River Basin Management Plans – Groundwater Classification

Phosphorus

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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 phosphorus.

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 phosphorus have been considered in the context of four of five tests developed for groundwater body chemical classification, based on WFD requirements and guidance provided at an EC and UK level[1]. The five tests consider groundwater chemical composition with respect to impacts on the groundwater body (including significant potable supplies), as well as 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.

Concentrations of phosphorus (P) found within groundwater in Northern Ireland are usually well below the Drinking Water Standard of 2200 µg/l. However, much lower phosphorous concentrations can be significant for surface water ecosystems. Indeed eutrophication of rivers and lakes is the most significant widespread water quality impact in Northern Ireland. Hence there is a need to assess whether groundwater is contributing much flow to such features and if so, whether the associated loading of P from groundwater is significant.

As part of the WFD Article 5 characterisation undertaken in 2005, a risk assessment was undertaken utilising predicted P concentrations in vertical drainage water (for 1km^2 cells) from the Sniffer diffuse model (WFD19). A 20 µg/l or above P value was considered as significant. The nature of the pathway was also considered, given that the majority of P is generally retained in the upper soil layer and broken down there. Hence only where groundwater was considered to be highly or moderately vulnerable was it assumed that P reached the water table. It was also assumed that where limited or poorly productive aquifers occur they would not contribute significant amounts of water to surface waters or GWDTEs. For initial characterisation (WFD Article 5) no groundwater bodies were determined to be at risk due to predicted loading rates of phosphorus.

Risks to groundwater from phosphorus include;

- deterioration of general groundwater quality
- impacts on groundwater-dependent surface water quality and ecology
- impacts on groundwater-dependent terrestrial ecosystems
- direct effect on specific groundwater abstractions and associated treatment requirements

Determining whether or not a surface water body or GWDTE is being impacted by phosphorus is a challenge. Only limited historical monitoring of phosphorus in groundwater at the low concentrations of interest for surface waters and GWDTEs is

[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.

available for Northern Ireland. In the past there has been little research carried out regarding groundwater inputs of P to surface waters although a recently completed SNIFFER R&D project (WFD85) includes a review of current knowledge. Matters such as whether significant attenuation of P occurs as groundwater passes through the hyporheic zone (region beneath and lateral to a stream bed, where there is mixing of shallow groundwater and surface water) as it discharges to surface water remain uncertain.

3.0 Classification

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

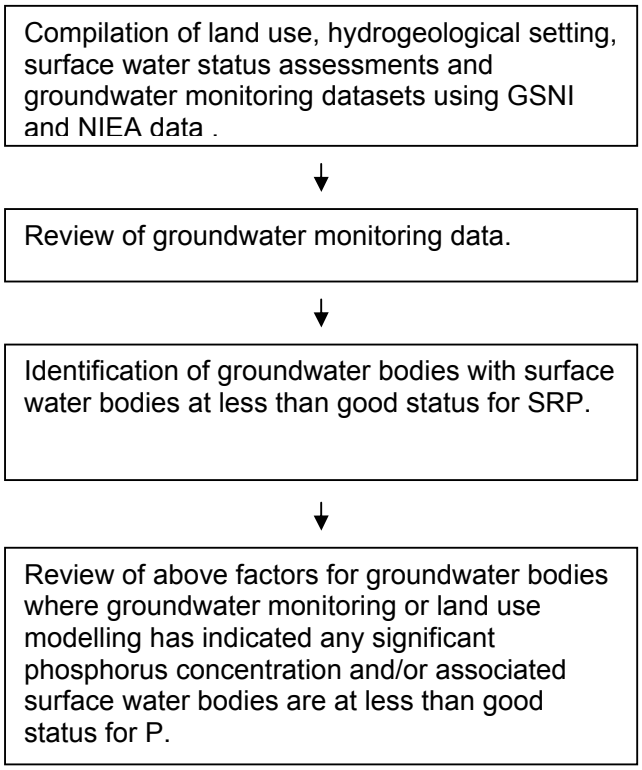
Chemical Classification

- No significant diminution of surface water chemistry and ecology
- Impact on Groundwater Dependent Terrestrial Ecosystems (GWDTEs)
- Impact on Drinking Water Protected Areas

4.0 Assessment Process

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

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.



The work undertaken as part of the SNIFFER research project WFD19 estimates residual phosphorus available for leaching from inorganic and organic sources from agricultural and forestry. A loading rate (kg/ha) was derived and combined with the 'groundwater' drainage component of the model water balance to estimate average phosphorus concentration (mg/l) leaching rates to groundwater for each 1 km^2.

This approach calculated that less than 1% of losses from agriculture and forestry were to groundwater, with the model processes designed to reflect the sorption and physical filtering of phosphorus from drainage waters.

The Article 5 analysis indicated that only 9 of the 1km^2 grid cells across Northern Ireland had predicted concentrations >20 µg/l P, the concentration taken as potentially significant for groundwater dependent surface waters (Table 1 and UKTAG, 2007b). As the grid cells only constitute a very small percentage of the total 'catchment' area none of the surface water body catchments in which these cells are located were considered to have increased phosphorous concentrations.

The majority of surface water bodies assessed as being of less than "good" status occur within groundwater bodies where the dominant aquifer type is only poorly productive. Estimation of groundwater contribution to surface waters based upon the Hydrology of Soil Types (HOST) data for such groundwater bodies indicates contribution of less than 45%. Taking the most stringent standard for surface waters of 40 µg/l (see Table 1) for the good/moderate boundary, for the surface water test to fail, mean groundwater concentrations would need to exceed ~ 45 µg/l (based upon 45% groundwater contribution to reach 50% of EQS). For the less stringent EQS of 120 µg/l for high alkalinity river types (dominant in Northern Ireland), the mean groundwater concentration would need to be 135 µg/l (for the same groundwater contribution to surface waters).

River type	Soluble Reactive P (µg/l)	
	High status	Good status
Low Alkalinity, upland	20	40
Low Alkalinity, lowland	30	50
High Alkalinity	50	120

Table 1 Type Specific Soluble Reactive P Concentrations for Rivers (from UKTAG, 2007b)

A review of available groundwater monitoring data for Northern Ireland for 2000-2008 showed that the vast majority of P concentrations were below the limit of detection (LOD) which generally ranged from 28-100 µg/l. This would indicate that where measured, groundwater concentrations are likely to be at or more likely below concentrations of significance with respect to phosphorus in surface waters. However the value of the available groundwater monitoring data is severely restricted due to the LOD being similar to or higher than the concentrations of interest with respect to receiving surface waters. The limited number of positive detections of phosphorus above the LOD in groundwater is however not unexpected for this mainly surface applied diffuse pollutant. With a dominance of poorly draining soils and sub-soils

across Northern Ireland it would not be expected that significant loadings reach the water table at depth. Research elsewhere has indicated that run-off and shallow drainage is the dominant transfer route for P to surface waters in Northern Ireland (Sniffer WFD19).

Scientists from Northern Ireland Environment Agency (Natural Heritage) were consulted to determine if there was any known evidence or concern about elevated nutrients and potential impacts on the associated ecology of GWDTEs.

The relatively limited amount of phosphorus groundwater monitoring data and the fact that a significant proportion of that data reports values less than a specific limit of detection reduces the degree of confidence that can be placed in some of the assessments.

Work undertaken for the WFD Article 5 characterisation which considered groundwater body scale potential leaching of P to groundwater together with this more recent review of available groundwater P monitoring data also indicates that general elevated mean P concentrations across a groundwater body is highly unlikely. Trial predictive modelling of P concentrations in groundwater undertaken as part of the Sniffer project WFD85 looking at phosphorus in groundwater indicated average concentrations of less than 5 µg/l across all groundwater bodies in NI. However it should be noted that this model has not been verified.

For the DWPA assessment where the relevant water quality standard is 2200 µg/l, all available monitoring data from assessed significant potable supplies indicates mean concentrations significantly less than a threshold value determined as 75% of the DWS (1650 µg/l). Consequently a high degree of confidence can be assigned in this case.

Greater uncertainty exists with respect to groundwater-fed rivers, lakes and GWDTEs. Although most monitoring data point to low concentrations of P in groundwater, as stated earlier, elevated P in surface waters is a significant problem with respect to eutrophication in some parts of Northern Ireland. Where surface water bodies are determined as being at “poor” status, historical, representative groundwater data within the groundwater body is not normally available (partially due to the higher LOD used at the time).

5.0 Outcome

No groundwater bodies have been identified as being at “poor” status for phosphorus. Confidence in the assessment for the most part is low due to the relatively limited amount of groundwater monitoring data available at the very low concentrations of interest and due to the uncertainties with respect to transfer of phosphorus from groundwater systems to surface water systems.

6.0 River Basin Planning Cycle

Information from more recent groundwater monitoring and surface water monitoring collected during the River Basin Management Plan period, along with improved understanding of surface water-groundwater interaction for rivers, lakes and wetlands will enable this assessment to be improved.

References

UKTAG (2007b) UK Environmental Standards and Conditions (Phase 1). Updated report (November 2007) SR1–2006

SNIFFER (2006) Project WFD19. Screening tool to identify and characterise diffuse pollution pressures

SNIFFER (2008) Project WFD85. An Improved Understanding of Phosphorus Origin, Fate and Transport within Groundwater and the Significance for Associated Receptors

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