

River Basin Management Plans – Groundwater Classification

Nitrate

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1.0 Purpose

This paper describes the method used to assess the Water Framework Directive (WFD) chemical status of groundwater bodies with respect to nitrates.

2.0 Background

The WFD requires that groundwater bodies must be classified as good or poor for both chemical status (in relation to a large range of pollution pressures) and quantitative status (in relation to groundwater abstraction pressures).

Potential impacts from nitrates have been considered in the context of three of five tests developed for groundwater body chemical classification, based on WFD requirements and guidance provided at an EC and UK level¹. The five tests consider groundwater chemical composition with respect to impacts both on the groundwater body itself (including significant potable supplies), and on the ecological receptors which depend on it. The worst result from all five tests is taken as the overall chemical status result for each groundwater body.

With the dominantly rural setting and agricultural land use across much of Northern Ireland, introduction of nitrate from agricultural and other sources (WWTWs, septic tanks, forestry, etc.) to the water environment has been identified as a potential significant environmental issue.

A report on nitrates in waters across Northern Ireland (DoE-DARD SWG, 2002) identified that agriculture was by far the most significant source of nitrate to surface waters and by corollary agriculture is also expected to be the main source to groundwater, where soil and sub-soils allow percolation (recharge) to the water table.

Management of the nitrate risk to the water environment has most recently resulted in Northern Ireland declaring as 'total territory' under the Nitrates Directive (91/676/EEC) with an associated action plan being produced, designed to reduce nitrate leaching and run-off to receiving waters.

Monitoring of surface water bodies has indicated that nitrate concentrations are relatively low with respect to the Nitrates Directive Standard of 50 mg/l NO₃. It is acknowledged however that nitrate can be a contributing factor to eutrophication, which is a very significant problem in rivers and lakes throughout Northern Ireland.

Rivers and Streams: In 2005, NIEA monitored nitrate concentrations monthly at 540 surface non-drinking freshwater sampling stations. These sites, which were located throughout Northern Ireland, gave an average concentration of 6.6 mg/l NO₃ (Figure 1).

¹ UK Technical Advisory Group on the Water Framework Directive. Paper 11b(i): Groundwater Chemical Classification for the purposes of the Water Framework Directive. This paper can be downloaded from the www.wfduk.org web site.

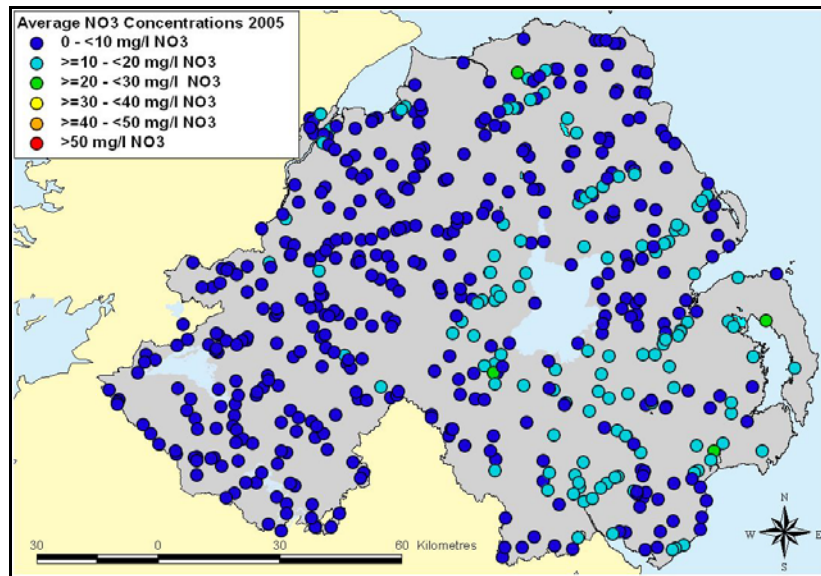


Figure 1. Distribution of average nitrate concentrations in streams and rivers monitored in 2005.

Average nitrate concentrations were less than 20 mg/l NO₃ at 99% of sites and no site exceeded an average concentration of 30 mg/l NO₃ (Table 1). Maximum nitrate concentrations were also low with 89% below 20 mg/l NO₃ (Table 1 and Figure 2).

Table 1 Distribution of average and maximum nitrate concentrations in river and stream monitoring network for 2005.

Nitrate range mg/l NO ₃	Average concentration		Maximum concentration	
	No of Sites	% Sites	No of Sites	% Sites
0 – <10	415	77	281	52
10 – <20	121	22	202	37
20 – <30	4	1	44	8
30 – <40	0	0	8	2
40 – <50	0	0	2	0.4
>50	0	0	3	0.6

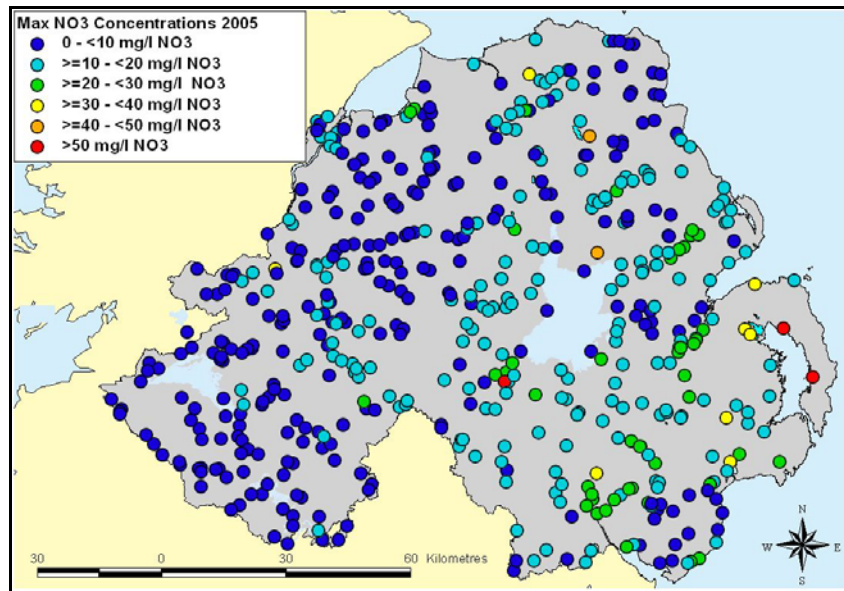


Figure 2 Distribution of maximum nitrate concentrations in streams and rivers monitored in 2005.

Lakes: Northern Ireland contains the two largest lake systems in the British Isles: Lough Neagh and Lower and Upper Lough Erne. Approximately 40% of drinking water in Northern Ireland is abstracted from these lakes. There are known to be 1665 other 'lake' water bodies but only 20 lakes and reservoirs have surface areas in excess of 50 ha. To meet the requirements of the EC Water Framework Directive (2000/60/EC) monthly monitoring of nitrate concentrations was extended during 2005 to 28 lakes and reservoirs, including those with a surface area greater than 50 ha and a number selected for intercalibration purposes. No monitored lake or reservoir had an average nitrate concentration in excess of 10 mg/l NO₃ (Table 2). These low concentrations are undoubtedly influenced by phytoplankton growth in the lake depleting nitrate. Maximum concentrations were also low occurring at the end of winter and therefore before spring algal growth and nitrate uptake.

Table 2 Distribution of average and maximum nitrate concentrations in lakes and reservoirs monitoring network in 2005

Nitrate range mg/l NO ₃	Average concentration		Maximum concentration	
	No of Sites	% Sites	No of Sites	% Sites
0 – <10	28	100	24	86
10 – <20	0	0	4	14
20 – <30	0	0	0	0
30 – <40	0	0	0	0
40 – <50	0	0	0	0
>50	0	0	0	0

Groundwater:

Risks to groundwater from nitrates include:

- i) deterioration in general groundwater quality
- ii) impacts on groundwater-dependent surface water quality and ecology
- iii) impacts on groundwater-dependent terrestrial ecosystems
- iv) direct effect on specific groundwater abstractions and treatment requirements

The WFD Article 5 characterisation process identified a number of groundwater bodies potentially at general risk from diffuse nitrate inputs originating from the spreading of slurry and application of inorganic fertilisers. These bodies were mainly in central and eastern Northern Ireland which corresponded to areas of more intensive agriculture or where effective rainfall is lower (providing less dilution). The risk assessment methodology was relatively conservative and led to some large groundwater bodies being assigned an 'at risk' status where there was only limited positive evidence in the form of groundwater monitoring data showing significantly elevated nitrate concentrations.

Prior to total territory designation under the EC Nitrates Directive, only seven groundwater Nitrate Vulnerable Zones (NVZs) were designated within Northern Ireland. These constituted less than 0.5% of the total land area.

A recent review of nitrate concentrations in groundwater in Northern Ireland (NI) was carried out by the British Geological Survey (MacDonald and McConvey, 2003). This study used the two most comprehensive monitoring datasets available and considered the relationship between factors such as land use and groundwater vulnerability with recorded nitrate concentrations. The study concluded, amongst other things:

- across NI, groundwater nitrate concentrations, where measured, are generally low and generally lower than found in many other parts of the UK;
- the most likely causes of low concentrations are: limited extent of arable agriculture; favourable denitrification conditions in NI soils; and dilution from high rainfall;
- there is a high correlation between nitrate concentrations and land use; and
- permeability of superficial deposits affects nitrate concentrations with higher probability of lower concentrations where superficial deposits have 'low' permeability (e.g. clayey till).

The study did identify however that there are likely to be significant numbers of smaller areas where land use and the hydrogeological setting is such that groundwater is locally vulnerable to diffuse pollution.

Review of monitoring data from the NIEA monitoring network between 2000-2008 and also from data obtained from some groundwater public water supply boreholes does indicate generally low nitrate concentrations (<25 mg/l NO₃) around most monitoring locations. It is generally thought that the soil and sub-soil conditions promote denitrification. In some localized areas higher nitrate levels are found due to high effective rainfall causing relatively low residence times in fracture-dominated aquifers. However, it is also accepted that some of the historic monitoring sites cannot be considered representative in the context of the WFD monitoring guidance.

The Sniffer “Diffuse Pollution Screening Tool” project (WFD19), was used to assess and predict potential nitrate loadings to surface waters. As part of this exercise, leaching of nitrate downwards through the upper soil zone (and potentially eventually to groundwater) was also predicted.

To consider the available data in context, information on land-use, groundwater vulnerability, aquifer type and mean nitrate concentrations from historical monitoring has been amalgamated for each groundwater body. Information on land-use, vulnerability and aquifer type has been specifically compiled to describe the percentage areal extent of the range of pressure-pathway scenarios across Northern Ireland.

3.0 Classification

This assessment has been undertaken to support the following elements of classification:

Chemical Classification

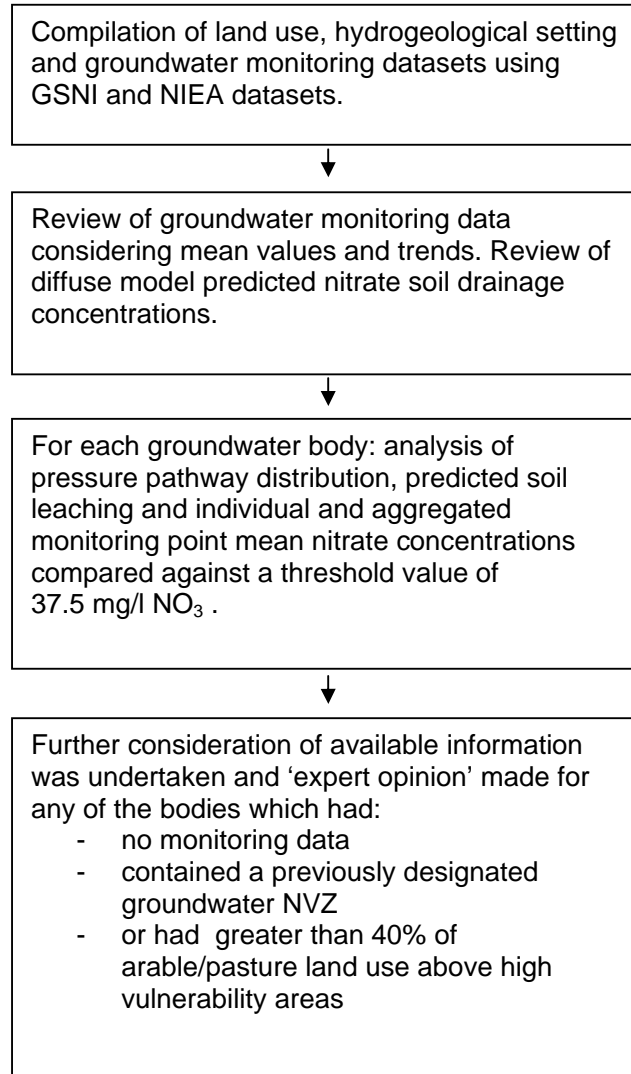
- General Assessment of Quality
- Impact on Drinking Water Protected Areas (DWPAs)
- Impact on Groundwater Dependent Terrestrial Ecosystems (GWDTEs)

Since actual nitrate concentrations in surface waters are significantly below the Nitrates Directive limit of 50 mg/l NO₃ and due to no nitrate standard being defined for WFD surface water classification, no assessment of the influence of nitrate in groundwater on surface water bodies was undertaken.

It should be noted that for potential GWDTEs (SPA, SAC, ASSIs and NNRs) limited knowledge is presently available regarding their groundwater dependency and sensitivity to water chemistry changes.

4.0 Assessment Process

The following assessment process was undertaken, managed within a GIS-based project.



All available groundwater quality data were compiled for DWPA sources using datasets including:

- Drinking Water Inspectorate Industrial sources;
- Drinking Water Inspectorate Public Water Supply (PWS) sources;
- NIEA monitored sources; and
- Northern Ireland Water Public Water Supply sources.

For each of the sources considered to be a significant drinking water source (including food production, bottled waters etc) the mean nitrate concentration was calculated and compared against the threshold value of 37.5 mg/l NO₃. Generally only limited monitoring data were available for the sources. Where the threshold

value was exceeded or was being approached an initial assessment of the trend was undertaken to give an overview of whether concentrations were rising or falling. It should be noted that for most of the non-NIEA data, the water quality data is non-raw water, i.e. quality 'at tap'. Raw water data for such sources is rarely available. However since there is very limited treatment in place at most sources it was considered that nitrate concentrations may not be significantly different between raw and production water (See assessment paper WFD-GW-9 Chemical pressures–drinking water protected areas (DWPAs) for further detail on this matter).

Scientists from NIEA Natural Heritage were consulted to determine if there was any known evidence or concern with respect to potential impact of elevated nutrients on the associated ecology of GWDTEs.

5.0 Outcome

No groundwater bodies have been classified as being at “poor” status for the general quality assessment or for impact on GWDTEs.

Two bodies have been determined as being at “poor” status for the DWPA test for this diffuse source pressure.

As part of work undertaken to meet the requirements of the long-standing EC Nitrates Directive, fairly extensive assessment of available groundwater nitrate monitoring data has been undertaken to date. Areas where groundwater nitrate concentrations are elevated have been identified. The analysis undertaken for the WFD has reviewed historical and recent monitoring data in the context of the threshold value set for nitrate at $37.5 \text{ mg NO}_3 \text{ L}^{-1}$. This exercise should help identify and provide information about areas where additional data should be collected over the current River Basin Management Plan period. However until further monitoring of the WFD network is carried out, a default confidence limit of “low” has been set for the GQA test.

A default confidence of low has been set for GWDTEs in Northern Ireland. This is in advance of further research and improved understanding of groundwater dependency and ecological requirements and in the absence of any specific impacts being identified by NIEA Natural Heritage.

6.0 River Basin Planning Cycle

To improve confidence in this assessment for the next review period there is a need to:

- review availability of monitoring points in the areas where the potential (both pressure and pathway) exists for nitrate leaching to groundwater and improve network where necessary;
- review frequency of monitoring and undertake detailed monitoring in the most sensitive locations; and
- improve understanding of the local hydrogeological setting for “poor” status or “at risk” bodies.

References

DoE-DARD SWG 2002. Report on the environmental aspects of the Nitrates Directive in Northern Ireland by a DoE-DARD Scientific Working Group (www.ni-environment.gov.uk)

MacDonald A M and McConvey P. 2003. Nitrate concentrations in groundwater in Northern Ireland. British Geological Survey Commissioned Report CR/03/051

SNIFFER 2006. WFD19 Screening Tool to Identify and Characterise Diffuse Pollution Pressures - Phase 2 (www.sniffer.org.uk)

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