

Preliminary Report on Source Protection

Mountain Lodge Group Water Scheme

(Lough Naglare)



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Table of Contents

1.0 Introduction	4
2.0 Methods	4
3.0 Overview of Lough Naglare and the Water Framework Directive (WFD)	6
4.0 Physical Site Description	6
5.0 Land use within the catchment	14
5.1 Overall interpretation of catchment and land use	15
6.0 Raw water Quality.....	16
6.1 Lake Water Quality.....	16
6.2 Important parameters for source protection	20
6.3 Overall interpretation of Water Quality	25
7.0 Recommendations	27
7.1 Future work.....	30

List of Figures

Figure 1 Ordnance Survey map showing the catchment outline	7
Figure 2 Bedrock geology in the Lough Naglare catchment.....	8
Figure 3 Aquifers present in the Lough Naglare catchment.....	9
Figure 4 Groundwater vulnerability in the Lough Naglare catchment.....	10
Figure 5 Subsoils present in the Lough Naglare catchment	11
Figure 6 Soils present in the Lough Naglare catchment.....	12
Figure 7 Corine land cover classification of the Lough Naglare catchment	14
Figure 8 Apparent colour in Lough Naglare	17
Figure 9 Turbidity in Lough Naglare.....	18
Figure 10 Iron (Fe) in Lough Naglare.....	19
Figure 11 Manganese (Mn) in Lough Naglare.....	20

List of Tables

Table1. Data sets used to describe the catchment.	5
Table 2. Subsoils in the catchment and map codes.....	11
Table 3. Soils in the catchment.....	13
Table 4 Total phosphorus, ortho-phosphorus and chlorophyll concentrations.....	22
Table 5 Modified Lake classification scheme based on annual maximum chlorophyll-a.....	22
Table 6 OECD Lake classification scheme	23
Table 7 Coliform data from Lough Naglare.....	25

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 potential 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, Co. Monaghan (2005-2009), was established by the National Rural Water Monitoring Committee and was overseen by the National Centre for Freshwater Studies (NCFS) 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 of 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* spp., *Escherichia coli*, *Cryptosporidium* spp.) of their water supplies, and to meet application conditions for a Water Services Licence under the Water Services Act (2007).

This report provides an overview of how Lough Naglare fits into the Water Framework Directive (WFD), the all-inclusive legal framework for raw water quality in the European Union. In addition to summarising issues highlighted in the wider River Woodford Water Management Unit Action Plan, the report provides a physical site description of the Lough Naglare catchment, explaining how this is relevant to water quality. The potential impact of land use is discussed, while the available raw water quality data is evaluated. Based on the above information the major concerns relating to source protection are highlighted and recommendations are made as how best to manage these in the future.

2.0 Methods

Catchment delineation

The catchment outline was defined using the available contours on the OS Discovery Series (1:50,000) maps. A map of the stream network and other water bodies was available in GIS format (Table 1). This allowed any streams flowing into the lake to be identified. These maps were complemented by use of old 6 inch to 1 mile (scale) maps of the area available at

www.osi.ie. Those maps were particularly useful in defining direction of flow in small streams. The results were cross-referenced with the River Woodford Water Management Unit generated as part of the Water Framework Directive.

Catchment description

Various national data sets (Table 1) relating to soils, geology, land cover etc. were accessed in GIS format and the appropriate sections clipped to the catchment area of Lough Naglare. This allowed for the potential impacts of these factors to be analysed.

Table1. Data sets used to describe the catchment.

Dataset	Source	Description
Corine	EPA Ireland	Image of land cover based on satellite imagery
Soils	Teagasc*	Irish Forestry Service soil types. Similar to great soils map
Subsoils	Teagasc*	Parent material is the material from which soils are formed
Bedrock Geology	GSI	Map of Irish bedrock
Aquifer Bedrock	GSI	Information of quality of aquifers
Aquifer Vulnerability	GSI	Information on connectivity between contaminants and aquifers
Streams/Lakes/Rivers	EPA Ireland	National data sets

*Soils and Subsoils data generated by Teagasc with co-operation of the Forest Service, EPA and GSI. Project completed May 2006.

Water Quality Data

Water quality data relating to Lough Naglare and its catchment were collated from a number of sources. Veolia Water carries out weekly monitoring of raw water for a number of parameters important to the treatment process. More detailed data on lake water quality was available from the design contract for the water treatment plant and occasional external monitoring carried out by Veolia Water. No monitoring of the lake was carried out by Cavan County Council or the EPA.

The maximum values for each parameter in the design contract are important for the GWS. The water treatment plant was designed to treat water of this quality and departures from this may be the responsibility of the scheme, not the operator.

The parameters of relevance to source protection, from the above mentioned data, were discussed in detail. The data was also interpreted to highlight potential water quality issues in Lough Naglare and their potential causes and impacts.

3.0 Overview of Lough Naglare and the Water Framework Directive (WFD)

Under the Water Framework Directive, the island of Ireland has been divided into 8 river basin districts, 2 of which are international. Lough Naglare and its catchment lie within the North Western River Basin District. Under the WFD each RBD is subdivided into water management units. Lough Naglare and its catchment are part of the Woodford Water Management Unit and an action plan for this area was available at www.wfdireland.ie.

This action plan presented an overview of water quality, information relating to potential causes of pollution and actions required to improve water quality to good status. Streams in Woodford Water Management Unit were mainly of moderate or poor status with small stream lengths of good status also present. Lakes within the area were mainly of less than good status. Lough Naglare was assigned moderate status even though it was not directly monitored.

Throughout the water management unit various pressures on water quality have been identified. These include, waste water treatment plants (WWTPs), integrated pollution prevention control (IPPC) licensed facilities, diffuse nutrients from agriculture and pollution from septic tanks. As there are no IPPC licensed facilities or WWTPs in the Lough Naglare catchment it is likely that agriculture and septic tanks constitute the main pressures on water quality. All water bodies in the WMU were potentially at risk from agriculture. The Action Plan proposed that issues relating to agriculture be addressed through the implementation of the Good Agricultural Practice Regulations. It is further proposed that on-site wastewater treatment systems (septic tanks) be prioritised for inspection

4.0 Physical Site Description

Catchment location and outline

Lough Naglare is located approximately 17km east of Cavan town in Co. Cavan (H585 024). The lake has an area of 6.4 hectares and it drains an area of approximately 157 hectares. The lake is surrounded by hills to the north, east and south which drain into the lake. Lough

Naglare is situated at 174m above sea level and the highest point within the catchment is approximately 240m, situated to the south of the lake (H 587 015). The main inflow to the lake enters from the east. This stream is visible on the OS 1:50000 series map and rises in the south east of the catchment (H 593 015). A smaller inflow stream was located on a historic map of the area (included in Figure 1). This stream enters the lake from the south west (H 584 023). The lake outflow leaves the lake just north of this inflow. The outflow drains generally north and then west before discharging into Lough Acanon.

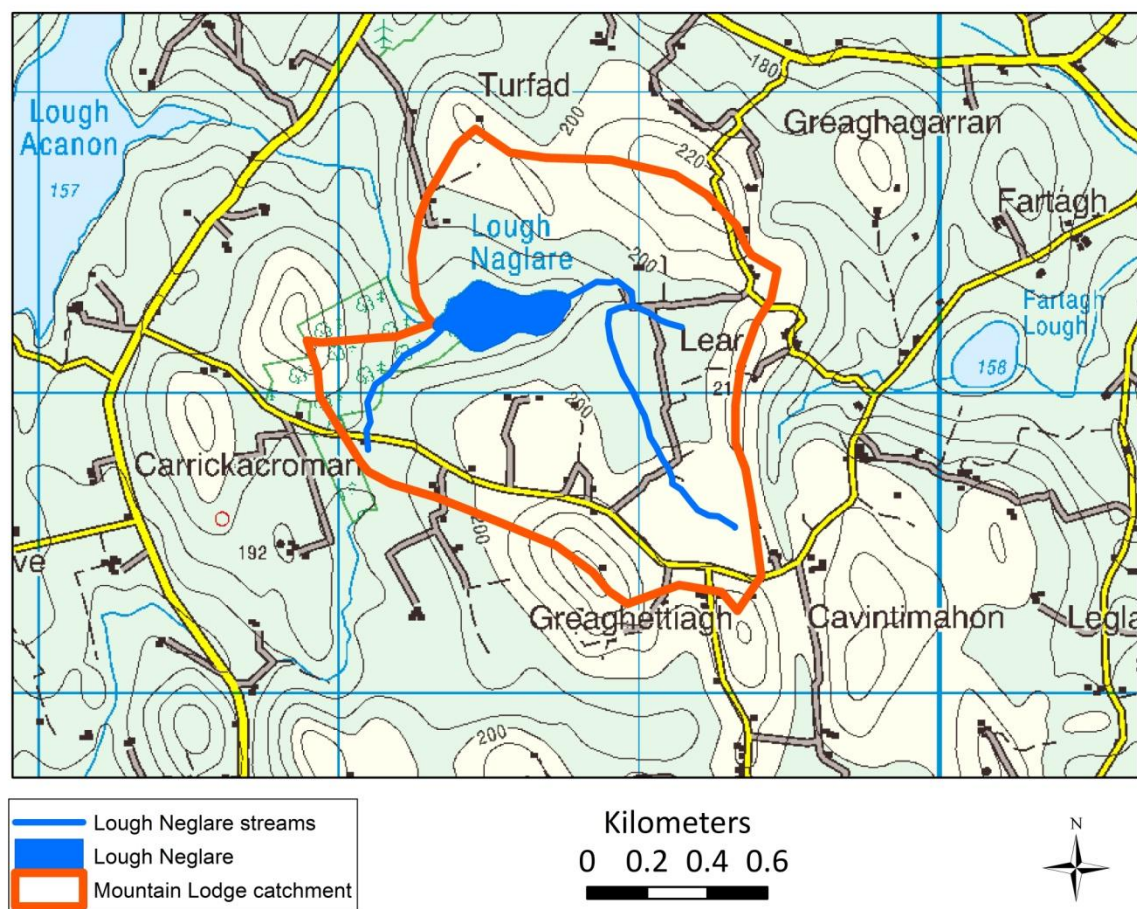


Figure 1 Ordnance Survey map showing the catchment outline

Bedrock geology

The Lough Naglare catchment is mainly underlain by Silurian metasediments and volcanics (Figure 2). These rocks were laid down during the Silurian period which represents the time period between approximately 444 million years ago and 416 million years ago. The metasedimentary rocks represent sedimentary rocks which have been altered through metamorphism. The volcanic rocks were formed from magma. These rock types do not contain large fissuring or cracking and are unlikely to support large aquifers. Similarly, the

Ordovician rock formations are unlikely to support large aquifer and ground water flows will be confined to the upper few metres of bedrock. The Ordovician period occurred before the Silurian and includes the geological time period between 488 and 444 million years ago.

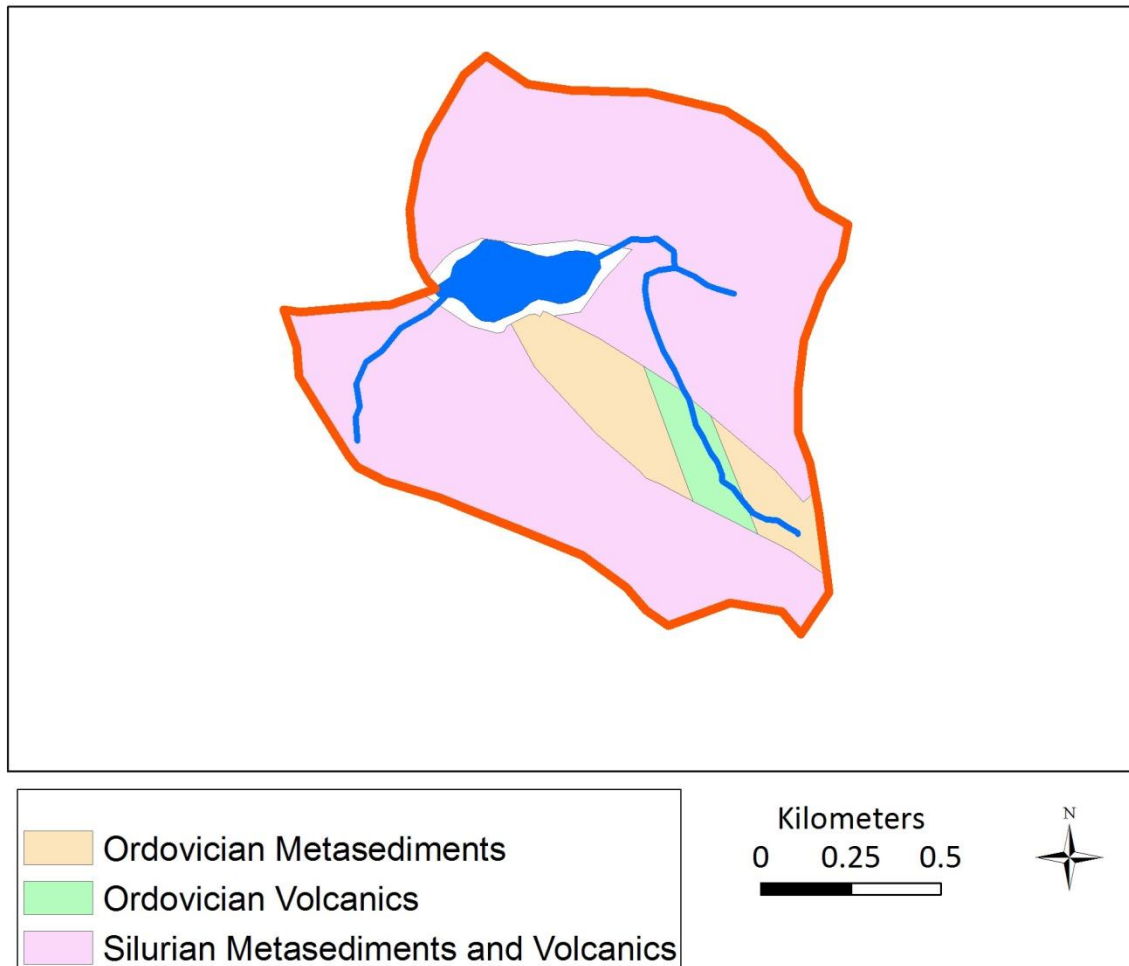


Figure 2 Bedrock geology in the Lough Naglare catchment

Aquifer Bedrock

All aquifers in the Lough Naglare catchment were described as poor aquifers (Figure 3). This is a reflection of the bedrock geology described above and means that the area is unlikely to support any large aquifers. Storage capacity, recharge acceptance, and base flow contributions are all likely to be low in this area. This suggests that during dry periods, stream levels will be very low and lake retention time will be high. This will make Lough Naglare particularly susceptible to pollution events during dry weather conditions.

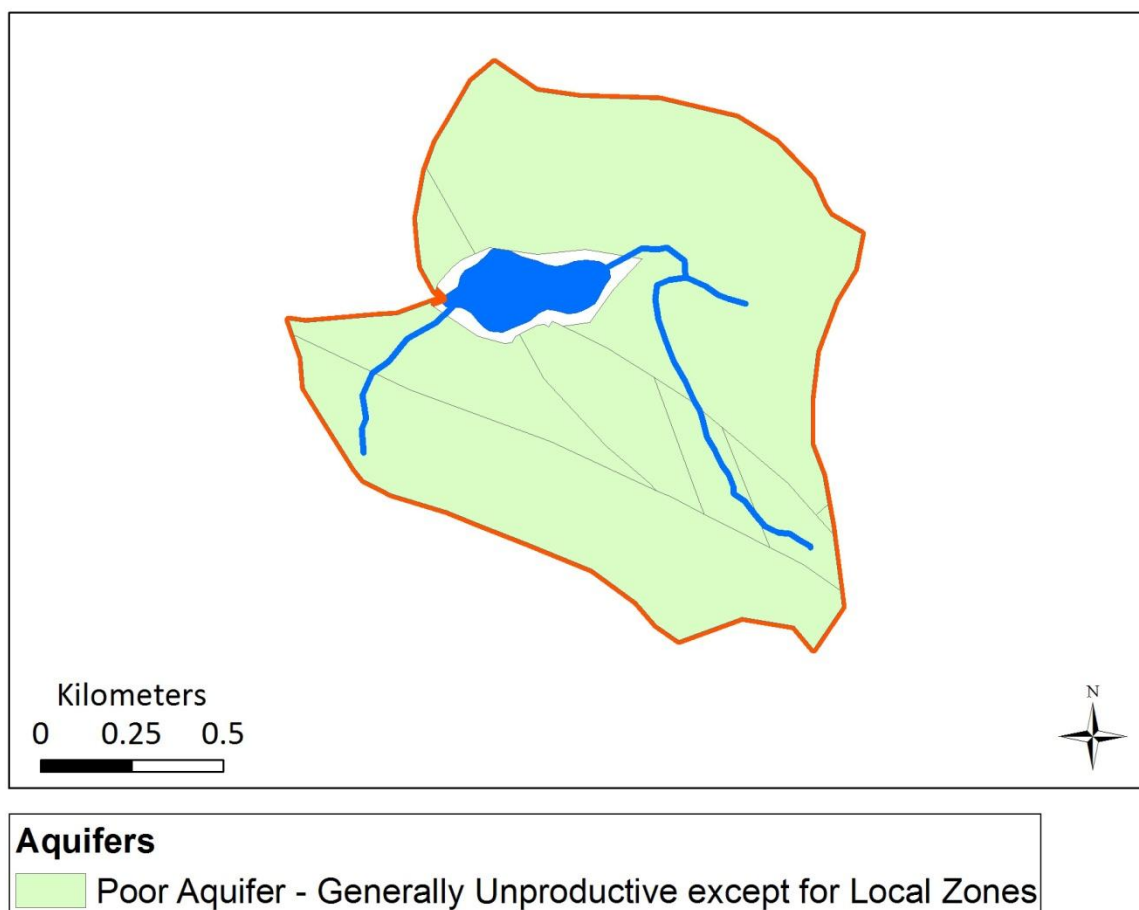


Figure 3 Aquifers present in the Lough Naglare catchment

Aquifer Vulnerability

The vulnerability of groundwater refers to the likelihood of surface contaminants reaching the groundwater store (Figure 4). The vulnerability of groundwater depends on: (i) the time of travel of infiltrating water (and contaminants); (ii) the relative quantity of contaminants that can reach the groundwater; and (iii) the contaminant attenuation capacity of the geological materials through which the water and contaminants infiltrate.

Only interim data on groundwater vulnerability was available for large parts to the Lough Naglare catchment. The areas that were monitored were described as extremely vulnerable indicating that the overlying soils were either very thin or offered little protection to local groundwater.

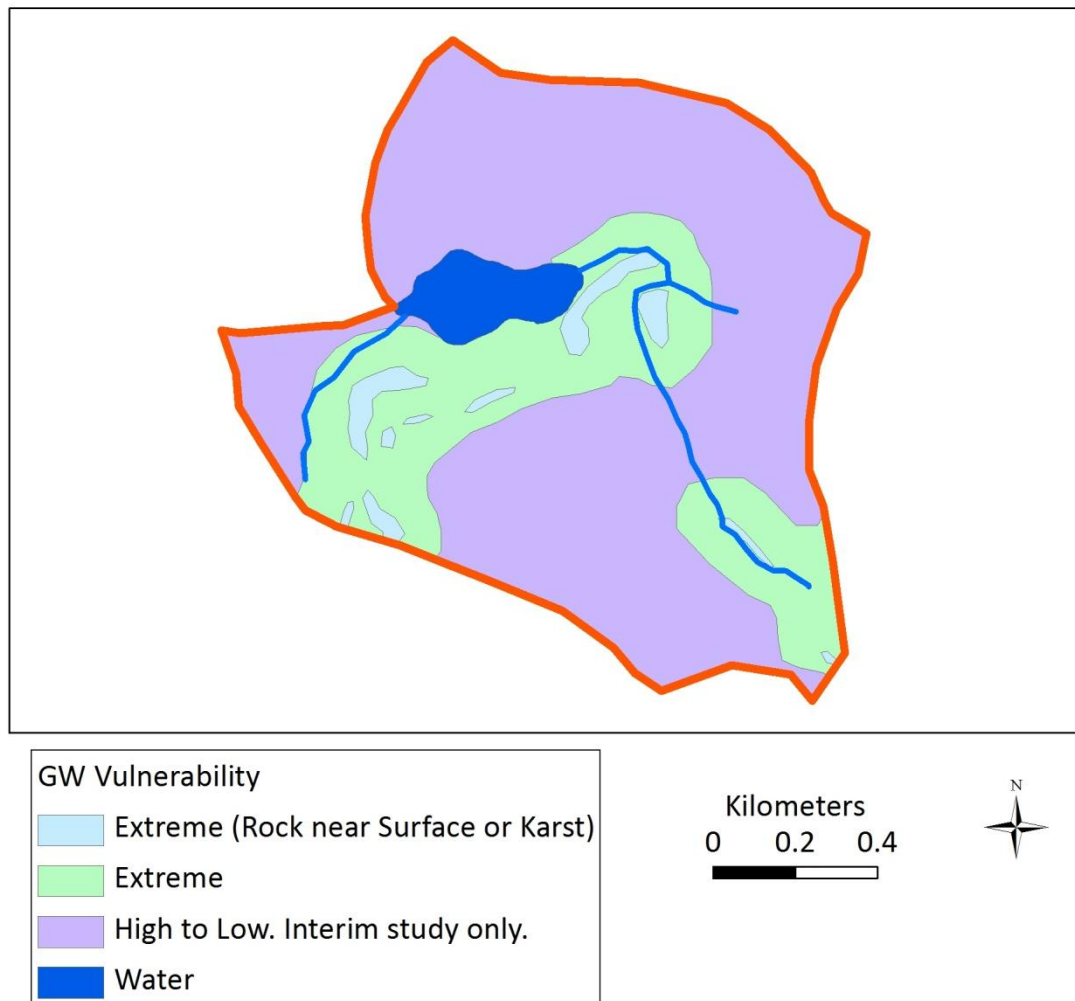


Figure 4 Groundwater vulnerability in the Lough Naglare catchment

Subsoils

Subsoils within the catchment are dominated by sandstone and shale dominated till (Figure 5). Till subsoils were generally deposited by glaciers after the last ice age. These soils are often tightly packed and contain particles of varying sizes. Depending on the depth of these tills and their drainage characteristics they may give rise to different top soils. There were also areas of rock and cut peat in the catchment. Peat subsoils will have poor drainage while rock at or near the ground surface is indicative of thin unproductive soils. The topsoil's present will be discussed below.

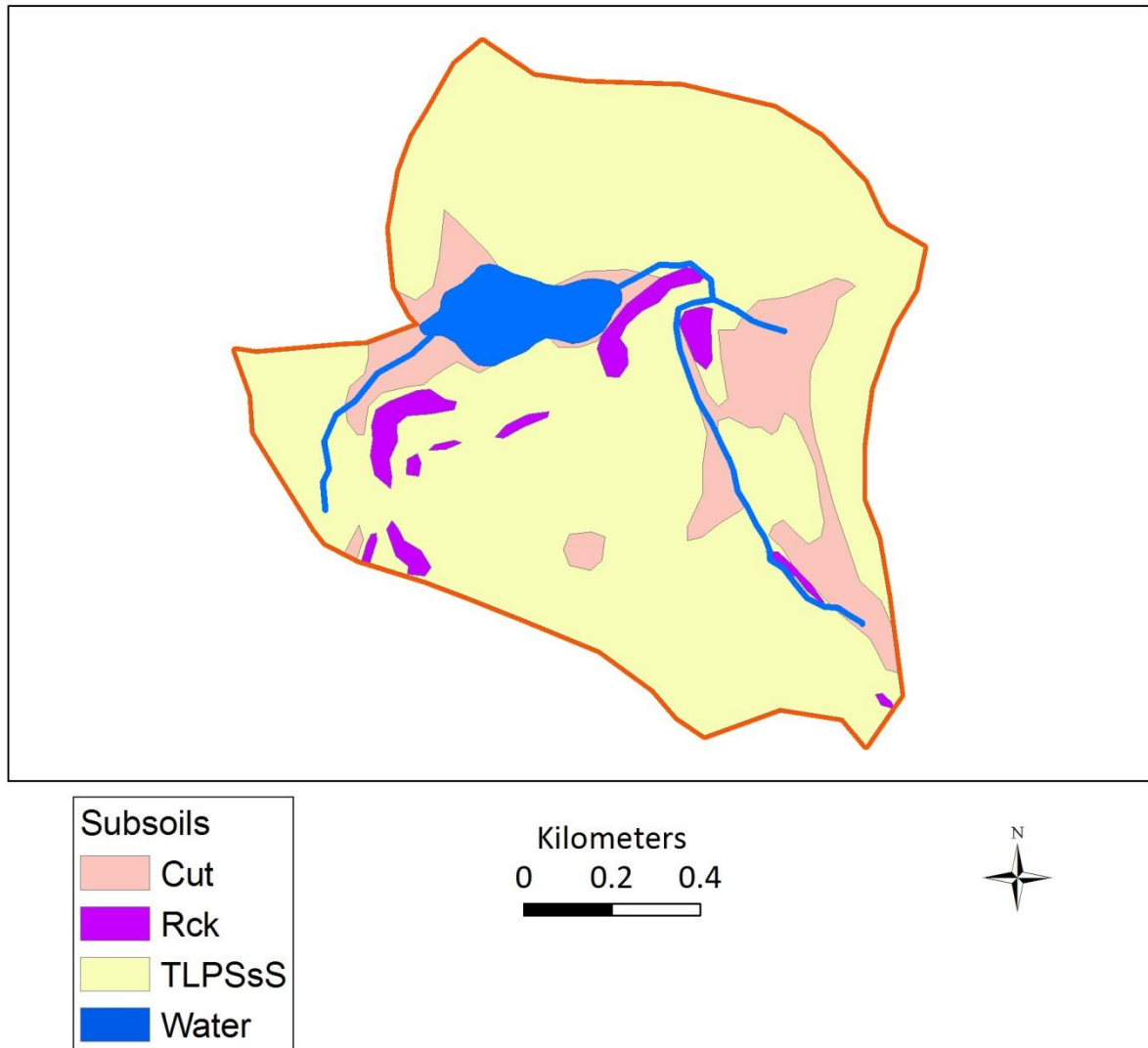


Figure 5 Subsoils present in the Lough Naglare catchment (see Table 2 for map codes)

Table 2. Subsoils in the catchment and map codes

Subsoil Description	Map code
Till type	
Sandstone and shale till (Lower Palaeozoic)	TLPSsS
Peat	
Cut-over peat	Cut
Other categories	
Bedrock at surface	Rck

Soils

Soils in the Lough Naglare catchment are dominated by the class AminPD soils (Figure 6). This category consists of gley soils. Gley soils have impeded drainage and have a poor physical condition. These conditions are unsuitable for cultivation or intensive grassland farming. If combined with steep slopes, these soils are likely to lead to overland flow of water during periods of rainfall. Cut peats are also present in the catchment. These soils are located near the inflow streams and are likely to represent the wettest parts of the catchment. Peat soils also have an inability to retain phosphorus so any fertiliser added to these soils is likely to be lost to local water courses. The remainder of the soils in the catchment consist of Amin SRPT and Amin SW. These groups represent poor quality soils that are either rocky or peaty in nature.

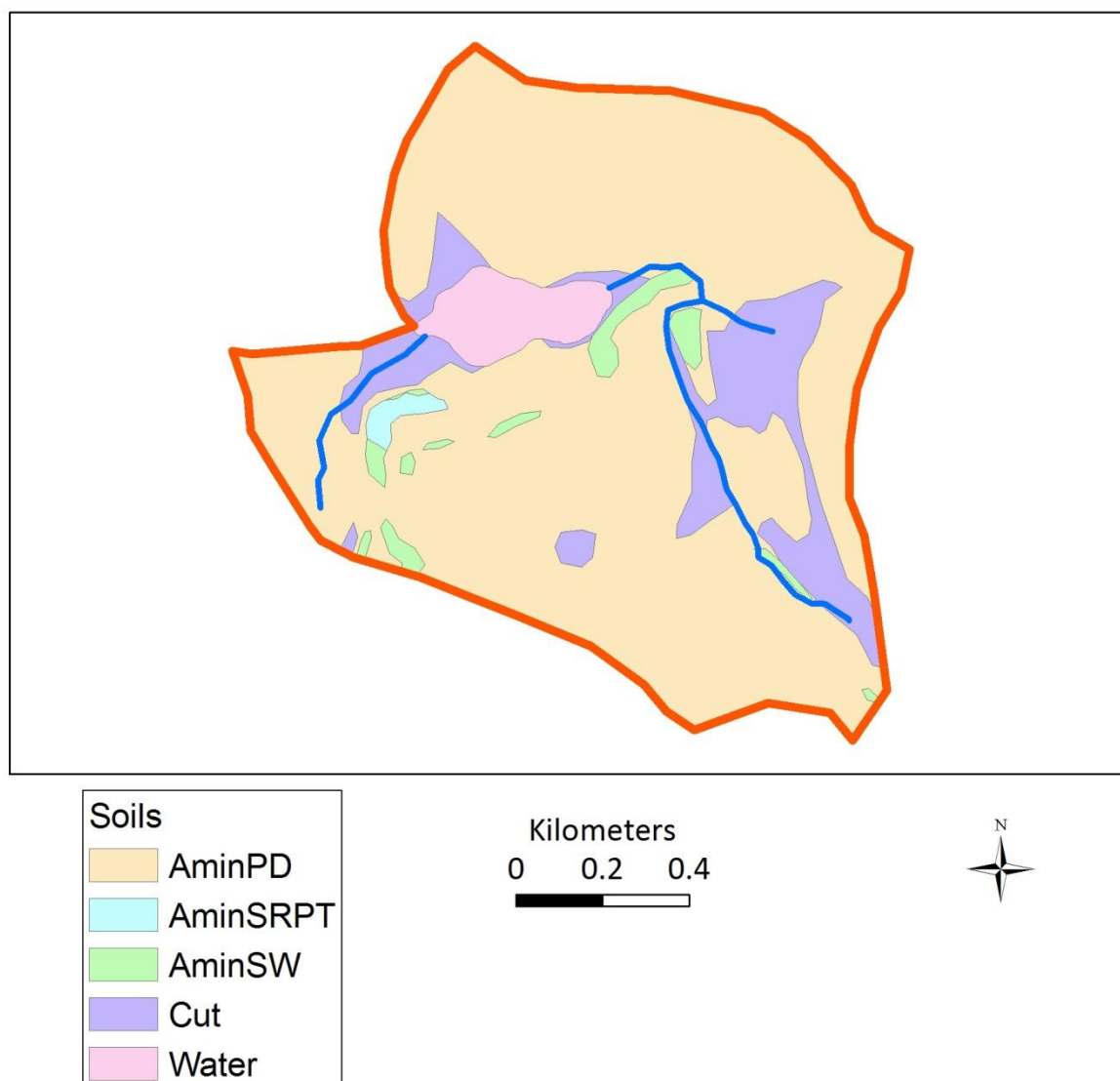


Figure 6 Soils present in the Lough Naglare catchment (refer to Table 3 for soil descriptions)

Table 3. Soils in the catchment

IFS Soil Description	IFS_soil	IFS Code	Included Great Soil Groups
Shallow well drained mineral			
Derived from mainly non-calcareous parent materials	AminSW	21	Lithosols Regosols
Deep poorly drained mineral			
Derived from mainly non-calcareous parent materials	AminPD	31	Surface water Gleys Groundwater Gleys
Shallow, lithosolic-podzolic type soils potentially with peaty topsoil			
Predominantly shallow soils derived from non-calcareous rock or gravels with/without peaty surface horizon	AminSRPT	43	Podzols (Peaty) Lithosols Peats
Peats			
Cutaway/cut-over peat	Cut	65	Basin Peats Blanket Peats
Miscellaneous			
Lake (including reservoirs)	Water	76	

Slope and run-off

The slope of lands leading to a waterbody is an important determinant of the rate at which water and pollutants move into the lake by overland and subsurface flows. Slope will ultimately affect the quantity of nutrients and pathogens entering the lake and, hence, its water quality. Steep slopes are vulnerable to surface run-off, particularly if combined with poor draining soils.

There are steep slopes located throughout the catchment. This is particularly true of land bordering the lake and near the catchment boundaries. Considering the poor drainage qualities of the soils in the catchment it is particularly important to consider slope when applying fertilisers and manure in this catchment. It will be particularly important to address pollution issues where steep slopes lead towards waterways (streams and lake).

5.0 Land use within the catchment

Corine

Corine land cover data gives some insight into land use within the Lough Naglare catchment. This satellite derived image, describes the catchment as totally dominated by pasture. Both improved and unimproved pastures were present with the unimproved pastures generally associated with land at higher elevations.

Based on a preliminary site visit, this map does not perfectly represent the complexity of land cover. Some of the improved pasture described here (Figure 7) was unexploited and boggy in nature.



Figure 7 Corine land cover classification of the Lough Naglare catchment

Forestry plantations present threats to water quality both during planting and early growing stages and during felling. Water quality can be affected by activities such as ground preparation, fertilisation, thinning, felling and construction of forestry roads.

There is forestry located to the west of the Lough Naglare catchment. Based on maps of the area and the preliminary site visit it was felt that the entirety of this forestry was outside of the lake catchment and unlikely to cause pollution to the lake.

Rural Housing, farm yards and on-site waste water treatment plants

The location of rural houses in the Lough Naglare catchment was estimated by viewing the Ordnance Survey map of the area as well as aerial photographs available online at www.osi.ie. While houses cannot be differentiated from other buildings, some insight into the location of houses and associated on-site waste water treatment plants (usually septic tanks) was gained. Two areas within the catchment were identified as possibly containing septic tanks. These were along the local road to the south of the catchment (H 593 015) and along the road to the east of the catchment (H 594 025).

There are a small number of farm yards within the catchment (exact number to be confirmed by local GWS). Generally these farm yards are near the catchment boundaries and away from the lake and open watercourses. However, the potential for soiled water, manure and silage effluent to pollute water should be noted.

Recommendation on how to deal with septic tank issues will be discussed later. Similarly, good farm yard management will be discussed in the recommendations section below.

5.1 Overall interpretation of catchment and land use

Lough Naglare has a surface area of 6.4 hectares and has a drainage catchment of approximately 157 hectares. The lake is located amongst steeply sloping hills in Co. Cavan. The main inflow to the lake is from a small stream (approx 1km in length) entering the lake at the eastern end. A smaller stream enters the lake through a boggy area at the western end of the lake. The outflow, which links Lough Naglare to Lough Acanon, leaves the lake just north of this point.

The geology of the catchment is unlikely to support large aquifers. This means that there is little potential for drilling large wells in the area. It also means that during dry periods input to the lake from streams and springs will be very low. This explains why lake level has fluctuated during the history of Mountain Lodge GWS. Another impact of low water input from streams is that any pollution incidents within the catchment will not be well diluted. Similarly, poor water quality in the lake will take a long time to be washed downstream. These factors make the protection of water quality in this catchment particularly important.

Soils within the catchment were dominated by poorly draining gley soils with some peat also present. These soils are unsuitable for intensive agriculture. All agriculture within the

catchment was grass based and out-wintering of cattle and sheep was noted during a preliminary site visit. The intensity of agriculture is low around the lake with areas of bog and rough grazing present. The poor nature of the soils, combined with the steep slopes noted above, make water susceptible to pollution from agriculture if care is not taken. Manure and fertiliser spread within the catchment has the potential to be washed into nearby watercourses. Also, high livestock densities on poor soils may lead to soil poaching. This may cause pollution if it occurs near waterways.

There are some farmyards and septic tanks within the catchment. In general, these are located away from the lake and the inflowing streams but they should be considered in a management strategy for the lake.

6.0 Raw water Quality

6.1 Lake Water Quality

Colour

Natural colour reflects the presence of organic molecules originating from humic matter such as peat, leaves and branches. A coloured water supply does not pose high health risks in itself but can react with chlorine in the treatment plant to create trihalomethanes and add significantly to the cost of treatment. For this reason high levels of colour should be avoided where possible. Colour is a parameter that varies greatly depending on quantities of precipitation and run-off, leading to spikes in results. Results may be presented as apparent colour (from an unfiltered sample) or true colour (filtered sample) in results. Colour in Irish Lakes ranged between 5 mg/L PtCo to 134 mg/L PtCo in a series of lakes presented by Irvine *et al.* (2001). The Surface Water Regulations (1989) specify a recommended value of 20 PtCo/hazen for A1 waters (true colour).

True colour

True colour in Lough Naglare ranged between 10 PtCo (4th May 2006) and 193 PtCo (13th March 2007). The average value between 2006 and 2010 was 79.3 PtCo. This average value is in excess of the specified limit value for A1 waters under the Surface Water Regulations (1989).

Apparent colour

Similar to true colour above, apparent colour varied greatly in the available data (Figure 8). Apparent colour, which is based on analysis of a non-filtered sample, can be seen to vary depending on rainfall amount. In the period between August and November 2007 apparent colour increased in response to greater rainfall. Again in 2008, the period between August

and November had both high rainfall and high apparent colour. This process was repeated between August 2009 and January 2010. Apparent colour values were frequently in excess of the threshold set out in the design contract for the plant (green line in Figure 8). These results show how heavy rainfall interacts with the catchment and deliver organic matter to the lake. Poor soil management and bank stability will increase the impacts of rainfall.

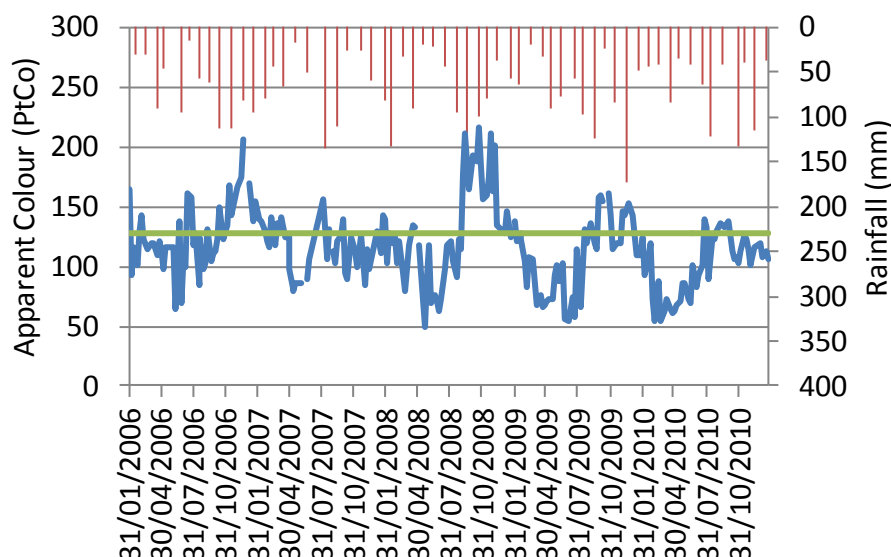


Figure 8 Apparent colour in Lough Naglare between January 2006 and December 2010 (axis-1). Red bars represent monthly rainfall (Armagh Observatory shown on the axis-2). Green line represents maximum allowable colour value from the DBO contract.

Turbidity

Turbidity in water consists of very finely divided particles (too small to be removed by normal 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. The following units are often used to present Turbidity: JTU (Jackson Turbidity Units), FTU (Formazin Turbidity Units) and NTU (Nephelometric Turbidity Units). These three units can be interpreted to mean the same thing.

Turbidity in Lough Naglare ranged between 1.4 NTU and 20.0 NTU (Figure 9). The average value between 2006 and 2010 was 5.1 NTU. Changes in turbidity followed a similar pattern to the parameters described above with rainfall likely a driving factor. Higher values between August and September 2006 were recorded during relatively dry months. This may indicate that turbidity was affected by algal growth during dry, warm periods. Turbidity in Lough Naglare was never in excess of the limit value set out in the design contract for the plant.

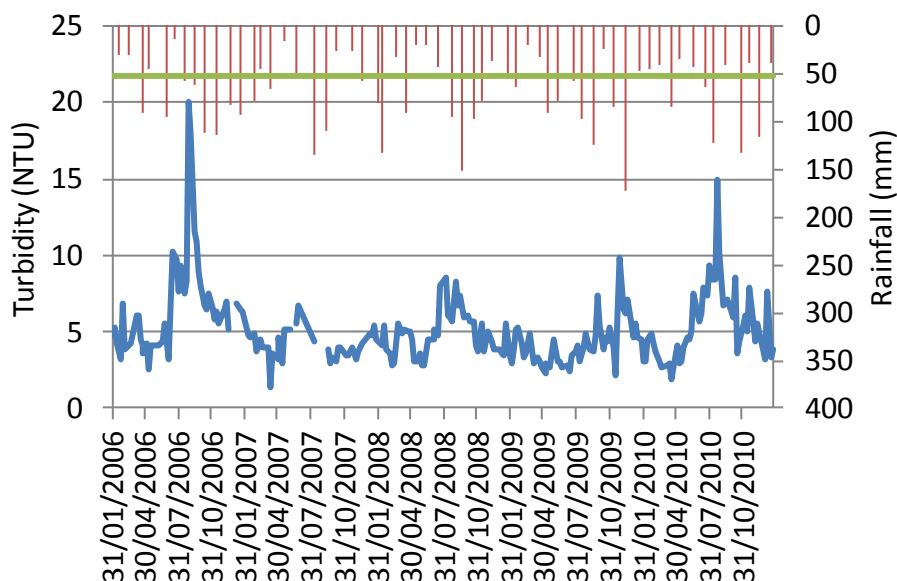


Figure 9 Turbidity in Lough Naglare between January 2006 and December 2010 (axis-1). Red bars represent monthly rainfall (Armagh Observatory shown on the axis-2). Green line represents maximum allowable turbidity value from the DBO contract.

Iron

Iron (Fe) is present in rocks and soils in an insoluble form but can become soluble when water passes through ground formations. Large amounts of iron in water do not normally have harmful effects for users but can be aesthetically unpleasing by causing colour changes or turbidity (due to oxidation of soluble ferrous to insoluble ferric). This can lead to staining of laundry, discolouration of vegetables following cooking, and taste problems. Under the Surface Water Regulations (1989) the recommended concentration of Fe in Class A1 waters is 0.2 mg/L.

Iron concentration in Lough Naglare ranged between 0.009 mg/L (1st January 2006) and 0.576mg/L (1st August 2006) (Figure 10). The average value between 2006 and 2010 was 0.21mg/L. While none of these values were in excess of the design contract for the plant, they were regularly in excess of the 0.2mg/L Fe recommended under the Surface Water Regulations (1989).

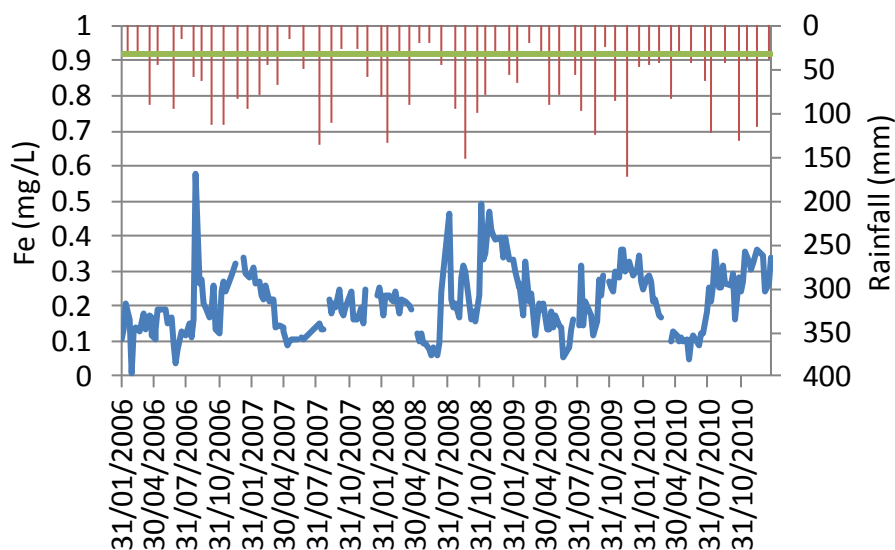


Figure 10 Iron (Fe) in Lough Naglare between January 2006 and December 2010 (axis-1). Red bars represent monthly rainfall (Armagh Observatory shown on the axis-2). Green line represents maximum allowable iron value from the DBO contract.

Manganese

Manganese (Mn) is found in soils and groundwater. It is generally not considered to be harmful to humans but can cause more severe staining problems than iron and adversely affect taste, and in large volumes, block pipes. Under the Surface Water Regulations (1989) the recommended value for Mn in Class A1 waters is 0.05 mg/L.

Raw water manganese concentrations in Lough Naglare were regularly in excess of the guidelines in the Surface Water Regulations (1989) for A1 waters. Despite these higher values, raw water sampling as part of the design contract contained even higher concentrations. This meant that values recorded in the raw water between 2006 and 2010 were not in breach of the limits set out in the design contract (see green line in Figure 11). High manganese concentrations may be a result of soil mineral content being washed into the lake but can also be released from the lake sediment if oxygen levels in the lake are significantly reduced.

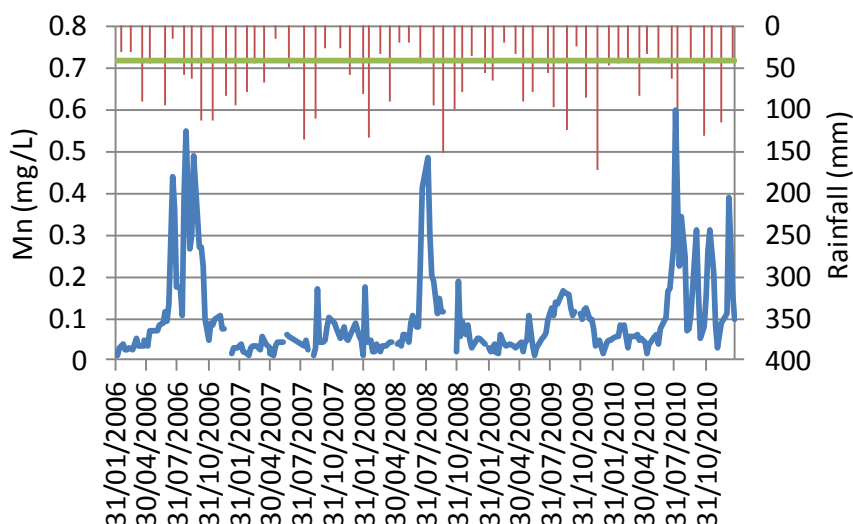


Figure 11 Manganese (Mn) in Lough Naglare between January 2006 and December 2010 (axis-1). Red bars represent monthly rainfall (Armagh Observatory shown on the axis-2). Green line represents maximum allowable manganese value from the DBO contract.

pH

The pH value of water is generally only of concern if it is extremely low or high, indicating extreme acidity or alkalinity, respectively, which in turn may have consequences for odour or taste, lead to corrosion in distribution systems, or affect fish survival. Water generally lies in the range of 6.5-8.0. The Surface Water Regulations (1989) recommend a range of 5.5-8.5 for Class A1 waters.

pH data for Lough Naglare was only available between January 2006 and June 2007. Within this period pH ranged between 6.38 and 7.93. These values were within the recommended range for A1 waters under the Surface Water Regulations (1989).

6.2 Important parameters for source protection

The parameters below present additional data available from Lough Naglare (Appendix A). These samples were presented by T.J. O'Connor and Associates, Consulting Engineers as part of the design contract for the GWS treatment plant (2002-2003). Some additional raw water samples have been taken by Veolia Water in more recent years. Many of these parameters give greater insight into raw water quality and the impact of human activities on water quality.

Eutrophication and Trophic Status (Note)

Eutrophic means well nourished and eutrophication is the process where pristine waterbodies become more eutrophic through the addition of nutrients (primarily N and P). These additional nutrients 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 from differing degrees of eutrophication, termed trophic status. Lakes are often characterised on the following scale; oligotrophic (low in nutrients and algal growth), mesotrophic (moderately productive, less clean than oligotrophic) and eutrophic (high levels of nutrients and algal growth, poor water quality). Sub categories are sometimes referred to and the term hypertrophic is used to describe lakes suffering from excessive eutrophication. Determination of trophic status is often made based on algal abundance (chlorophyll-a) or total phosphorus concentration (the most important nutrient in this process).

Total phosphorus

Phosphorus occurs widely in nature but most phosphorus in water is added through anthropogenic activities. Human and animal wastes contain large amounts of phosphorus and therefore agriculture and waste water treatment plants are major sources. Artificial fertilisers used in agriculture and forestry add further phosphorus to the environment, much of which is lost to watercourses. Phosphorus, and to a lesser extent nitrogen are the main nutrients involved in eutrophication. The negative impacts of eutrophication on water quality may include a loss of biological diversity and of desirable species, increased macrophyte growth, the development of algal scums as well as a general deterioration in water quality. Eutrophication is the largest threat to Irish water quality and is of central importance to drinking water sources. Specific to drinking water sources, increased algal abundance can lead to problems in treatment plants and decomposing algae can produce toxins and cause taste and odour problems. The management of phosphorus loading is central to the long term viability of many drinking water sources.

Total phosphorus concentrations were only monitored in Lough Naglare during the development of the design contract (Table 4). The average from these nine samples was 0.11 mg/L. According to the OECD lake classification scheme (Table 6) for lakes, this value would categorise Lough Naglare as hypertrophic. This is the worst category based on total phosphorus concentration and is indicative of significantly deteriorated water quality.

Table 4 Total phosphorus, ortho-phosphorus and chlorophyll concentrations from Lough Naglare.

Date	Total phosphorus (mg/L as P)	Ortho-phosphorus (mg/L as P)	Chlorophyll mg/m ³
06/09/2002	0.089	0.02	19.7
09/10/2002	0.078		26
05/11/2002	0.059	0.038	14.3
04/12/2002	0.089	0.113	19.4
27/01/2003	0.055	0.028	5.5
25/02/2003	0.045	0.029	17.4
21/03/2003	0.046	0.013	18.6
29/04/2003	0.058	0.016	<3
16/05/2003	0.477	0.007	33.8
20/06/2003			4.7
17/07/2003			23.6
Average 2002-2003	0.11	0.03	18.3

Chlororophyll

Chlorophyll is a very important parameter in lake water quality. It is used as an indicator of overall algal abundance within a lake. The presence of algae can be problematic for treatment processes within the water treatment plant and can also lead to taste and odour problems in treated water. Generally chlorophyll values are highest in summer when weather is warmer and light availability is high.

Similar to total phosphorus above, chlorophyll was only monitored between 2002 and 2003 (Table 4). While chlorophyll did not completely conform to the expected annual trend (higher in summer, lower in winter) some interpretation is still possible. The average concentration was indicative of mesotrophic status (Table 6). This is more positive classification that gained using phosphorus above but still indicated the lake had deteriorated water quality.

These results, combined with local knowledge of the lake confirm that algal blooms occur sporadically in Lough Naglare. Controlling these algal blooms will be central to the long term management of the lake and will be addressed in the recommendations section below.

Table 5 Modified lake classification scheme based on annual maximum chlorophyll-a

	Oligotrophic	Mesotrophic	Eutrophic			Hypertrophic
			Moderately	Strongly	Highly	
Annual maximum Chlorophyll	<8.0	8-25	25-35	35-55	55-75	>75

Table 6 OECD Lake classification scheme

Lake Category	Total P	Chlorophyll		Transparency	
	(mg L ⁻¹)	(mg m ⁻³)		(m)	
	Mean	Mean	Max.	Mean	Min.
Ultra-Oligotrophic	<0.004	< 1.0	<2.5	> 12	>6
Oligotrophic	<0.010	<2.5	<8.0	>6	> 3
Mesotrophic	0.010-0.035	2.5-8	8-25	6-3	3-1.5
Eutrophic	0.035-0.100	8-25	25-75	3-1.5	1.5-0.7
Hypertrophic	>0.100	>25	>75	< 1.5	<0.7

Nitrogen

Nitrogen is a key nutrient for plant growth (including algae) and together with phosphorus is central to the development of eutrophication. Nitrogen gas makes up approximately 78% of the Earth's atmosphere. As Nitrogen gas is not available to plants it is converted into different forms through the nitrogen cycle. Because of this, different forms of nitrogen are presented in water analysis. Nitrite, nitrate and ammonium are commonly analysed in water. Nitrate is the most common form of nitrogen in rivers and lakes. It usually originates from human or animal wastes or from the application of artificial fertilisers to agricultural lands. Nitrite is an intermediate form of nitrogen between ammonium and nitrate and normally only accounts for a couple of % of nitrogen in water. Nitrite and nitrate are often presented together as Total Oxidised Nitrogen (TON).

Ammonium is also a precursor to nitrite and nitrate in the nitrogen cycle. As human and animal wastes are the most likely source of ammonia, high concentrations can be indicative of pollution from these sources. Ammonium is present in natural waters but if it is found in excess of 0.1mg/L N, it is seen as an indication of human waste or industrial contamination. Due to the potential link between high ammonia concentrations and human waste, it is an important parameter to monitor at a drinking water source.

Nitrate and nitrite

The Surface Water Regulations (1989) have a limit value of 11.3 mg/L nitrate (as N) for A1 waters. All available values for nitrate were <2 mg/L nitrate (as N).

Ammonium

The Surface Water Regulations (1989) contain a limit value of 0.155 mg/L (as N) for A1 waters. While only limited samples were taken from Lough Naglare, this limit value was exceeded on three occasions; 5th November 2002 (0.33mg/L), 21st March 2003 (0.18 mg/L)

and 12th August 2011 (0.29 mg/L). Some of these dates also had elevated coliform results and will be discussed below. These results together may suggest some form of animal or human waste entering the lake.

Dissolved oxygen (DO)

DO is an important parameter for fish survival. Generally when water quality is suitable for fish survival, it meets the quality requirements for most other forms of water consumption. Under the Surface Water Regulations (1989), Class A1 waters must have a DO saturation level of > 60%.

DO saturation is dependent on water temperature with warmer waters containing less oxygen. This concept, combined with low water levels can make waters particularly vulnerable to organic pollution during summer. DO saturation and concentration are also effected by photosynthesis. Increased eutrophication and photosynthesis leads to very high oxygen concentration in waters during daylight hours. While such high concentrations are not a problem they may be indicative of oxygen depletion at night when respiration takes over from photosynthesis.

DO was only monitored in Lough Naglare during 2002 and 2003 as part of the baseline assessment carried out as part of the design of the water treatment plant. Oxygen concentration was never below the 60% threshold in the Surface Water Regulations (1989). Values ranged between 72% saturation (9.3 mg/L @ 5.3°C) and 107% saturation (12.3 mg/L @ 11.7°C).

Coliforms

Faecal coliforms (e.g. *E. coli*) originate in either human or animal wastes. Total coliforms include faecal and soil-borne coliforms. Coliforms are used as an indicator of pathogenic organisms within a waterbody. Under the Surface Water Regulations (1989), A1 waters should not exceed 5,000 total coliforms per 100ml or 1,000 faecal coliforms per 100ml.

Eleven monthly coliform samples were available between 2002 and 2003 with other sporadic samples (4 samples) taken between 2008 and 2011 (Table 7). Generally both faecal and total coliform numbers were low and reflected the lack of a major waste water facility within the catchment. However, on the 14th October 2008 and 12th August 2011 levels were higher than on other occasions. On the later of those dates, faecal coliforms were in excess of the levels outlines in the Surface Water Regulations (1989) for A1 waters. Given the infrequency of the data collection it is difficult to highlight one source for this pollution. Similarly, it is likely that other high pollution levels were missed by the low frequency of sampling. These results do show that there is potential for this type of pollution within the Lough Naglare catchment.

Table 7 Coliform data from Lough Naglare

Date	Faecal Coliforms (no. per 100 ml)	Total Coliforms (no. per 100 ml)
06/09/2002	0	8
09/10/2002	0	0
05/11/2002	5	95
04/12/2002	15	43
27/01/2003	6	10
25/02/2003	0	1
21/03/2003	0	50
29/04/2003	1	10
16/05/2003	4	6
20/06/2003	1	3
17/07/2003	3	8
14/10/2008	120	686.7
02/10/2009	<1	387
04/02/2011	2	60.9
12/08/2011	1046	3255

6.3 Overall interpretation of Water Quality

The baseline assessment carried out as part of the design of the GWS water treatment plant was relatively detailed and useful. This data gave a good insight into water quality at that time. However, very little information on nutrient concentrations, chlorophyll levels and microbial contamination (coliforms etc.) was available in more recent years. This lack of detailed data makes interpretation of water quality more difficult. The more detailed data collected by Veolia is helpful but is more focused on the running of the plant, not the overall health of Lough Naglare.

In general, despite Lough Naglare being located in a relatively isolated area, the available water quality data suggests that water quality in the lake is significantly deteriorated.

Average true colour from the Veolia Water data was higher than the levels expected for A1 waters under the Surface Water Regulations (1989). Colour was shown to vary over the annual cycle with rainfall effecting colour within the lake. Similar to colour, turbidity also varied greatly between samples. While rainfall was undoubtedly a factor, poor catchment practices can heighten the problem. For example, poor bank stability, soil poaching and cattle access to streams can increase the amount of organic matter delivered to streams during rainfall events. Algae within the lake can also add to spikes in colour and turbidity.

Both iron and manganese concentrations in Lough Naglare were regularly in excess of the threshold for A1 waters under the Surface Water Regulations (1989). While these

concentrations are a reflection of catchment soils and geology, poor management can increase the amount of these minerals delivered to the lake.

Eutrophication has been highlighted as the main threat to Irish water quality and is the main focus of this report (see p21 for explanation). The relevant data to interpret the degree of eutrophication within Lough Naglare was only available between 2002 and 2003. During that period, total phosphorus concentrations were typical of a hypertrophic lake (worst category). Trophic classification based on average chlorophyll-a data (indicator of algal biomass) was more favourable and suggested the lake was of mesotrophic status (medium status).

Analysis of the detailed total phosphorus and chlorophyll data support the suggestion, by the GWS staff, that algal blooms are sometimes present in the lake. Such blooms are highly undesirable and catchment management is the sustainable approach to managing the issue. It is likely that agricultural land is the main source of these nutrients with possible additions from septic tanks and farm yards which are located close to the lake or inflowing streams. Recommendations made later will focus on the management of these issues.

Nitrite and nitrate concentrations within the lake were not excessively high compared to the Surface Water Regulations (1989). Despite this, ammonium concentrations were in excess of the 0.1mg/L threshold identified as potentially indicating human or animal waste entering a water body.

Microbiological analysis, used as an indicator of potentially disease causing organisms, was also carried out. Despite very low sampling frequency in recent years, one faecal coliform sample during 2011 was in excess of the Surface Water Regulations 1989 standard for A1 waters. This value is particularly high in an area where there is no urban waste water treatment plant. More sustained sampling may highlight the source of this contamination. It is likely that the same source is responsible for both nutrient inputs to the lake and microbial contamination. For this reason, the implementation of source protection measures will help to improve several water quality parameters.

7.0 Recommendations

Put source protection on the agenda

Within many GWS's 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 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 public awareness, installation of source protection measures and potential pollution within the catchment should also be discussed.

Reporting of potential pollution issues

The 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 the investigation, either dealing with the problem themselves or passing relevant information on to the County Council where there is evidence of deliberate and/or serious pollution. A pollution reporting form could be distributed to members where they can record the relevant details and return them to the scheme staff by post. Providing the reporter's personal details should not be compulsory.

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. The protocol should set out if oral communication or written communication is suitable and at what point incidences are passed on to the authorities. Having a protocol in place ensures that all complaints are dealt with in an agreed and equitable way

It is recommended that this protocol should, in the first instance, rely on personal contact to resolve any issues amicably and by agreement. However, if the offender chooses not to respond to personal contacts from either a committee member or member of staff, the County Council Environment Section should be consulted.

Agriculture and farmyard management

Until specific areas of the catchment are highlighted as being problematic some general recommendations can be put into practice.

(a) Create a database of all farms and landowners within the catchment.

(b) Make members aware of potential problems caused by agriculture and the relevant rules and regulations relating to spreading of fertiliser and manure (See section 5.1 of this report).

Fertiliser and manure application should be strictly managed within the catchment. As these are major sources of nutrients in agricultural catchments their careful management is essential to improve water quality.

There are strict regulations relating to the land spreading of manures and fertilisers, European Communities (Good Agricultural Practice for Protection of Waters) Regulations 2010. It is in the interest of the GWS that these regulations are adhered to.

These regulations are available online (www.irishstatutebook.ie) but here are some important points to remember;

- Artificial fertiliser cannot be spread within 2m of any watercourse. This will include all lakes, inflowing streams and drains within the catchment.
- Organic fertilisers cannot be spread within 200m of the abstraction point of the GWS. As Lough Naglare is used as a drinking water abstraction point for volumes in excess of 100m³ per day the 200m exclusion zone applies.
- Organic fertiliser cannot be spread within 20m of any lake shore.
- Organic fertilisers cannot be spread within 5m of any surface waters. This will apply to all the inflowing streams within the Lough Naglare catchment. This distance may be reduced to 3m for open drains.
- Organic fertiliser or soiled water shall not be applied to land within 10m of any surface waters where the land has an average incline greater than 10% towards the water.

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 waters, soil condition, ground cover and rainfall- there is significant risk of causing water pollution.

(c) To increase compliance, the scheme should meet with farmers reminding them of their legal obligations and the benefits to the scheme of complying with this code of good

agricultural practice.

Farmyard management (Note)

As part of the NSPPP a survey of 126 farms in Monaghan was carried out. The most common faults encountered were;

A lack of guttering on sheds which allowed the mixing of clean rainwater and effluent on the farmyard.

Lack of sufficient slurry storage.

Out-wintering of cattle leading to soil poaching and erosion, giving a high potential for runoff.

(d) Soil nutrient analysis and nutrient management planning.

This is dealt with under the future work section below but some recommendations from the NSPPP should be considered here;

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

The section below on future work will highlight how fields bordering streams and the abstraction lake should be prioritised. Also the potential of cost sharing will be discussed.

(e) It was discussed earlier how cattle access to streams and lakes can lead to pollution. The NSPPP made recommendations relating to cattle access which are relevant to this catchment.

- The NSPPP recommended that cattle should be excluded from all waterways. Exclusion fencing is one way of achieving this objective but alteration of management practices could also be applied. For example, fields bordering streams could be prioritised for silage instead of grazing.

Septic Tanks

(a) generate a list of householders within the catchment who have septic tanks.

(b) Meet all households that have septic tanks and advise them of the correct maintenance of septic tanks and the potential pollution threats.

The recommendations from the NSPPP suggest that education should be provided to householders regarding the correct care and maintenance of their on-site waste water treatment systems (OSWTS's). Several OSWTS's in that study were shown to suffer from ponding, backing up and several were never emptied.

Also, septic tank inspections are due to commence around the country in the coming years according to Phil Hogan T.D. However, if certain septic tanks are suspected to be causing pollution to water it may be possible to get these tanks inspected by Cavan County Council as a priority.

7.1 Future work

1. Generate water quality data.

There has been very limited raw water quality analysis since the scheme was established but the available data does suggest impacted water quality.

It is recommended to carry out a sampling programme for an initial period of one year to gain further insight into water quality and potential pollution issues. The exact frequency and location of sampling sites can be discussed later but as a minimum, the lake and the inflowing stream should be monitored 12 times per year. The following parameters should be included in the sampling programme; ammonium, nitrate, nitrite, total phosphorus, molybdate reactive phosphorus (MRP), total coliforms, faecal coliforms, chlorophyll-a (lake only). Probe readings such as dissolved oxygen, conductivity and total dissolved solids could also be included.

2. Identify livestock access and congregation points.

It is recommended to carry out a walkover survey of the lake and streams to highlight areas where cattle access and livestock congregation points are causing pollution (at feeders, gates, drinkers etc.). Drinkers, feeders and gates act as livestock congregation points which may lead to soil poaching. Such areas that are close to streams and lakes act as pollution sources. Such areas should be identified and actions taken to relocate these congregation

points. For example, moving a feeder away from a stream will reduce the risk of pollution to the stream. Such a survey would highlight fields where fencing is needed and prioritise particular areas for remediation works. This survey would also identify suitable areas for the location of alternative livestock drinkers.

While such a programme would not be cheap, certain perks could be offered by the GWS to landowners. Also, by prioritising the worst areas, investment can be made in a targeted way. Also, certain agricultural schemes may offer funding for the required work.

Some of these issues could also be addressed by altering management practices. Fields bordering streams and lakes could be prioritised for silage cutting instead of grazing thus reducing cattle access to streams.

3. Soil nutrient analysis

The implementation of soil nutrient analysis throughout the catchment would be a valuable initiative. Soils with high nutrient status are most likely to result in losses to nearby waterways. If soils have sufficient nutrient content farmers could save money by not applying extra fertilisers to fields. Knowledge of soil nutrient status will allow farmers to match fertiliser application to crop needs. This analysis would be beneficial to both the GWS and the farmers and therefore costs could be shared.

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Appendix A. Raw data from Lough Naglare. Baseline assessment carried out by T.J. O'Connor and Associates, Consulting Engineers. Annual data presented by Monaghan County Council. Highest values from baseline assessment are highlighted in yellow. Codes for data sources are: a = Design Contract- Samples presented by T.J. O'Connor and Associates, Consulting Engineers, b= Veolia Water- External monitoring. Codes; chl=chlorophyll, Mn=Manganese, turb=turbidity, DO=dissolved oxygen.

Data	Date	Ammonium	Chl	Faecal Coli.	Total Coli.	Colour (App)	Iron	Mn	pH	Turb	Nitrite	Nitrate	Othho P	Total P	DO	DO
		mg/L (N)	mg/m ³	no./100ml	no./100ml	PtCo units	mg/L	mg/L	pH unit	NTU	mg/L N	mg/L N	mg/L P	mg/L P	mg/L	% sat
a	06/09/02	<0.12	19.7	0	8	106	0.57	0.60		11.69	0.02	<0.09	0.02	0.09	9.0	90
a	09/10/02	<0.12	26.0	0	0	81	0.49	0.29	7.6	18.12	0.03	<0.09		0.08	9.3	93
a	05/11/02	0.33	14.3	5	95	107	0.50	0.06	7.2	9.61	0.08	1.49	0.04	0.06	9.1	75
a	04/12/02		19.4	15	43	106	0.56	0.07	6.3	9.05	<0.005	0.36	0.11	0.09	9.5	75
a	27/01/03	<0.02	5.5	6	10	83	0.44	0.05	7.7	6.05	0.02	0.41	0.03	0.06	9.7	80
a	25/02/03	0.08	17.4	0	1	75	0.77	0.11	7.2	3.85	0.02	0.52	0.03	0.05	9.3	72
a	21/03/03	0.18	18.6	0	50	68	0.21	0.02	6.7	3.26	0.02	0.32	0.01	0.05	11.6	98
a	29/04/03	0.09	<3	1	10	63	0.14	<0.0002	7.3	5.04	0.02	<0.04	0.02	0.06	11.7	107
a	16/05/03	0.15	33.8	4	6	62	0.09	<0.004	7.3		0.02	<0.04	0.01	0.48	10.4	98
a	20/06/03	0.06	4.7	1	3	94	0.09	0.00	7.4	7.76						
a	17/07/03	0.11	23.6	3	8	77	0.11	0.02	7.3	6.2						
b	14/10/08	<0.10		120	686.7				7.2	3.9		<2	<1.5			
b	02/10/09	<0.10		<1	387		0.35	0.21	7.5	<0.5	<0.02					
b	14/01/11					116	0.42	0.17								
b	04/02/11	<0.10		2	60.9	106	0.37	0.06	7.6	4.2		<2	<0.5			
b	12/08/11	0.29		1046	3255	81	0.22	0.45	7.4	4.3	<0.02	<2				