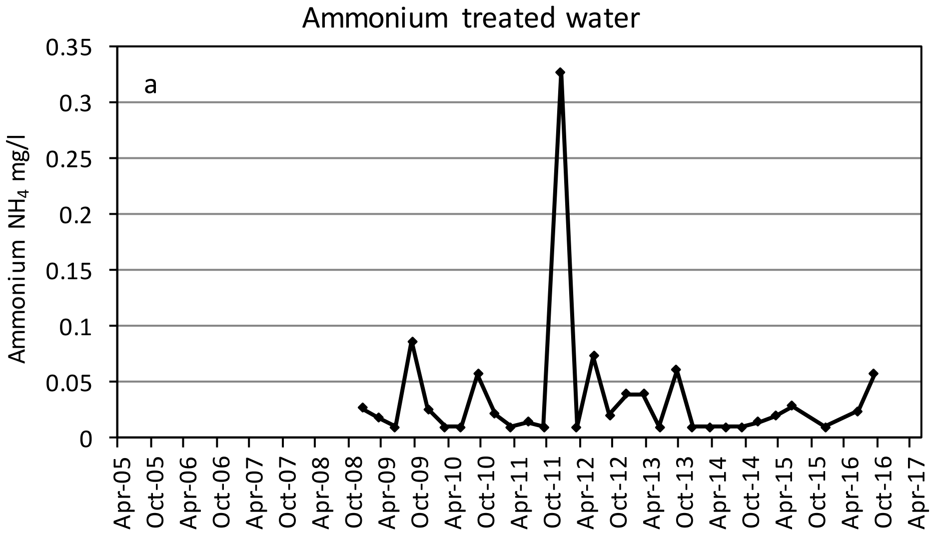



Figure 28: a) Treated water nitrate and b) treated water nitrites concentrations in Kilmovee Urlaur GWS network from April 2005 until March 2017. Data sources: Mayo County Council.

***Ammonium***

Ammonium has been monitored in the treated water on behalf of Kilmovee Urlaur at the water treatment plant from December 2008 until December 2016 (Figure 29a). The maximum ammonium concentration measured in treated water was 0.32 mg/L in December 2011, with an average of 0.02 mg/L. Mayo County Council monitored Ammonium from April 2005 until April 2017 in the treated water from a number of locations in Kilmovee Urlaur GWS network (Figure 29b). The maximum ammonium value was 0.073 mg/L in August 2008, with an average of 0.03 mg/L.



Ammonium treated water
a
Ammonium NH$_4$ mg/l
0.35
0.3
0.25
0.2
0.15
0.1
0.05
0
Apr-05
Oct-05
Apr-06
Oct-06
Apr-07
Oct-07
Apr-08
Oct-08
Apr-09
Oct-09
Apr-10
Oct-10
Apr-11
Oct-11
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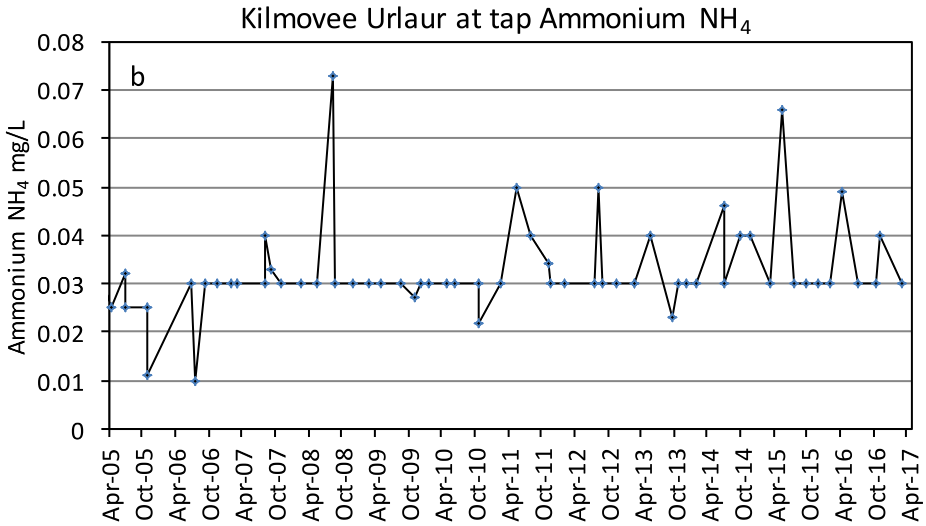
Apr-16
Oct-16
Apr-17

Kilmovee Urlaur at tap Ammonium NH$_4$
b
Ammonium NH$_4$ mg/L
0.08
0.07
0.06
0.05
0.04
0.03
0.02
0.01
0
Apr-05
Oct-05
Apr-06
Oct-06
Apr-07
Oct-07
Apr-08
Oct-08
Apr-09
Oct-09
Apr-10
Oct-10
Apr-11
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Apr-16
Oct-16
Apr-17

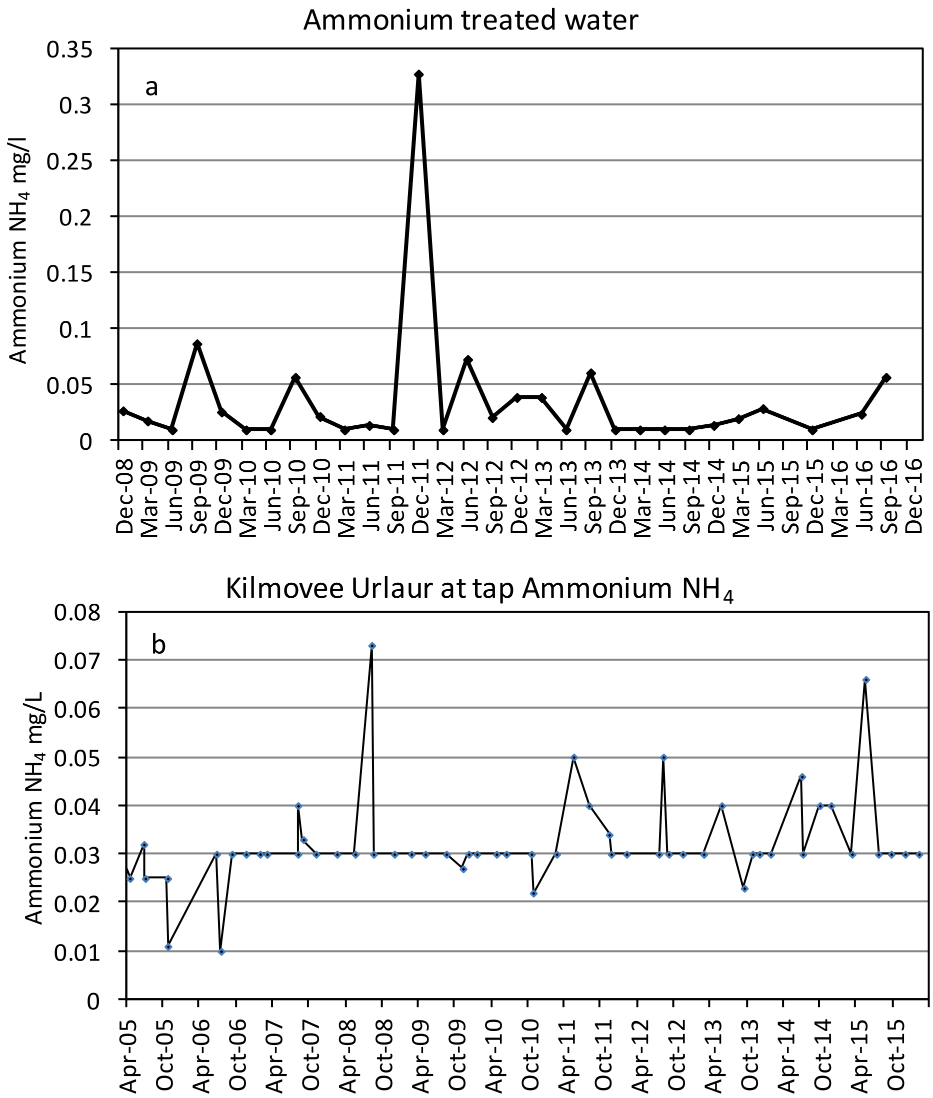


**Figure 29: a)** Treated water Ammonium concentration at Kilmovee Urlaur water treatment plant from December 2008 until September 2016 (date Source AECOM and Glan Agua) and b) Treated water from Kilmovee Urlaur GWS April 2005 until April 2017. Data sources: Mayo County Council.

Mayo County Council monitored ammonia at two locations in Urlaur Lough from April 2010 to October 2016. The maximum concentration of ammonia was 0.08 mg/L in April 2011, with an average of 0.017 mg/L.

### 6.1.11 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 Kilmovee Urlaur water treatment plant from December 2008 until September 2016 (Figure 30). There was no measurement of conductivity on the raw water supply. The conductivity values ranged from minimum of 218 µS/cm in September 2010 to a maximum value of 395 µS/cm in March 2013, with an average of 287 µS/cm. Conductivity values were below the Drinking Water Regulations (2014) of 2500 µS/cm on all sampling occasions.

Conductivity was monitored in the Kilmovee GWS network on the treated water at the tap from April 2005 until February 2016. Conductivity values were below the Drinking Water Regulations (2014) of 2500 µS/cm on all sampling occasions.

Conductivity was also measured on Urlaur Lough by Mayo County Council from April 2010 to October 2016. Conductivity measurements ranged from a minimum of 239 µS/cm in August 2008 to a maximum of 336 µS/cm in April 2014. All Conductivity values measured in Urlaur Lough were within the Surface Water Regulations (1989) specify a limit of 1000 µS/cm at 20°C for Class A1 waters.

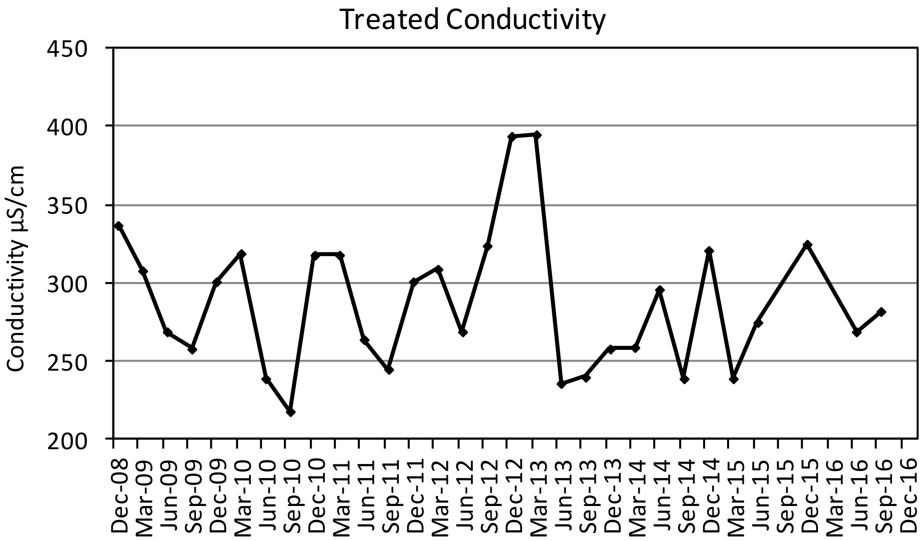


Figure 30: Treated water Conductivity from Kilmovee Urlaur water treatment plant from December 2008 until September 2016. Data source: AECOM and Glan Agua.

**6.1.12 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.

Dissolved Oxygen has not been monitored by AECOM or Glan Agua at the Kilmovee Urlaur water treatment plant.

The EPA has monitored Dissolved Oxygen at a two of locations on Urlaur Lough from April 2010 until October 2016 (Figure 31). The values ranged from a minimum of 90 % DO saturation in November 2011 to a maximum of 121 % DO saturation in August 2012, with an average of 100 % DO saturation over the monitoring period. Excessive, super saturation levels were observed at Urlaur Lough during the summer of 2012. These high values are likely indications of algal blooms. However, chlorophyll values were recorded as being low (up to 1 µg/L) during this time (Figure 25).

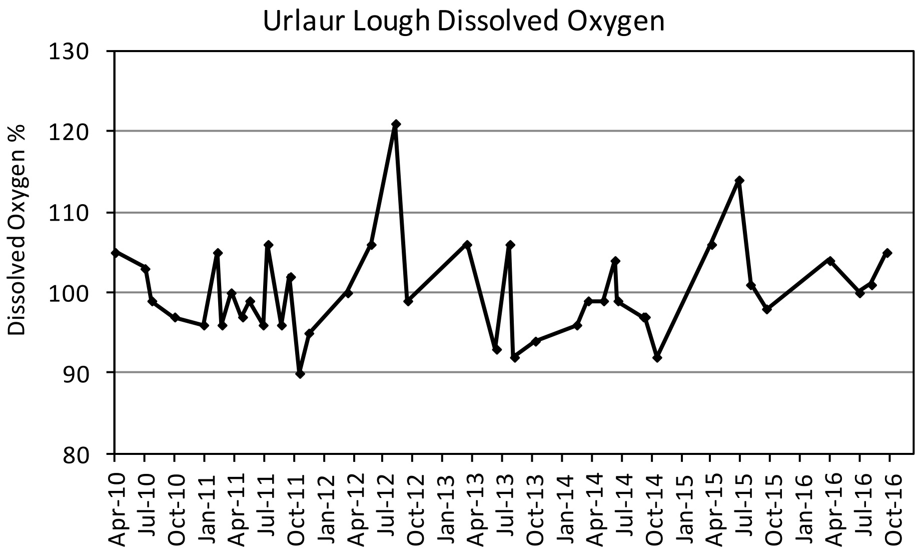


Figure 31: Dissolved oxygen saturation (%) for Urlaur Lough from April 2010 to October 2016. Source Mayo County Council and EPA.

**6.1.13 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 within the raw water supply

**6.1.14 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.

Faecal Coliforms have been monitored on the treated water at the Kilmovee Urlaur GWS water treatment plant from April 2008 until December 2016. In the treated water, Faecal coliforms values were <1 cfu/100ml over the sampling period, 0 cfu/100ml as required by the Drinking Water Regulations (2007 and 2014).

Mayo County Council measured *E. coli* from April 2005 until April 2017 (Figure 32) on treated water from a number of locations in Kilmovee Urlaur GWS network. There was three failures of 1 MPN/100ml recorded in *E. coli* levels in the Kilmovee Urlaur treated water in September 2007, June 2010 and October 2013 and exceeding the Drinking Water Regulations (2007 and 2014). Since October 2013 the level of *E. coli* level was zero for all sampling occasions.

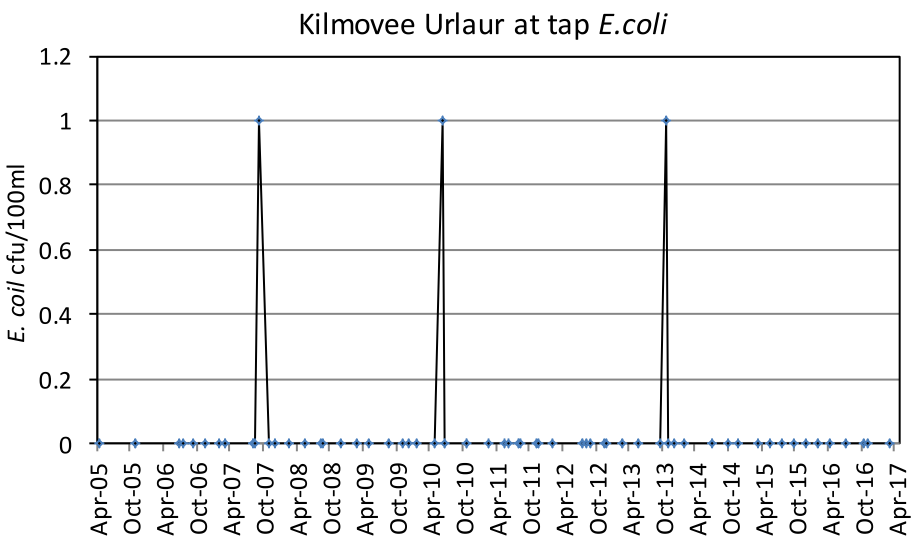


Figure 32: Treated water *E. coli* values at Kilmovee Urlaur GWS catchment from April 2005 until April 2017. Data source: Mayo County Council.

***Clostridium perfringens***

*Clostridium perfringens* exists as part of the natural bacterial intestinal flora of humans and therefore serves as an indicator of faecal pollution. *Clostridium perfringens* has been monitored on the treated water at the Kilmovee Urlaur GWS water treatment plant from December 2008 until December 2016. *Clostridium perfringens* values were zero over the sampling period, as required by the Drinking Water Regulations (2007 and 2014).

Mayo County Council measured *Clostridium perfringens* from October 2005 until April 2017 (Figure 33) in the treated water from a number of locations in Kilmovee Urlaur GWS network. *Clostridium perfringens* exceeded the Drinking Water Regulations (2007 and 2014) on three sampling occasions over the monitoring period, in September 2007, August 2011 and November 2012. The *Clostridium perfringens* levels were zero on all other sampling occasions as required by the Drinking Water Regulations (2007 and 2014).

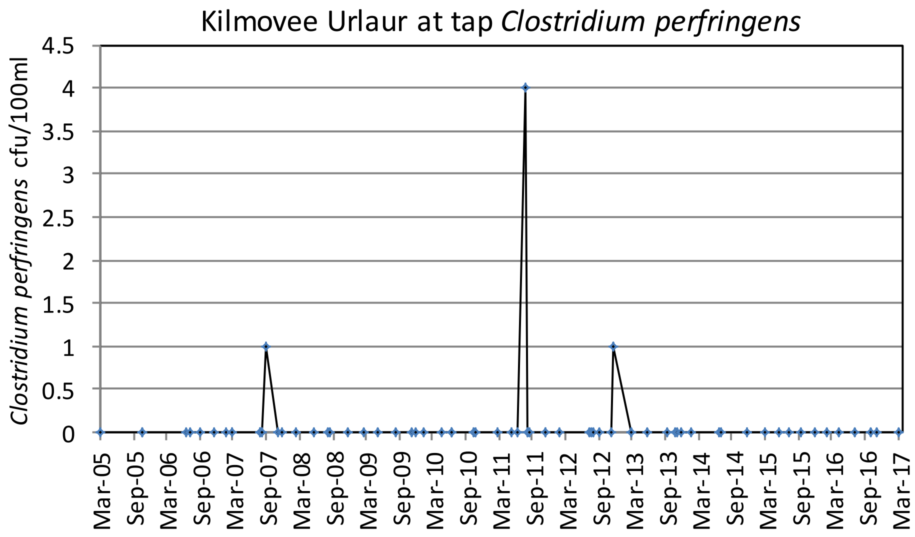


Figure 33: Treated water *Clostridium perfringens* values from Kilmovee Urlaur GWS network from April 2005 until April 2017. Data source: Mayo County Council.

**Total Coliforms**

Total Coliforms have been monitored at the Kilmovee Urlaur water treatment plant on treated water from April 2008 until December 2016. In the treated water supply, Total Coliforms values were zero over the sampling period, as required by the Drinking Water Regulations (2007 and 2014).

Mayo County Council measured Total Coliforms from April 2005 until April 2017 on treated water at the tap from a number of locations in Kilmovee Urlaur GWS network (Figure 34). The Total Coliforms exceeded the Drinking Water Regulations on fourteen sampling occasions from April 2005 until December 2013. Since December 2013 the Total Coliforms was 0 MPN/100ml as required under the Drinking Water Regulations 2014.

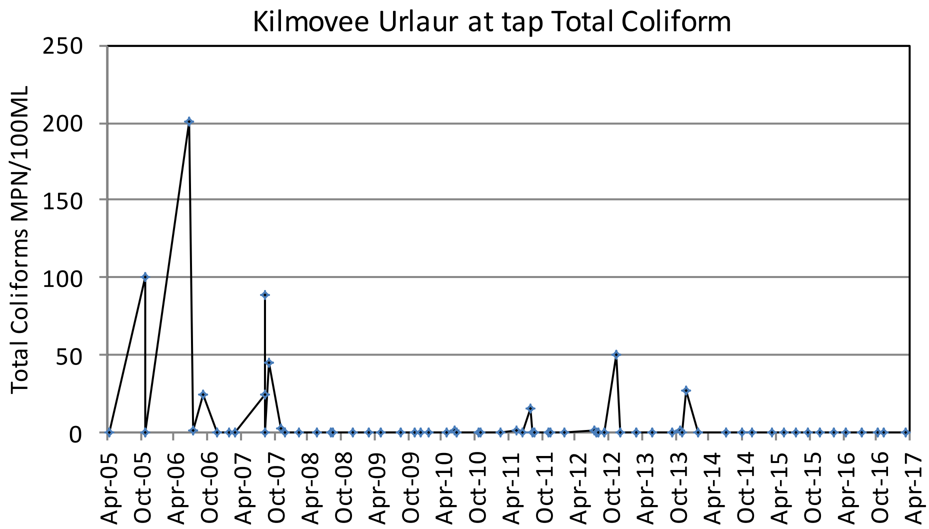

**Figure 34**: Treated water Coliforms from April 2005 until April 2017 from Kilmovee Urlaur GWS network. Data source: Mayo County Council.

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

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

Macroinvertebrates have not been monitored within the Kilmovee Urlaur GWS Catchment.

## 6.3 Overall Interpretation of Water Quality

A range of water quality parameters have been monitored throughout the Kilmovee Urlaur GWS catchment by AECOM and recently Glan Agua (on behalf of the GWS), Mayo County Council and the EPA.

High water colour values were recorded (average 56 PtCo mg/L) for raw water at the Kilmovee Urlaur water treatment plant. As discussed in this report, high levels of colour do not represent a health risk. However, upon treatment with Chlorine, Trihalomethanes (THMs) can be produced when the chlorine reacts naturally occurring organic matter in the raw water (high colour values can be an indication of high organic matter). Given the high values of water colour present in the raw water, the likelihood of Trihalomethanes (THMs) being produced during the treatment process is extremely high. THM samples are taken at the tap in a number of locations in the Kilmovee Urlaur GWS distribution network by Mayo County Council. From these THM results it clearly shows that THM levels consistently and significantly exceeded the Drinking Water Regulations (2007 and 2014) from February 2013 until April 2016. THM sampling is a requirement of the Drinking Water Regulation and at present THM monitoring is being undertaken in the treated water supply of Kilmovee Urlaur GWS on average two occasions throughout the year.  It should be noted that the timing of THM sampling should be focused on periods between late summer and early winter when the possibility of THM formation is likely to be greatest. In addition, consideration should be given to modifying chlorination processes within the GWS network. Further details of the proposed monitoring activities are given in Section 7.

The proposed upgrade of the Kilmovee Urlaur water treatment plant to a Dissolved Air Floatation (DAF) treatment process undertaken on raw water prior to chlorination should help to further reduce the water colour and potential formation of THM within the network. However, consistent THM monitoring as outlined in Section 7 is required to ensure that the Drinking Water Regulations (2014) parametric limit for THMs is not exceeded.

Apparent water colour measurements are available from AECOM and Glan Agua on raw and treated water in the water treatment plant and from Mayo County Council from January 2014. Some regular monitoring of True water colour would enable comparisons of raw water values with that of Surface Water Regulations (1989) which is based upon true water colour (parametric value of 20 mg/L PtCo for True Colour for Class A1 waters).  In addition, consideration should be given to monitoring Total organic Carbon (TOC) on raw water entering the Kilmovee Urlaur water treatment plant. AECOM measured TOC in treated water annually from October 2009 to October 2015.

Nutrient levels measured in treated water (Nitrate and Nitrite and Ammonium) are typically low. Urlaur Lough has been classified as being of 'Good' over ecological status in EPA report, (2009); although the EPA Water Framework lake waterbody status 2010-2015 for Urlaur Lough is 'Bad' and at risk of not achieving good status in the future. Despite the typically good nutrient levels overall on treated water, it would be important to monitor nutrient status of the raw water supply. Mayo County Council monitors nutrients, specifically Nitrite, Total Nitrogen, Ammonia and Total Phosphorus on average four times per year on Urlaur Lough.

Despite the typically low levels of nutrients overall, diffuse pollution from agriculture, particularly as the majority of the catchment CORINE land cover is classified as pasture, is likely to be the primary source of nutrients, with contributions also likely from point sources such as domestic wastewater treatment systems. The possible presence of springs within Kilmovee Urlaur GWS network may facilitate the delivery of nutrients, microbes and other contaminants into the raw water source from areas outside of the surface water catchment that has been delineated in this report. Recommendations are made in Section 7 with regards to addressing domestic wastewater treatment systems in the locality of Kilmovee Urlaur GWS catchment and engagement with the GSI to assess the zone of ground water contribution in the catchment.

Microbial contamination in the treated water supply is a significant concern and in breach of the Drinking Water Regulations (2014). The UV treatment undertaken by Kilmovee Urlaur GWS reduces the risk of *Cryptosporidium* contamination of the treated water. The microbial contamination levels are currently not been monitored in the raw water supply.

The dilapidated fencing surround the Kilmovee Urlaur water treatment plant and grounds, including the area over the underground water storage tanks is not adequate to ensure site security and needs immediate attention. Kilmovee Urlaur GWS raised concern of the potential public access to the grounds water treatment plant.

Figure 35: The dilapidated timber fencing surrounding the Kilmovee Urlaur water treatment plant.

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

# 7.0 Recommendations

The Kilmovee Urlaur GWS catchment is relatively small at 13.6 $km^2$ and there are agricultural pressures acting within the catchment. A number of key issues are recommended to be addressed in order to improve source protection and maintain high quality raw water supplies for the GWS.

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

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

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

**Monitoring Trihalomethanes (THMs) and Total Organic Carbon (TOC)**
As discussed in this report, the levels of raw apparent colour that are present in the Kilmovee Urlaur GWS raw water supply do not represent health risks. However, upon treatment with chlorine, THMs can be produced when the chlorine reacts with naturally occurring organic matter in the raw water. These THMs have potentially significant health implications, and from the data provided for this report, there appear to be sufficient THM monitoring being undertaken in the treated water supply, given the THM values that have been recorded in the current monitoring programme. Monitoring of THMs is a requirement of the Drinking Water Regulations (2007 and 2014). As THM monitoring has been undertaken and because this monitoring has identified high THM issues, the Scheme should initiate a monitoring programme for Total Organic Carbon (TOC) in the treated and raw water supply respectively in conjunction with the THM sample. Monitoring TOC gives an indication on the level of organic matter in the raw water supply that can react with chlorine during the treatment process to produce THMs. It is recommended that THM and TOC monitoring is focused over the period from late summer through to early winter as this is when true colour values are highest, with additional occasional THM monitoring undertaken throughout the rest of the calendar year. Monitoring of TOC and THM should be undertaken simultaneously: TOC should be monitored on raw water and the monitoring of THM should occur on treated water after chlorination (the formation of THM occurs

within the first ten hours post-chlorination), in the GWS storage reservoir and at the consumer tap. 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 such as groundwater.

The challenge remains between maintaining low THM levels whilst increasing chlorine treatment to remove coliform contamination. It is in this arena where source protection and the catchment-level management actions outline in this report are important. Hence the importance for monitoring microbial contamination in the raw water supply, fencing where appropriate, improving slurry application and management as well as local septic tank management. Reducing microbial contamination may lead to a potential reduction in chlorination treatment levels which in turn can help reduce the risk of THM formation. 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.

**Agriculture and farmyard management**

Levels of nutrients within the Urlaur Lough are low, although there remains the risk of nutrient and microbial pathogen contamination throughout the catchment as identified through groundwater vulnerability and groundwater flow from outside the delineated surface water catchment. The primary sources of nutrient enrichment and microbial contamination of freshwater systems are diffuse agricultural pollution and point source pollution (frequently from domestic wastewater treatment systems). Therefore a number of key issues related to these pollution sources are addressed below:

***(a) Fencing of water bodies***

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

***(b) Nutrient management***

Given the dominance of agriculture in the catchment landscape, 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 2014).

Some important points include:

- 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 catchment, including areas near Urlaur Lough, 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.

Further aspects of nutrient management planning are discussed in Section 7.1 Future Work.

**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). Much of the area surrounding Urlaur Lough has been classified by the EPA's Domestic Wastewater Risk Assessment as being low risk in a non sensitive area. The ground water vulnerability within the catchment is predominantly classified as High or Moderate. Therefore good OSWTS management is vital within the catchment in order to reduce the potential for nutrients 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/.

Kilmovee Urlaur GWS should meet with Scheme members within areas of High ground water vulnerability 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 de-sludged once a year.
- Only permitted waste contractors should remove the sludge –a list of contractors is available from Mayo County Council.
- If effluent is observed sitting on the ground near the tank/system then the system should be checked for blockages and emptied if required. If this is due to poor drainage then expert advice should be sought by contacting Mayo County Council.

## 7.1 Future Work

Within the Kilmovee Urlaur GWS catchment, a number of issues have been identified and recommendations made, and 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 Kilmovee Urlaur GWS 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. Filling water quality monitoring gaps.**

In assessing the water quality monitoring data it is evident that Total Organic Carbon (TOC) (in the raw water) and THM (in the treated water) should be monitored simultaneously. Monitoring TOC gives an indication of the level of organic matter in the raw water supply that can react with chlorine during the treatment process to produce THM. It is recommended that THM and TOC monitoring is focused over the period from late summer through to early winter as this is when colour values are highest, with additional occasional THM and TOC monitoring undertaken simultaneously throughout the rest of the calendar year. The monitoring of THMs should occur on water after chlorination (the formation of THM occurs within the first ten hours post-chlorination), in/near the GWS storage reservoir and at a representative consumer tap within the network.

**3. Engage with Mayo County Council and Glan Agua regarding the management and mitigating measures of THMs within the distribution network.**

The excessive concentrations of THMs of treated waters within the network and at the tap are of concern. As discussed above, it is recommended that THM monitoring is focussed during the period of late summer through to early winter, with additional occasional THM monitoring undertaken throughout the rest of the calendar year. The proposed upgrade of the Kilmovee Urlaur water treatment plant to Dissolved Air Floatation Treatment (DAFT) process (undertaken on raw water prior to chlorination) should help to reduce the water colour and potential formation of THM within the network. Continued consistent monitoring of THMs is recommended during autumn periods to ensure that Drinking Water Regulations are not being exceeded following the DAFT installation. Additional mitigation options that aim to reduce THM concentrations in the treated water supply should be discussed with both Glan Agua and Mayo County Council.

- An assessment of the chlorination procedures within the GWS distribution network is essential in order to help reduce the formation of THM while maintaining sufficient chlorine residual levels post reservoirs to eliminate the potential for microbial contamination along the distribution network.
- Assess aging water within the GWS reservoir and distribution network.

**4. Engage with Mayo County Council and Glan Agua Group regarding site security**

Immediate attention is required to ensure on site security. It is recommended that palisade fencing replaces the existing dilapidated timber fencing currently surrounding the Kilmovee water treatment plant and grounds.

**5. Engage with Mayo County Council and Glan Agua Group regarding water treatment plant operations.**

- An assessment of the current depth of the water intake pipe in Urlaur Lough and it is also recommended that the intake pipe is maintained and cleaned regularly.
- An annual analysis of treated water at the Kilmovee Urlaur was sampled and reported by AECOM (parameters monitored included Copper, Sodium, Chloride, Nitrite, TOC, Pesticides herbicides, Pesticides (ocp) Chromium, Boron, Lead, THM, Iron, Mercury). It would be important to establish if this sampling regime will continue under the new DBO contractor, Glan Agua. The monitoring of iron and manganese on the raw water supply in addition to routinely measured pH, colour and turbidity are also recommended.
- Apparent water colour measurements are available from AECOM and Glan Agua on raw and treated water in the water treatment plant. Some regular measure of True water colour would enable comparisons of raw water values with that of Surface Water Regulations (1989) which is based upon true water colour (parametric value of 20 mg/L PtCo for True Colour for Class A1 waters).
- It is also recommended that a *Cryptosporidium* risk assessment is recommended, given the predominantly Karstic geology and the landuse in the catchment.

**6. Engage with GWS members with regard to on-site waste treatment systems (septic tanks) maintenance.**

Group water scheme members within areas of High ground water vulnerability should be engaged to ensure good septic tanks are maintained and serviced regularly in order to reduce the potential for nutrient and other contaminants entering the surface and ground water bodies.

**7. Engage with Geological Survey Ireland (GSI) regarding groundwater zone of contribution.**

This report this report is solely representative of surface water inputs. With the karstic nature of the catchment geology, there is the strong likelihood of the delivery of groundwater into the lake from areas outside of this surface water catchment. Therefore it is recommended for the GWS to contact GSI with regards to delineating the groundwater zone of contribution for Urlaur Lough.

**8. Soil nutrient analysis**

Given the EPA Water Framework Directive, Lake Waterbody status 2010-2015 classification for Urlaur Lough of 'Bad' and at risk of not achieving good status in the future the implementation of soil nutrient analysis for lands bordering Urlaur Lough would be valuable. Soils with high nutrient status are most likely to result in losses to nearby waterways. Knowledge of soil nutrient status would allow farmers to match fertiliser application to their needs and to save money by not applying fertiliser to fields that do not require it. This analysis would be beneficial to both the GWS and the farmers and therefore the costs could be shared also helping to maintain the good ecological status of Urlaur Lough.

**9. Fencing of land with livestock access to Urlaur Lough**

Restricting direct livestock access to water bodies in the vicinity of Urlaur Lough will assist in reducing potential nutrient and faecal contamination of the raw water source. This action, in combination with the monitoring of faecal coliforms in the raw water, will help to identify further source protection measure required to improve water quality for the GWS and potentially reduce treatment costs in the longer term.

**10. Initiate a communications drive**

Kilmovee Urlaur GWS should undertake a communications initiative to remind scheme members of their legal obligations with regards to nutrient enrichment practices, to recommend Good Agricultural Practices and to highlight the importance of wastewater treatment system management. Highlighting the importance of Scheme members' actions in regards to improving raw water quality could also raise awareness for facilitating improvements in environmental status of all the water bodies within the Kilmovee Urlaur GWS catchment. The location of the treatment works on the edge of Urlaur Lough presents an opportunity for a community open day when members of the local community and GWS members can learn more about the source of their drinking water, be informed about the treatment process, the work that is required to ensure good quality water reaches their taps and the source protection measures that need to be implemented to ensure good raw water quality. Consideration should be given to engaging local schools to take an interest in local water resource management issues and to encourage students to undertake projects that can ultimately help raise the profile of GWS and the source protection measures required to help improve the environmental status of the catchment area whilst also providing cost-savings in the water treatment process.

## 8.0 References

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

EPA (2010). Poorly productive aquifers. Monitoring installations and conceptual understanding. Environmental Protection Agency.

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

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

EPA (2014). Shannon, D., Wall, B. and Flynn, D. Focus on Urban Wastewater Treatment in 2012. Environmental Protection Agency.

EPA_Drinking_Water, Drinking Water Monitoring Results and Water Supply Details for Ireland - Year 2010. Associated datasets and digital information objects connected to this resource are available at: Secure Archive For Environmental Research Data (SAFER) managed by Environmental Protection Agency Ireland http://erc.epa.ie/safer/resource?id=9def7675-407b-11e1-adca-005056ae0019 (Last Accessed: 2016-03-09)

EPA_Drinking_Water, Drinking Water Monitoring Results and Water Supply Details for Ireland - Year 2011**.** Datasets Available At: Secure Archive For Environmental Research Data managed by Environmental Protection Agency Ireland http://erc.epa.ie/safer/resource?id=f588f768-4519-11e2-b52a-005056ae0019 (Last Accessed: 2016-03-09).

EPA_Drinking_Water, Drinking Water Monitoring Results and Water Supply Details for Ireland - Year 2012**.** Associated datasets and digital information objects connected to this resource are available at: Secure Archive For Environmental Research Data (SAFER) managed by Environmental Protection Agency Ireland http://erc.epa.ie/safer/resource?id=c434eae6-697f-11e3-b233-005056ae0019 (Last Accessed: 2016-03-09).

EPA_Drinking_Water, Drinking Water Monitoring Results and Water Supply Details for Ireland - Year 2013**.** Associated datasets and digital information objects connected to this resource are available at: Secure Archive For Environmental Research Data (SAFER) managed by Environmental Protection Agency Ireland http://erc.epa.ie/safer/resource?id=3883b560-7666-11e4-8d3a-005056ae0019 (Last Accessed: 2016-03-09).

EPA_Drinking_Water, Drinking Water Monitoring Results and Water Supply Details for Ireland - Year 2014**.** Datasets Available At: Secure Archive For Environmental Research Data managed by Environmental Protection Agency Ireland http://erc.epa.ie/safer/resource?id=a0a17d78-725a-11e5-ab63-005056ae0019 (Last Accessed: 2016-03-09).

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

Inland Fisheries Ireland (2010) Water Framework Directive Fish Stock Survey of Urlaur Lough. Inland Fisheries Ireland, Swords Business Campus, Swords, Co. Dublin, Ireland.

NPWS (1999) Site *synopsis: Urlaur Lough. Site code: 001571*. Site Synopsis report, National Parks and Wildlife Service.