

2021 River Basin Management Plan

Nitrates

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Background

This summary document is one of a series of pressure focused evidence narratives. A pressure is defined as a factor affecting the water environment. These narratives, or stories, have been produced to support the 2019 challenges and choices consultation as these pressures affect, or are affected by, the challenges described in the consultation. These pressure narratives cover chemicals, phosphorus, nitrates, fine sediment, physical modification, abstraction and flow, faecal contamination, invasive non-native species and drinking water protected areas.

The pressure narratives support engagement at national level and help build a common understanding of the issues. They also provide the national context for discussions at the local level during the consultation period from October 2019 for six months

Relevance and accuracy of data

This document has been produced by bringing together the readily available information on the topic. Quality assurance of the information included so far is not complete. As a result the document may contain some errors or inaccuracies. Please let us know of any other relevant evidence or if you are aware of any issues with the information. This will help us to build a comprehensive and robust evidence base to underpin decision-making in river basin management planning. Contact details are given in Section 4 of the document.

Executive Summary

What are the problems with nitrate in water in general and in England?

The main concerns with high concentrations of nitrate in water are:

- the risks to human health from drinking water after abstraction from ground or surface waters
- eutrophication of lowland surface waters
- acidification and eutrophication of upland waters
- nutrient enrichment in other sensitive habitats like Groundwater Dependent Terrestrial Ecosystems

Groundwater is a major source of drinking water supply and nearly 30% of groundwater used for that purpose in England must now be blended, treated, or replaced in order to meet tap water nitrate standards. Treatment is expensive with a nitrate removal plant costing upwards of £8m. This cost is ultimately passed on to the water consumer through higher bills. All groundwater bodies are Drinking Water Protected Areas where we aim to prevent any need for increased levels of water treatment. In 2015, 189 of the 271 (69%) groundwater bodies in England were found to be at risk of failing WFD objectives, mainly due to high or rising nitrate concentrations.

Future risks are posed by climate change as more frequent storm events are predicted to increase nitrate losses from land to water, with hotter summers exacerbating the effect of eutrophication.

What progress is being made in tackling nitrate pollution of water?

Agriculture is the dominant source of nitrate in water (about 70% of total inputs), with sewage effluent a secondary contributor (25-30%) nationally. In general, nitrate concentrations are greatest in the drier, arable-dominated southern and eastern areas of England. This coincides with where we are most dependent on groundwater for public water supply and base flow to rivers.

55% of England is designated as a Nitrate Vulnerable Zone (NVZ) due primarily to elevated nitrate concentrations in groundwater and rivers, and to a lesser degree because of eutrophication of estuaries and lakes/reservoirs. NVZ action programmes to reduce agricultural nitrate pollution have been in place since the late 1990s. During that time, river nitrate concentrations have seen a general reduction, but not dramatically and in the last 2 years they have risen.

Groundwater nitrate concentrations are broadly stable in many places except in southern England where they are rising in some areas. This is partly because of the lag time or delay it takes for the peak agricultural nitrate loadings of the 1980-90s to percolate through the water table. Recent changes in farming practice such as spreading more materials on land also have the potential to greatly increase nitrate loading locally. Further work is needed to consider the implications of land spreading.

What is needed for the future?

Because of the time lag issue precluding water quality improvements being realised for decades, meeting Water Framework Directive (WFD) objectives for nitrate is challenging, particularly for groundwater. However, irrespective of this, the current measures appear insufficient to deliver WFD objectives in the long term and a review of the policy options appears to be needed.

Targeting measures to where they can be most effective would have most value, in terms of improvements to water quality, uses and associated costs. This could mean, for example, targeting:

- catchments used for public drinking water abstraction that are at risk of deteriorating to the point that treatment must be introduced or increased, requiring additional capital expenditure
- drinking water protected areas where significant numbers of small or private water supplies from groundwater are particularly at risk

The Farming Rules for Water and Nitrate Vulnerable Zones form the regulatory baseline. Catchment schemes, safeguard zone action plans and the proposed new Environmental Land Management Scheme (ELMS) will have important roles to play in securing the necessary improvements as far as this is feasible.

1. The problem

1.1 Evidence for the problem

The total amount of reactive, or biologically available, nitrogen created by human activities has increased significantly between 1890 and 1990, with most of that increase taking place in the second half of the twentieth century as a result of the global increase in use of fertilisersⁱ. This has led to increased nitrate concentrations in rivers, lakes, ground waters, transitional and coastal waters and wetlands.

There are multiple standards and objectives for nitrate for different EU Directives and water categories, making implementation of controls complex. We need to consider the following directives and associated domestic regulations in relation to nitrate control:

- Urban Waste Water Treatment Directive (UWWTD)
- Nitrates Directive
- Water Framework Directive (WFD), in particular WFD Article 7 that concerns no deterioration of water quality in Drinking Water Protected Areas (DrWPAs)
- Drinking Water Directive
- Groundwater Directive (GWD).

The main concerns with nitrate in water are:

- the risks to human health from drinking water with elevated nitrate concentrations of nitrate, after abstraction from ground or surface waters (the World Health Organisation standard is 50 mg/l nitrate at the tap)
- eutrophication of lowland surface waters including estuaries and coastal waters
- acidification and eutrophication of upland waters
- the impacts on nutrients on Groundwater Dependent Terrestrial Ecosystems

The extent of Nitrate Vulnerable Zones (NVZs) designated under the Nitrates Directive regulations is a good measure of the extent of nitrate pollution nationally, particularly in lowland areas:

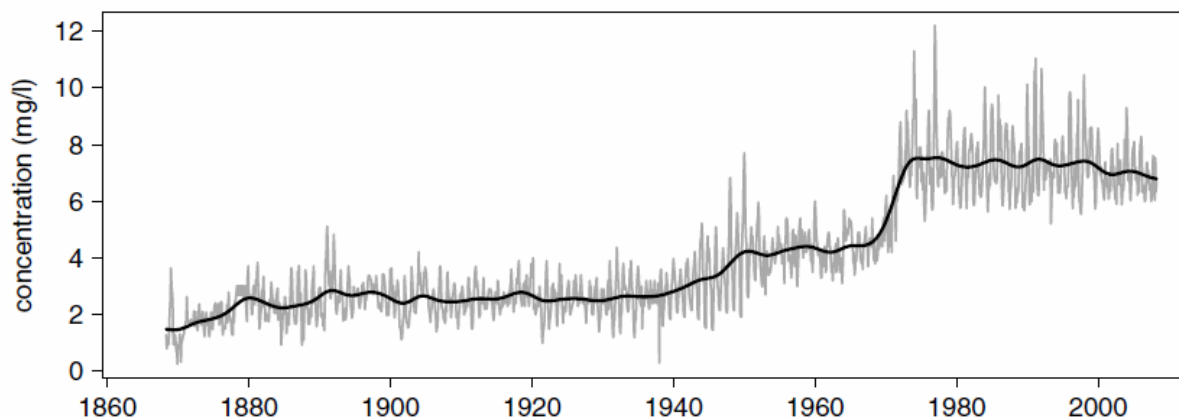
- 44% of land in England is NVZ because rivers breach the 50 mg/l test.
- 25% of England is NVZ because groundwater breach the 50 mg/l test.
- 6% of England is NVZ because of eutrophication in estuaries and lakes/reservoirs.

These designations overlap resulting in 55% of England being NVZ.

1.2 Nitrate in rivers and lakes

Figure 1 displays the increase in nitrate over time in the River Thames with a peak around the mid-1970s - similar trends are seen in other UK riversⁱⁱ.

Figure 1. Nitrate ($\text{mg NO}_3 - \text{N/L}$) concentrations in the River Thames (1860-2010)ⁱⁱⁱ



Under the Water Framework Directive we must identify Drinking Water Protected Areas and, if there is a risk of deterioration, put in place measures that aim to reduce the level of purification treatment in producing drinking water.

In England, there are 12 surface water bodies identified as failing the WFD Article 7 'no deterioration' objective^{iv}) due to high levels of nitrate. Nitrogen compounds, such as nitrate and ammoniacal nitrogen, are the reason that 70 groundwater DrWPAs are classed as being at poor chemical status. Within those 70, there are 227 Safeguard Zones (SGZ) aimed at reducing deterioration.

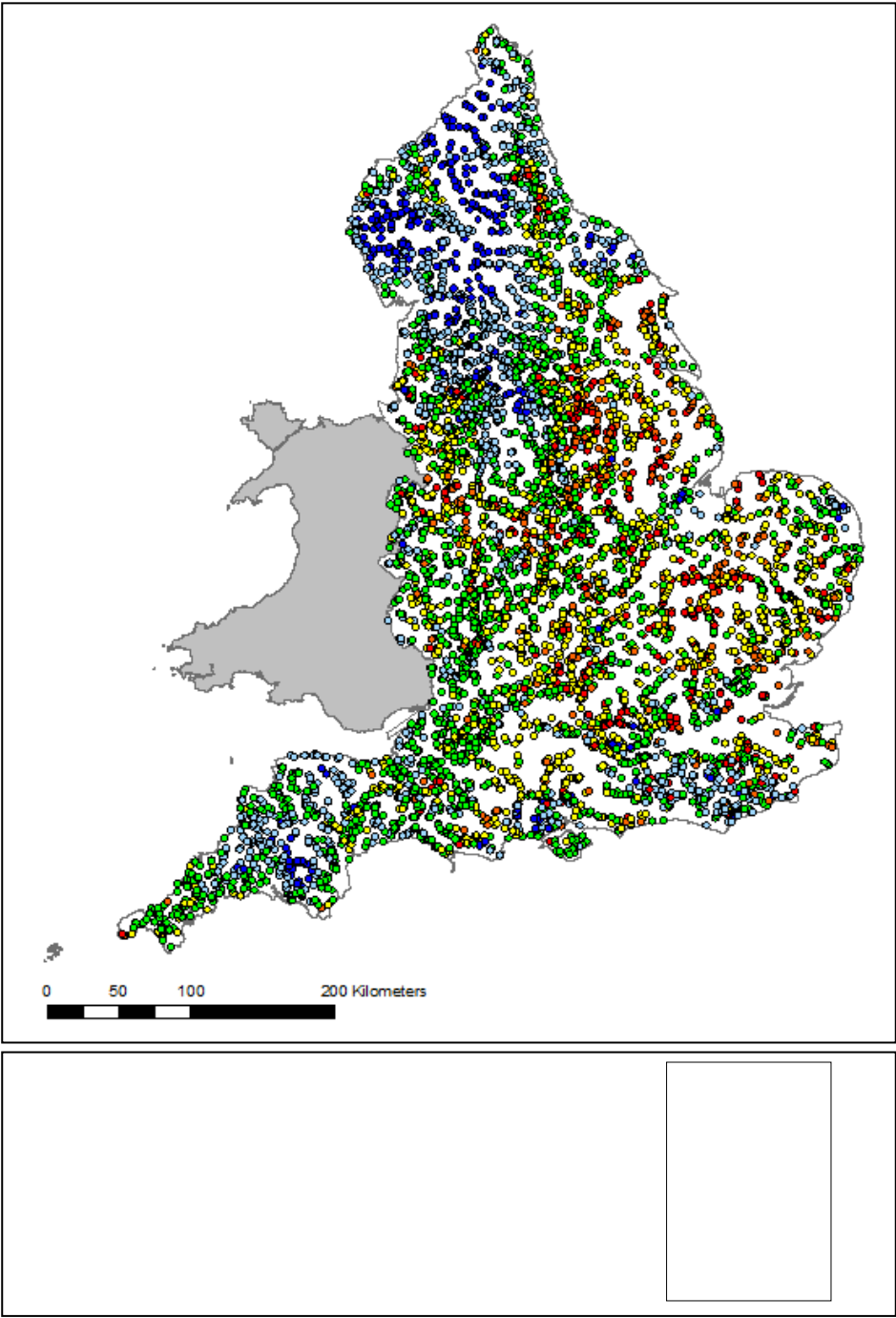
Nitrate in drinking water is also expensive to treat. A new nitrate removal plant for groundwater can cost some £8m for example, with annual running costs of some £250k. These costs are ultimately funded by water consumers.

Elevated nitrate can also affect the ecological quality of surface waters through the process of eutrophication. This is when excess nutrients cause algal/plant proliferation, damaging the quality and uses of waters as well as the ecology. Nitrate is generally the main nutrient involved in eutrophication of estuaries and coastal waters. However, recent studies have demonstrated that nitrate may play more of a role than was previously considered the case, alongside phosphorus, in eutrophication of some freshwaters, particularly lakes^v. The UK Technical Advisory Group (UKTAG) for the WFD is consulting in 2019 on proposed lake nitrate standards, for use alongside the current phosphorus standards for eutrophication control.

68 lakes/reservoirs and 16 estuaries in England are designated as eutrophic under the Nitrates Directive. In these areas nitrate from agricultural sources dominates.

Figure 2 shows the nitrate concentrations in rivers across England and Wales for the reporting period to 2015^{vi}. The low levels of nitrate in western and northern England contrast with higher levels in central and eastern areas. These differences are due to rainfall and land use, with eastern areas having predominantly drier, arable agricultural land and western and northern England being wetter with more livestock. More recent information on current levels of nitrate can be found in the protected area register (<https://ea.sharefile.com/d-s487ae61bf2a4b4fb>, and <https://www.gov.uk/government/collections/river-basin-management-plan-update>)

Figure 2. Mean nitrate concentrations (mg NO₃/L) in rivers and lakes sampling points, current reporting period 2014-2015 inclusive^{vii}



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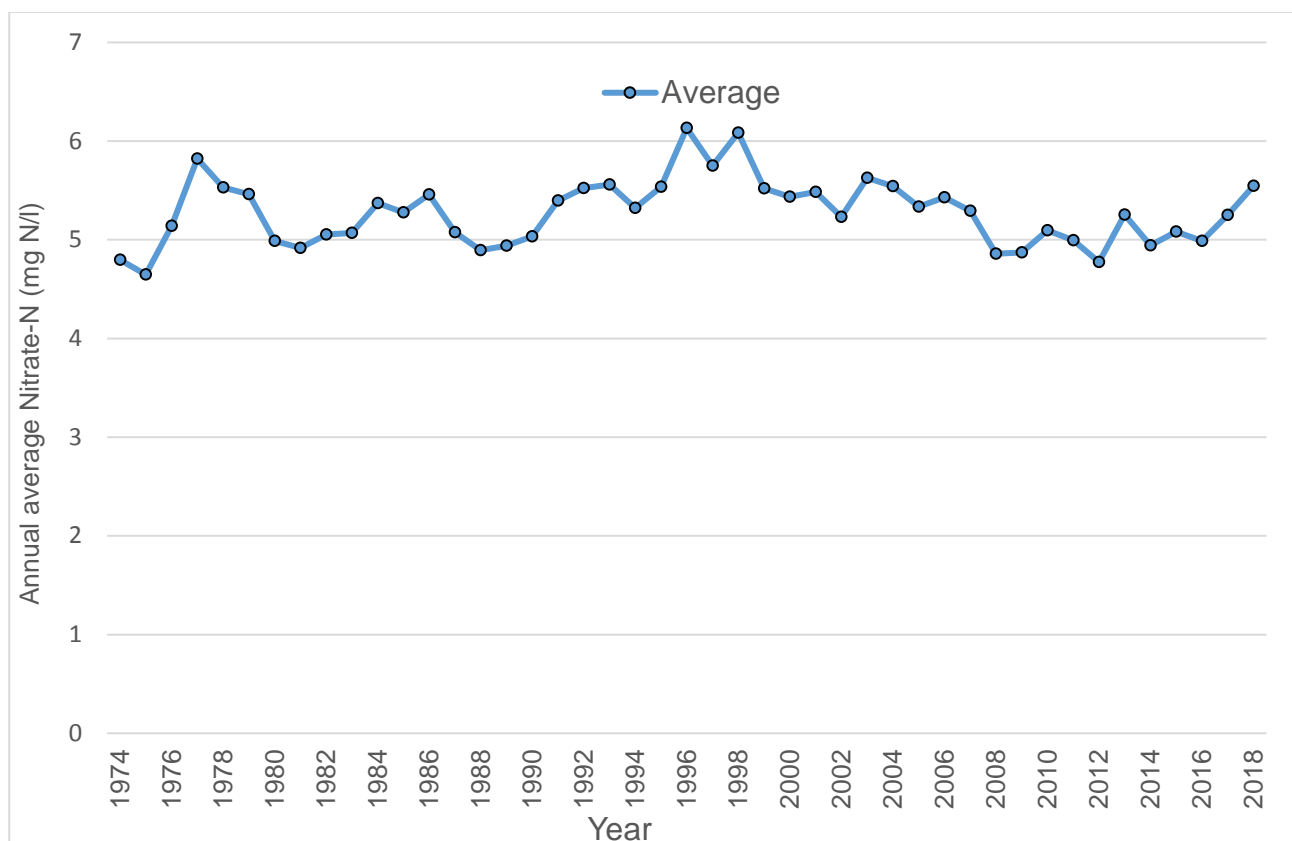
Table 1. Nitrate concentrations (mg NO₃/L) in rivers and lakes: current reporting period (% of sampling points)

% of points (mg /L)							
	No value	0 to 2	>2 to 10	10 to 25	>25 to 40	>40 to 50	> 50
Rivers and lakes annual average	0%	6%	22%	36%	24%	6%	6%
Rivers and lakes winter average	6%	5%	19%	31%	25%	8%	7%
Rivers and lakes maximum	0%	3%	14%	25%	23%	11%	23%

There have been widespread but gentle measured declines in nitrate concentrations in English rivers since 2000. Figure 3 is based on data from the Harmonised Monitoring Scheme which uses data from the bottom end of most major rivers, pooling the data for England. This graph indicates overall declining nitrate concentrations from 1998 (when NVZs measures began in England) until 2015. However, there is a notable rise in the last 2 years.

The reason for this increase in the last 2 years is not fully understood but it is likely to be due to the impact of recent dry weather, changes in cropping patterns and increased spreading of materials to land.

Figure 3. Annual average concentrations of nitrate in rivers from 1974 to 2018 (courtesy of Professor Fred Worrall, Durham University)



1.3 Nitrate in groundwater

Natural groundwater typically contains nitrate concentrations less than 10 mg/l. However, for some decades, concentrations of nitrate in groundwater have been shown to be on a rising trend^{viii}. From 1945 to 1996 the average nitrate trend for 13 of the major aquifers was an increase of 0.4 mg/l/yr^{ix}.

Nitrate movement to the water table is often slow, taking years or even decades to filter down through the thickness of the overlying unsaturated zone. Where nitrate applications to the ground surface decrease, this can have a diluting effect if newer waters interact with older groundwater. However, the speed of water movement through the unsaturated zone and the amount of interaction between old and young groundwater is variable. This makes it difficult to predict with accuracy when peak concentrations of nitrate will occur in groundwater^x. In areas where nitrate concentrations in groundwater have not yet peaked, concentrations in base flow to rivers will also continue to be high.

In general, nitrate concentrations are greatest in the drier, arable-dominated southern and eastern areas^{xi} of England, where we are also most dependent on groundwater for public water supply and base flow to rivers^{xii}.

In 2015, 189 of the 271 (69%) groundwater bodies in England were found to be at risk of failing WFD objectives, the majority because of high or rising nitrate concentrations. In addition, 100 groundwater bodies (37%) are classed at poor chemical status or have rising trends because of elevated nitrate. These account for 81% of the total number of groundwater water bodies being classed at poor status or failing the trend requirements.

Groundwater is a major source of drinking water supply. Nearly 30 per cent of groundwater used to supply drinking water now has to be blended, or treated, or has been replaced^{xiii} in order to meet the 50mg/l standard. All groundwater bodies are Drinking Water Protected Areas (DrWPAs), along with 496 surface waters in England.

Groundwater safeguard zones (SgZs) are non-statutory areas delineated around a borehole used for drinking water supply where the water quality has deteriorated. Within SgZs, measures are put in place with the aim of stopping any further deterioration and reducing the level of drinking water treatment. 227 of 253 SgZs in England have pressure from nitrate.

In terms of private drinking water supplies the DWI's Drinking water 2017 report^{xiv} shows that nitrate continues to pose a major problem. With 452 failing samples in 2017 (7.8% from 5,785 total samples taken), nitrate continues to be the biggest risk to water quality in the private supply catchments.

Figure 4 shows average nitrate concentrations in groundwater across England.

Figure 4. Mean nitrate concentrations in groundwater sampling points, for the period January 2009 to March 2019

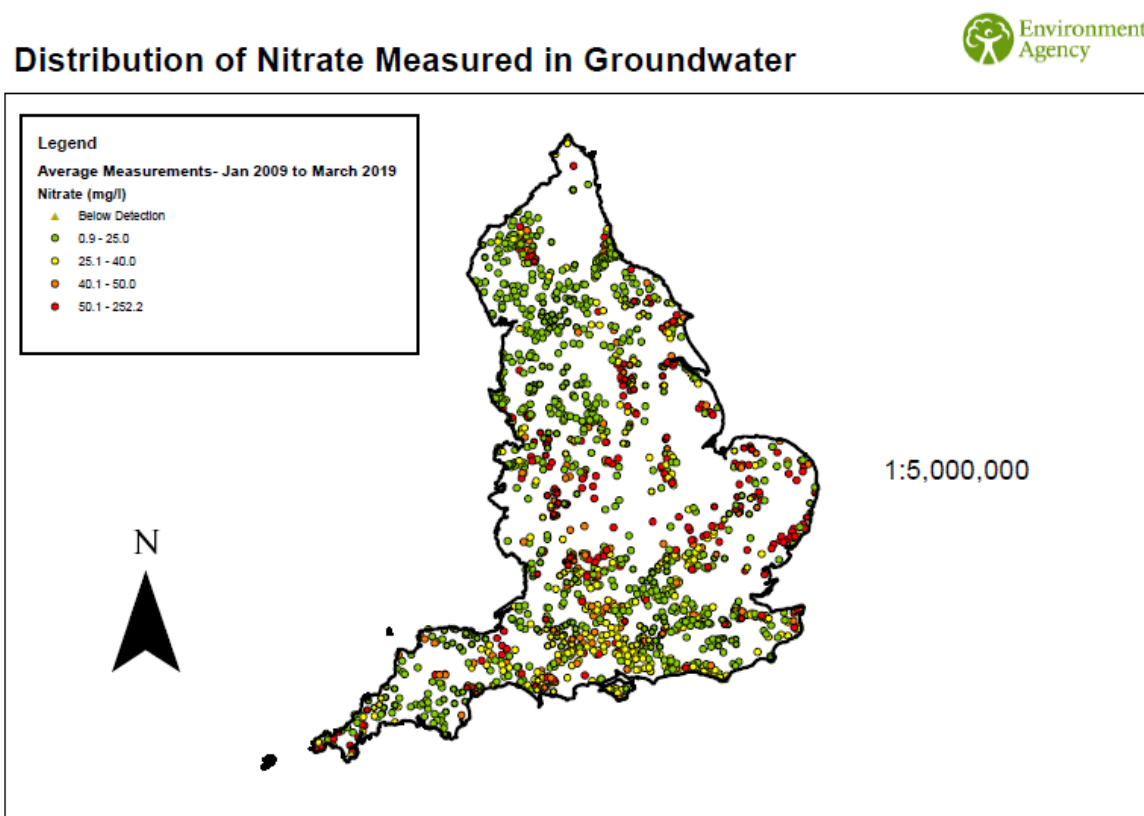


Table 2 Quality classes for average nitrate concentrations (mg NO₃/L) in groundwater
For the period January 2009 to March 2019: (numbers of sampling points)

	% of points mg nitrate / L			
	< 25	>= 25 to 40	>= 40 to 50	>50
Groundwater total	1417	515	191	344

1.4 Acidification and eutrophication of upland waters

Acidification and nitrogen (N) enrichment (eutrophication) resulting from deposition are issues which primarily affect lakes and streams in upland areas of England, for example the Lake District, Pennines, Dartmoor/Exmoor. These are long term issues that result from emissions that occurred between the mid-1800s through to the 1980s, largely from burning fossil fuels.

Levels of sulphate (the main acidifying anion) in UK streams fell substantially from 1988 to 2008 following reductions in emissions. pH and acid neutralising capacity have improved and levels of aluminium have fallen sharply in the most acidic streams. Nitrate (a secondary acidifying anion) has shown minimal change, being influenced primarily by inter-annual variations in climate. Despite the chemical improvements there has been relatively little biological recovery to date.

1.5 Eutrophication in estuaries and coastal waters

WFD nitrogen standards for good ecological status exist for estuaries and coastal waters in the UK. 93 per cent of monitored estuarine water bodies and 47 per cent of monitored coastal water bodies in England exceed this standard.

A large programme of impact monitoring has been undertaken to establish whether elevated nitrogen is giving rise to eutrophication in the waters that exceed their numerical nitrogen standards. 16 shallow tidal harbours or estuaries in England and Wales are currently designated under the Urban Waste Water treatment (UWWT) and Nitrates Directives. The main issue in transitional and coastal waters is excessive growth of macroalgae on the inter-tidal areas of shallow 'harbours'.

1.6 Nutrient enrichment in Groundwater Dependent Terrestrial Ecosystems (GWDTE)

Groundwater dependent terrestrial ecosystems (GWDTE) are wetlands which critically depend on groundwater flows and nutrient levels. As part of the assessment of groundwater status, the Environment Agency needs to determine whether a GWDTE has been significantly damaged via the groundwater supplying it. Nitrate threshold values have been established for GWDTE between 4 - 26 mg/l nitrate, which are considerably lower than drinking water standards.

1.7 Sources

The major sources of nitrate are fertilisers (including inorganic fertilisers, compost, manure, sewage sludge^{xv} and other materials spread on land), atmospheric deposition (from fossil fuel combustion and ammonia emissions from farming), leaking water mains and sewage effluent (from both leaking sewers and discharges of treated effluent).^{xvi}

Across England and Wales, agriculture is estimated to account for 50-60% of nitrate losses to the water environment. Figure 4 shows the proportion of nitrate derived from different sectors that reaches waters in England and Wales^{xvii}. Agriculture is the largest contributor to nitrogen loadings, with the greatest contribution occurring in the East Midlands, East of England and the South West. Nitrate concentrations in water draining from agricultural soils still exceed 50 mg/l over 35 per cent of England^{xviii}.

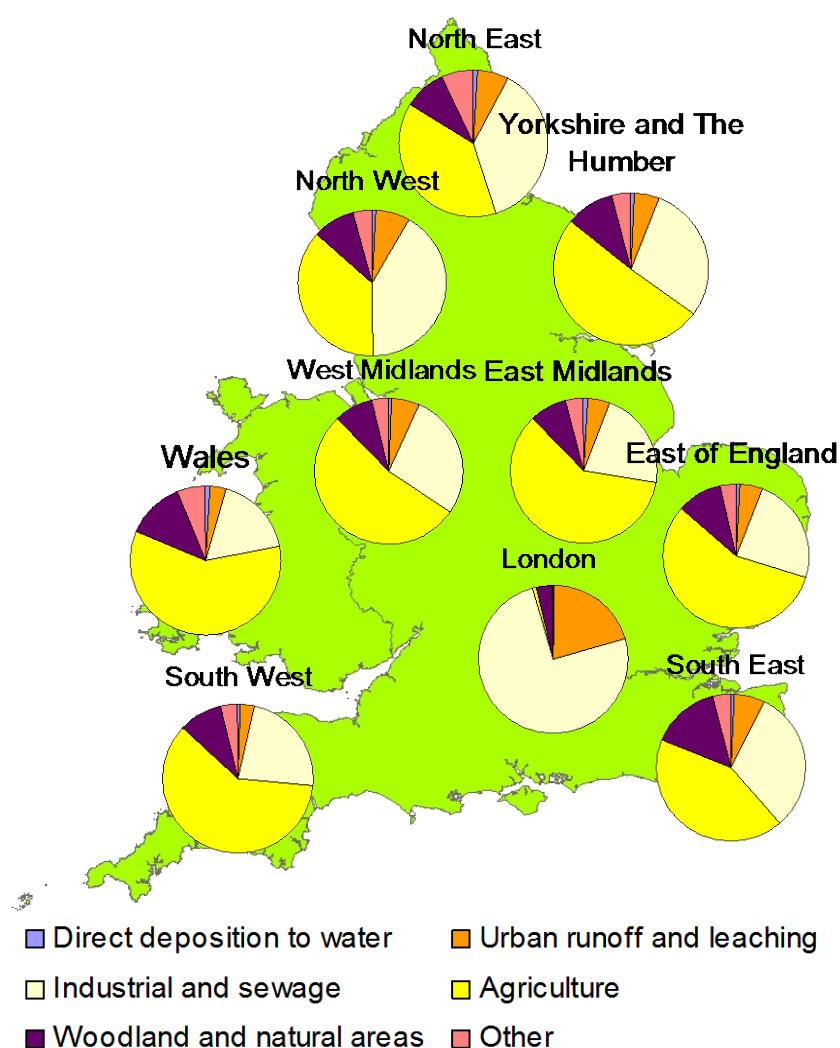
Local apportionment studies also show the dominance of agricultural sources to nitrate loadings. For example, three public water supply catchments in East Anglia were studied in detail and agriculture was responsible for 74%, 94% and 95% of the nitrate^{xix}.

The second most important contribution of nitrogen in surface water bodies is from sewage effluent, contributing about 25-30% of the national apportionment^{xx}.

Recent modelling undertaken by the Environment Agency estimates the national loading to rivers from diffuse sources (predominantly agriculture) to be 75%, with point sources (predominantly sewage treatment works) contributing 25%. The agricultural contribution is estimated as 69% of the total nitrate-N loading to rivers.

Figure 5 shows the proportion of nitrate derived from different sectors that reaches waters in England and Wales^{xxi}.

Figure 5. Sectoral contribution of nitrogen^{xxii}



Nitrate concentrations in water draining from agricultural soils still exceed 50 mg/l over 35 per cent of England.

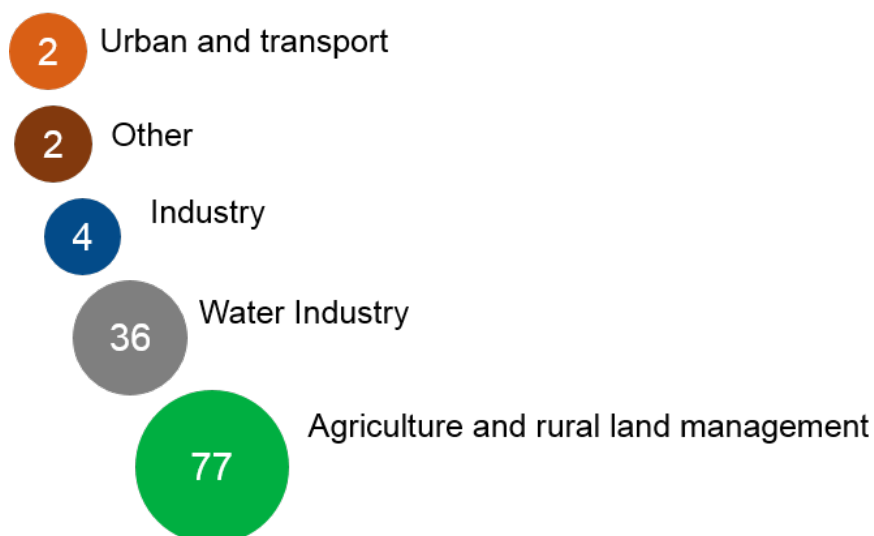
The second most important contribution of nitrogen in water bodies is from sewage effluent. The figure shows that the greatest contribution from sewage occurs in London, the North West and parts of eastern England where urban impacts are expected to be predominant.

Industry is a less significant source and other sources, such as misconnections, leaky water mains and runoff require further investigation to determine their contribution. Leaking water mains have recently been estimated to contribute around 3.6 kt of nitrogen per year to ground and surface waters in England, comprising around 20% of total N inputs to water in urban areas. (Mains leakage is also a significant source of phosphorus inputs to water, so is a concern with respect to both the main nutrients involved in water pollution.)

Where sewerage connections are not available (usually in rural areas), domestic septic tanks may also provide a locally significant nitrogen loading to groundwater^{xxiii}.

Figure 6 shows counts of numbers of reasons for not achieving good status (RNAGS) in England due to nitrate by the sector responsible. Known sources are mostly assigned to agriculture and rural land management followed by the water industry.

Figure 6. Counts of numbers of reasons for not achieving good status (RNAGS) (not number of water bodies), due to nitrate by sector responsible, England only (Environment Agency March 2019)



1.8 Atmospheric emissions

The main sources of emissions of nitrogen oxides (NO_x), sulphur dioxide and ammonia are power generation, refineries, chemicals/metals industry, agriculture, road transport and households. Emissions have been greatly reduced in recent decades through The United Nations Economic Commission for Europe and EU control measures e.g. UK NO_x emissions are down 50% since 1986 and SO₂ emissions are down 94% between 1970 and 2010.

Direct deposition of nitrogen compounds is a minor contributor (just 0.7 per cent) to the nitrate budget for inland surface waters. However, recent research has found that 90 per cent of groundwater dependent wetlands were exceeding the critical load for atmospheric nitrogen deposition. In addition, since 2013 ammonia emissions have started to increase, with potentially significant implications for biodiversity and human health. The agricultural sector is the biggest contributor to ammonia pollution, producing 82 per cent of all UK ammonia emissions in 2016.

1.9 Acidification

Recovery from acidification is underway but is a slow process. Soils continue to release pollutants such as sulphur, nitrogen and metals to water for many years until buffering capacity is restored. However, we expect further significant reductions in emissions of SO_x and NO_x in the next few years, mainly at fossil-fuelled power stations through regulatory controls under the Large Combustion Plant Directive and the Industrial Emissions Directive.

1.10 Risk of deterioration

Until the rise of the last 2 years, nitrate concentrations in rivers had been, in general, gently decreasing which is likely to reflect reduced use of nitrogen based fertilisers (Figure 7) and reduced livestock numbers. This could reflect improved nutrient management practices through better farm business decision-making coupled with regulatory drivers (e.g. NVZs) and other measures such as Catchment Sensitive Farming (CSF) and specific agri-environment schemes. Figure 8 shows that nitrate loading from agriculture has fallen in recent years both inside and outside of nitrate vulnerable zones. The reduction in

modelled nitrate pressure is corroborated by the reduction in N soil balance in English soils.

Figure 7. Overall application rates (kg/ha) of total nitrogen on tillage crops and grassland, Great Britain 1983 – 2016 (British Survey of Fertiliser Practice, 2016)

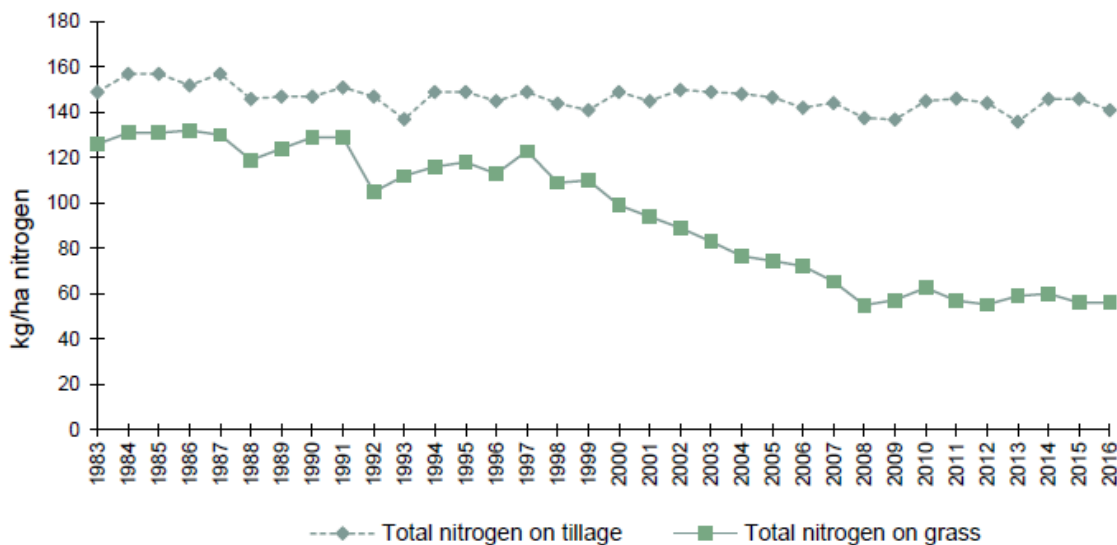
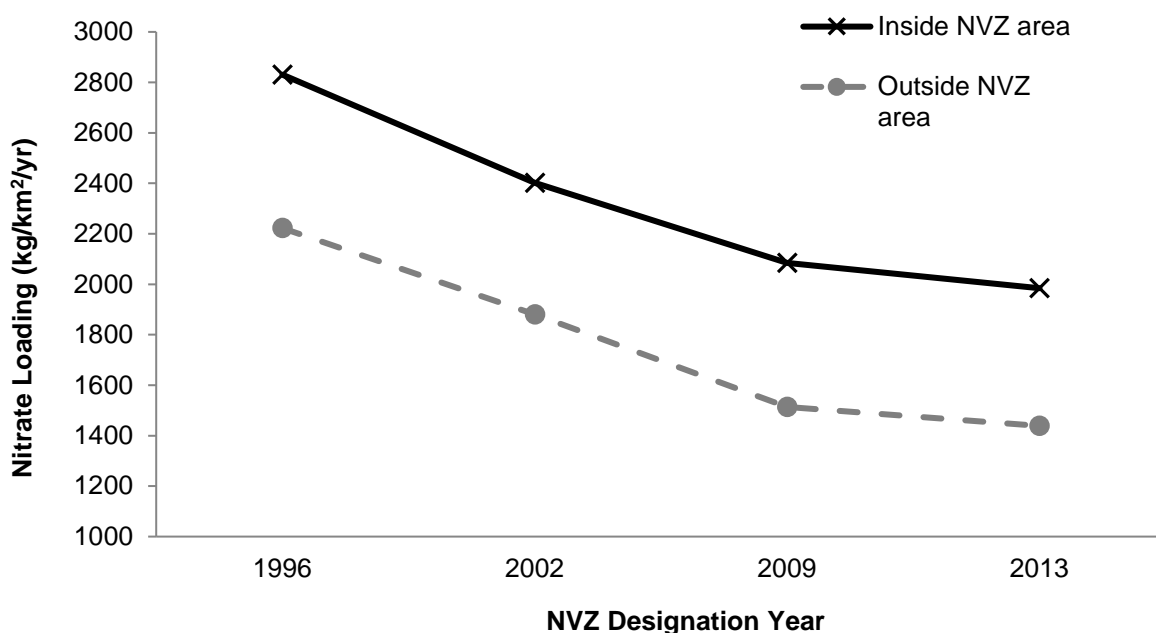


Figure 8. Comparison of N loading between inside and outside NVZ areas across each designation round (data taken from NEAP-N model runs).



However, recent changes in farming practice and the growth of anaerobic digestion have meant that more materials are now being spread on land, some of which would previously have gone to landfill. The nitrate from these materials is often not utilised by the crop as they can be spread at times of the year when crop growth is slow. Therefore this ‘hidden’ nitrate may be contributing to local increases in nitrate leaching. An Environment Agency study has shown that nitrate leaching from materials to land could be having a significant impact on raw groundwater in some sensitive locations. Further work is needed to understand this risk and put in place further action to reduce the risk of pollution.

In future, climate change may affect nitrate dilution and loading by altering rainfall intensity, duration and location, and agricultural practices^{xxiv}. More frequent storm events, particularly in winter, are likely to increase nitrate losses from land to water while hotter summers seem likely to exacerbate the effects of eutrophication. Population change and concern for food security and food pricing could lead to agricultural intensification, with increasing nitrate loadings to water and different distribution patterns.

Population increase would also bring challenges in dealing with increased volumes of sewage effluent. Measures used by the water industry to reduce nitrate is energy intensive and besides extra cost will increase greenhouse gas emissions.^{xxv}. Assessments of the risk of deterioration by 2030 and 2050 have been undertaken for nitrate, providing an indication of the possible 'direction of change' in quality.

The risk assessment made use of existing WFD monitoring data to identify water bodies close to the lower class status boundaries (for rivers) or where nitrate concentrations were in relation to standards (estuaries and coastal waters) or where there may be rising nitrate trends (groundwater bodies).

The effect of population increase and changes in agricultural activities were also factored into the assessment alongside a weighting of these scores based on estimates of apportionment of their impacts. These risk factors and weightings were combined for assessment using Geographical Information Systems (GIS) overlays. Climate change was considered where this could compound pressures from particular activities. The resulting activity scores were then applied to water bodies that, from current information, were seen to be potentially at risk of deterioration. Water body scores from all activities were divided into three equal categories to correspond to low, medium and high risk of deterioration.

The results indicate that there is some risk of deterioration from the current nitrate standards in estuaries and coastal waters, groundwater and Drinking Water Protected Areas. The results also suggest that there will be broadly the same number of water bodies at risk of deteriorating in status in 2030 and in 2050. This may simply confirm that there are certain areas that are most vulnerable to deterioration, or it could indicate that the assessment method used was not able to discriminate between the impacts from pressures to 2030 and to 2050.

The qualitative assessment indicates that around 8 per cent of estuaries and coastal waters in England may be at risk of deterioration compared with current nitrate standards. This was based on deterioration from a nitrate standard, and so does not necessarily translate directly to a eutrophication problem or risk.

Over 86 per cent of groundwaters in England are at risk of failing their chemical objectives for nitrate by 2027, this figure also includes those at risk of deteriorating from their current status. Groundwater is expected to continue to deteriorate for nitrates between now and 2050 unless interventions to prevent the continued deterioration and pressures of climate change and population growth are mitigated.

A 2007 study showed that more than 40% of sampled groundwater sites had rising nitrate trends that could exceed the drinking water standard by 2015^{xxvi}. More information on drinking water protected areas can be found in the Drinking Water Protected Areas Pressure Narrative.

1.11 Evidence gaps

Our main evidence gaps regarding the problem are:

- there are currently no formal nitrate standards for freshwaters within the WFD, although there are thresholds in the Defra/EA methodology for the Nitrates Directive

- a review into climate change impacts is needed as we do not fully understand the impact that changes in climate may have on nitrogen transport and fate
- a review of how we monitor for nitrate and assess the impacts of nitrate pollution is needed because our monitoring networks are now much smaller. This review should include a consideration of how we monitor in the unsaturated zone to help us predict future nitrate concentrations
- greater evidence on how and where river base flow is affected by nitrate from groundwater is needed
- a review of nitrate leaching to groundwater is needed as there is growing concern that some recent changes in farming (e.g. spreading materials on land) may be leading to an increase in nitrate leaching
- further research on the health effects of nitrate concentrations

2. Current control measures

Control measures to address the impact of nitrate cover two main sources: agriculture and direct discharges of sewage.

2.1 Nitrate Vulnerable Zones

Areas of land that drain into waters that are polluted or threatened by nitrate, and which contribute to nitrate pollution, are currently designated as Nitrate Vulnerable Zones (NVZs). These zones cover approximately 55 per cent of England following the review completed in 2017. Farmers with land in these areas must follow statutory management requirements to tackle nitrate loss.

Figure 6 shows the designations of NVZs on grounds of high nitrate in rivers, groundwater and eutrophication^{xxvii}. Nearly 605 of farm holdings in England are in an NVZ. Estimates of costs to the agricultural sector of complying with the (2008 revised) NVZ regulations are between £44 million and £65 million per year^{xxviii}.

Estimates of the effectiveness of NVZs (based on the 2002 programme) put the overall national reduction of nitrate lost to the water environment in NVZs as between 2 and 7% (reductions at a catchment scale varied between 2 and 20%). Measures outside of NVZs may result in a further 4% reduction in nitrate losses from agriculture. Modelling approaches at a catchment scale predict reductions of environmental losses for Catchment Sensitive Farming (CSF) Target Areas of up to 20% for nitrate (2010) (but with very high uncertainty). Such NVZ and CSF reductions would not be cumulative.

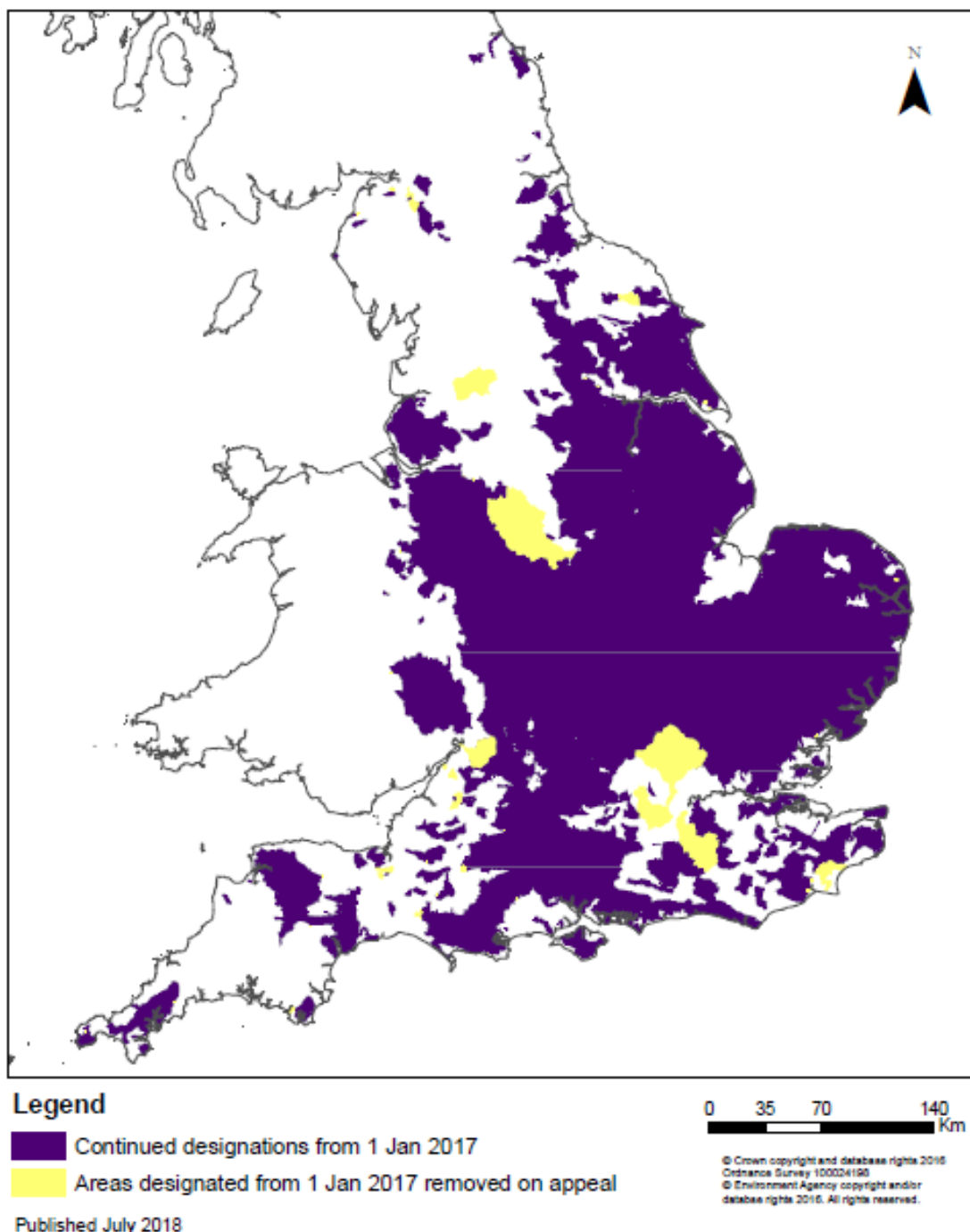
The current NVZ action programme (began in 2016) is more stringent than the 2009 programme and is therefore expected to deliver greater reductions than those stated above. The revised programme requires all livestock farmers to provide storage for the slurry they produce which allows optimum spreading, and also to observe closed periods for slurry spreading. However, adherence to the NVZ action programme is compromised by inadequate slurry storage preventing efficient and timely use of slurries. Slurry stores built pre 1991 are currently exempt from the Silage, Slurry and Agricultural Fuel Oil (SSAFO) Regulations 2010 which cover the construction and maintenance, positioning and minimum capacity of stores.

Figure 6. NVZ designations (2012)

Revised version of the NVZ map published on 1st December 2016

Final 2017 - 2020 NVZ designations following appeal decisions

(England Only)



Business as usual predictions suggest a 19% reduction in agricultural nitrate losses by 2015, mainly due to reducing animal numbers in response to economic drivers^{xxix}.

Although the NVZ action programme has been effective at making a modest reduction in nitrate leaching, the measures are not sufficiently robust to improve failing groundwater bodies to good chemical status. In terms of delivering measures to get groundwater bodies to good status substantial changes to farming practice are needed, such as widespread use of cover crops or applying nitrogen at below the economic rate. Currently there are insufficient mechanisms available to put these effective measures in place.

2.2 Farming Rules for Water (2018)

The Farming Rules for Water (2018) may also provide a modest reduction in nitrate leaching. They will also provide a statutory countrywide baseline for reducing agricultural diffuse pollution. Advice-based voluntary schemes such as Catchment Sensitive Farming, together with incentive-based approaches such as Countryside Stewardship are also helping. The Catchment-Based Approach is maturing and is also contributing to improvements. Through its project on water quality and agriculture Defra has been reviewing future measures and mechanisms for controlling diffuse water pollution from agriculture, based on the latest evidence available. The new environmental land management scheme, proposed by the government, will be an important future mechanism for reducing diffuse pollution from agriculture. It has the potential to deliver some of the improvement needed if water quality measures such as cover crops and applying N below the economic rate are included.

2.3 Voluntary action

There are several voluntary or incentive programmes targeted at reducing nitrate input from agriculture. These include the new [Environmental Land Management Schemes \(ELMS\)](#), Catchment Sensitive Farming (CSF), Environmental Stewardship Schemes and farm Nutrient Management Plans. 62% of farm holdings in England have implemented at least half of the CSF farm specific recommendations. 79% of practices implemented were solely as a result of advice from the CSF, with the remaining 21% influenced by more than one scheme^{xxx}.

For agriculture, the most effective measures (in terms of cost and nitrate leaching reduction) are:

- have a nutrient plan and know the nitrogen content of manures, composts and slurries
- grow cover crops (an ELS option) as a low cost option compared to land-use change
- calibrate fertiliser spreaders (predicted 8% reduction in leaching)
- land-use change, for example change intensively farmed arable land to less intensively managed grassland or woodland, is the most effective and also most costly measure. It could involve a large cost in terms of influencing or compensation
- reducing stocking density is the most effective measure to reduce nitrogen loading from livestock, but again this is a costly measure^{xxxi}
- local circumstances would dictate which combinations of measures would be the most cost-effective

2.4 Water supply and effluent management

Conditions on permits for discharges are used to regulate the contribution of nitrate entering surface waters from wastewater (sewage) treatment works and industry. Conventional primary and secondary treatment at sewage works removes 20-30% of the nitrogen in raw sewage^{xxxii}. Where effluent needs tertiary treatment, for example to meet Urban Waste Water Treatment Directive (UWWTD) requirements for saline waters affected by eutrophication, levels of nitrate reduction can be around 70-80% to meet effluent nitrogen standards of 10-15 mg/l^{xxxiii}.

Improvements to leaking sewers will reduce nitrogen loss to groundwater, and to surface waters where there is good connection with groundwater. Leakage reduction programmes for mains water pipelines where nitrate in drinking water is at relatively high concentration will have the additional benefit of limiting the return of this pollutant to groundwater.

Case study: Estuaries and coastal waters

Langstone Harbour was designated as a Sensitive Area (Eutrophic) in 1999 and an NVZ in 2008. A major sewage discharge was transferred elsewhere and farming practices were controlled to reduce nitrate losses. The harbour now meets its nitrogen standard and there are signs that the excess macroalgal growth is diminishing.

Nutrient stripping at Poole waste water treatment works has significantly reduced the nitrogen from the works. Falling levels in the bay into which it discharges are hoped to contribute in a reduction in macroalgae cover.

2.5 Safeguard Zones

Non-statutory safeguard zones (SgZ) are areas identified to focus efforts in tackling pollution in DrWPAs. Activities within a SgZ could include CSF, environmental permits, pollution prevention advice, local campaigns, product labelling and other voluntary initiatives.

There are also water company led catchment schemes to reduce nitrate concentrations in their abstractions in SgZ, and many of these schemes are delivering positive outcomes. Between 2020 and 2025, companies will complete 29 measures to improve the water they abstract from the environment (all of these will improve nitrate in groundwater and 7 will also to improve microbial quality). A further 236 measures to prevent deterioration of abstracted potable water quality; and 77 investigations into why water quality is deteriorating which will result in recommendations for measures. Mostly these measures to prevent deterioration and investigations are for nitrates and pesticides. Indicative costs for these measures and investigations are £95 million to £115 million. This equates to 1.9 to 2.3% of the entire indicative capital costs (£4.9 billion) that companies will spend between 2020 and 2025. Between 2015 and 2020 approximately £69 million was apportioned to companies to implement 170 DrWPA measures identified in Safeguard Zones.

2.6 Measures acting in combination

Estuaries and coastal waters will benefit from direct interventions and should also benefit from those aimed at land use and discharges in the rest of the catchment. Two case studies on eutrophication control measures in estuaries and coastal waters are summarised below. These demonstrate the degree of progress in eutrophication control in different scenarios.

Case study: ChaMP Project

Brighton ChaMP for Water was established to protect and improve the quality of groundwater in the Brighton Chalk block, to ensure it remains a sustainable resource for public water supply. The project is a collaboration between the South Downs National Park Authority, the Environment Agency, Southern Water, the University of Brighton and Brighton & Hove City Council, working together with Natural England and the Brighton and Lewes Downs UNESCO Biosphere (the Living Coast) to protect the aquifer. The project involves:

- Providing practical advice and improvements to land management in the urban and rural area
- Raising public and land-manager awareness of groundwater protection
- Undertaking research to increase knowledge of the issues and monitor the project's success

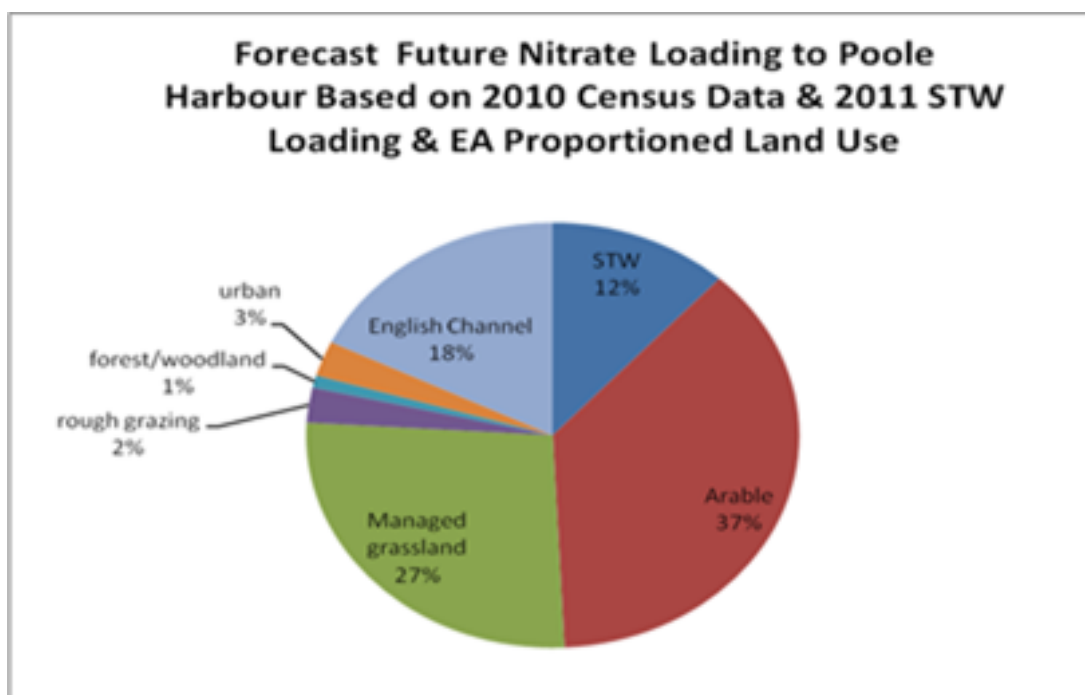
Brighton ChaMP for Water covers the following area:



Case study: Poole Harbour

Poole Harbour is a designated 'transitional water body' and 'protected area' under the Water Framework Directive (WFD). The intertidal habitats and coastal waters of Poole Harbour are of international nature conservation importance. The harbour is failing to achieve conservation status as a result macroalgae growth and high nutrient loads.

Source apportionment indicates nitrate loads entering the harbour are likely to stabilise at around 2300 tonnes N/yr but need to be reduced to around 1730 tonnes N year, together with a c30-50% reduction in Phosphorus. The Nitrate source apportionment is as follows:



Wessex Water have largely delivered their fair share N reduction but need to reduce their phosphorus inputs. The Environment Agency and Natural England

have been working with the agricultural community to identify how total agricultural nitrogen losses can be reduced by around 32% to c1200 tonnes N/yr, a maximum leaching of 24 kg/N/ha.

The Environment Agency and Natural England have an agreed position statement outlining that farmers should implement all reasonable measures to deliver these objectives and will be putting forward options to Defra in consent order document. These options will include applying a 'nutrient trading' approach. This would involve encouraging all farmers to become a member of Poole Harbour Agricultural Board (PHAB), the objective of which would be to become some of the world's most efficient farmers and to farm sustainably producing food without adversely impacting on the environment. Farmers would be set a glide path leaching target which will reduce annually so that the overall catchment target can be delivered in a reasonable time period (about 10 years). Farmers would then be required to: maximise their nutrient management efficiencies; annually undertake nutrient planning and calculate their N loss. Where these exceed the catchment target they would either need to implement more measures to reduce N loss or purchase N credit. Where they were below the target they could sell any spare N credit. Annual nutrient planning returns would be submitted to a third party who would validate the data and ensure farmers complied with set rules. Non-compliance would result in removal of PHAB membership and would increase the likelihood of EA compliance visit. Data from annual returns would be collated on a sub-catchment basis and used by the management group to ensure targets are met to an agreed timeframe.

3. Potential solutions and possible approaches

3.1 Overview

Overall the progress towards delivering the nitrate related objectives in the first two cycles of the WFD has been slow. From a groundwater perspective there has been further deterioration and, whilst some of this is due to historic nitrate, it is increasingly clear that current measures are not sufficiently robust to deliver WFD objectives in the long term. A comprehensive review of measures and approaches appear to be needed in order to achieve good ecological status and other WFD objectives in the long-term.

Meeting WFD objectives is unlikely for most groundwater bodies covered by the NVZ action programme and will be very difficult for those that are outside NVZ^{xxxiv}. A review under the Nitrates Directive is undertaken every 4 years.

Because of the time-lag between changes in agricultural practice and resultant improvement in groundwater quality, even dramatic land use change may not be effective in delivering good status by 2027. Targeting measures to where they can be most effective is expected to have greatest value, in terms of both improvements to water quality in the environment and in delivering tangible benefits. This could mean, for example, targeting:

- catchments used for abstractions for public water supply that are at risk of deteriorating to the point that treatment needs to be introduced or increased, where this would require additional capital expenditure
- drinking water protected areas where significant numbers of small water supplies from groundwater are particularly at risk.

3.2 Preliminary ecosystem services context

The ecosystem services approach is one potential solution to the nitrates pressure. The National Ecosystem Assessment underlines the importance of managing ecosystems in a more integrated way, to achieve a wider range of services and benefits. But the distribution of providers and beneficiaries of ecosystem services is not evenly spread, and the management of ecosystem services can be localised, while the beneficiaries may be widely distributed. Utility companies are increasingly involved in land-management intervention aimed at improving the quality of raw water supplies, such as the Sustainable Catchment Management Programme (SCaMP)¹. Where beneficiaries are local to the source of ecosystem services, this will affect the way those ecosystems are valued and managed.

Assessment of the evidence presented in the Nitrates Evidence Pack indicates the following (note that this is not a comprehensive assessment).

Beneficiaries of nitrate use include:

¹ SCaMP is the Sustainable Catchment Management Programme. It is a partnership approach between RSPB and United Utilities that facilitated payments to farmers for more sustainable operations, establishing one of the most recognised Payments for Ecosystem Services (PES) schemes in the country. These schemes have potential to promote sustainable land use, deliver ecosystems service benefits, and reduce costs for firms.

- farmers, through improved yields and income
- food industry, through cheaper source materials
- consumers, through availability of food and cheaper pricing
- secondary polluters, through availability of cheaper disposal options for sewage sludge and other organic wastes

Owners of dis-benefits associated with nitrate use and pollution include:

- water-dependent biodiversity impacted by nitrate in water bodies
- water companies, through treatment needed to ensure clean drinking water in supply (costs for treatment or blending)
- people, through higher nitrate in drinking water, higher costs of drinking water supply and its pricing, loss of amenity in eutrophic waters

Principal players are farmers, waste water treatment companies, general public (as users of water and food, plus producers of waste).

Interveners/facilitators are water companies (end of pipe, land management intervention), farmers (changed land practice, fertilisers), retail (supermarket) sector, government at all levels (regulation, incentive schemes), the Environment Agency and co-deliverers.

4. Contacts

If you have any feedback or comments on the evidence contained in this summary please contact: enquiries@environment-agency.gov.uk

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