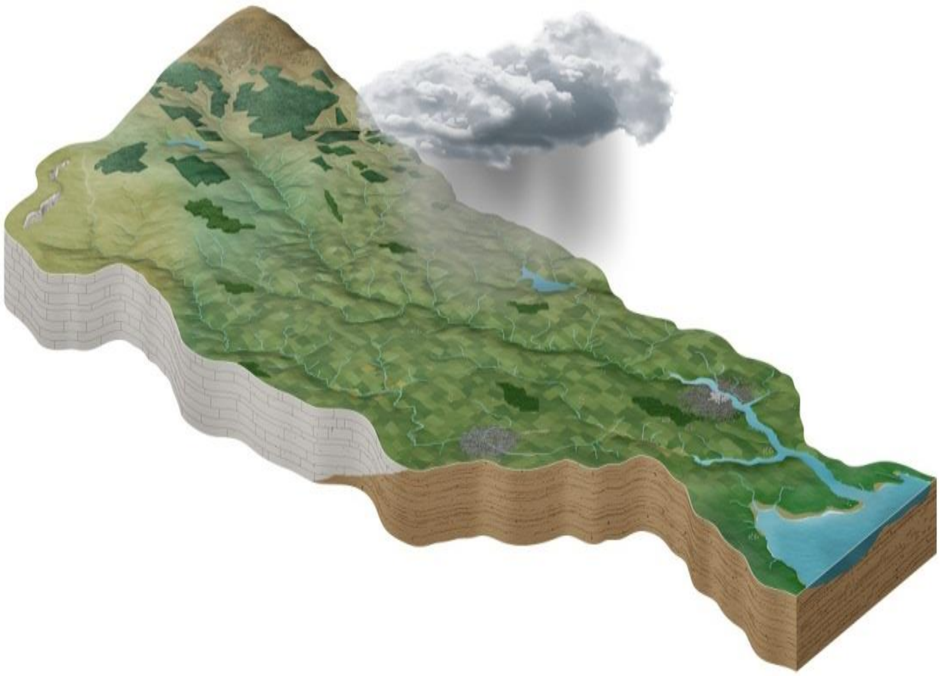
Assessment of the catchments that need reductions in nitrogen concentrations to achieve water quality objectives

WFD River Basin Management Plan – 3rd Cycle

June 2021



EPA Catchments Unit

Version no. 1.6

Key Highlights

- Elevated nitrogen concentrations in waters is one of the factors that leads to poor water quality outcomes in all waters. Estuaries and coastal waters, and groundwater drinking water supplies are particularly at risk.
- There are a number of key catchments of concern with elevated nitrogen concentrations along the south, southeast and east coasts including the Maigue/Deel, Bandon, Lee, Blackwater, Suir, Nore, Barrow, Slaney, Tolka/Liffey and the Boyne river catchments.
- Nitrogen concentrations in waters have been increasing since 2013 — between 2013 and 2019, all but one of the catchments of concern showed increasing trends in the amount, or load, of nitrogen discharging to the sea via our rivers.
- The nitrogen load discharging to sea needs to be reduced in the catchments of concern to support healthy aquatic ecosystems. The scale of reduction needed ranged from zero in some years, to just over 8,000 tonnes of nitrogen in the Barrow catchment in 2018.
- The data show that in the predominantly rural catchments, more than 85% of the sources of nitrogen in the catchment are from agriculture, from chemical and organic fertilisers. In contrast, the majority of the nitrogen in Liffey/Tolka catchment, which incorporates Dublin City, is from urban waste water.
- Maps have been developed of the critical source areas for nitrogen. These are the highest risk areas in the landscape where nitrogen from agriculture leaches to waters. Measures to reduce leaching should be targeted in the critical source areas, in the catchments of concern, to deliver maximum environmental benefits.

Purpose of this report

The EPA has carried out an analysis to identify the catchments where nitrogen concentrations are too high to support healthy aquatic ecosystems, or at least Good Ecological Status under the Water Framework Directive. The reductions in nitrogen in waters that are needed in these catchments has been calculated, and critical source area maps have been developed to help target nitrogen control measures in the landscape. Although achieving Good Ecological Status requires that relevant standards are also met for other quality elements, such as macroinvertebrates, dissolved oxygen, phosphorus, fish and other relevant parameters, for the purposes of this document, the focus is on nitrogen.

This document describes the following:

- The catchments of concern that have elevated nitrogen concentrations;
- The annual load (tonnes) of nitrogen that has discharged from major catchments out to sea over the last decade;
- The annual nitrogen load reductions that would have been needed to keep the nitrogen concentration below the Environmental Quality Standard[1] over the decade;
- The sources of nitrogen in the catchments of concern; and
- The critical source area maps that have been developed by EPA to help target nitrogen measures in catchments.

Assessment of the types of actions on land that will be needed to achieve the required reductions in nitrogen in waters is being considered by the Department of Agriculture, Food and the Marine and

[1] Nitrogen reductions were also needed in the years prior to this period but for the purposes of this report, the focus is on the last decade.

the Department of Housing, Local Government and Heritage, with support from Teagasc, and is outside the scope of this assessment.

Background

The primary water quality issue of concern in Ireland is elevated concentrations of nutrients (nitrogen and phosphorus), which contributes to an increase in the growth of algae and aquatics plants, which in turn impacts on aquatic ecosystem health. Excess nitrogen in waters can also impact on drinking water quality.

Nitrogen losses to waters are of particular concern at present because our estuaries are in the poorest condition overall, with only 38% meeting their water quality targets, and these waters are particularly sensitive to elevated nitrogen concentrations. Trends in nitrogen concentrations in waters have also been increasing since 2013. The key catchments of concern are in the south and south east of the country (Figure 1).

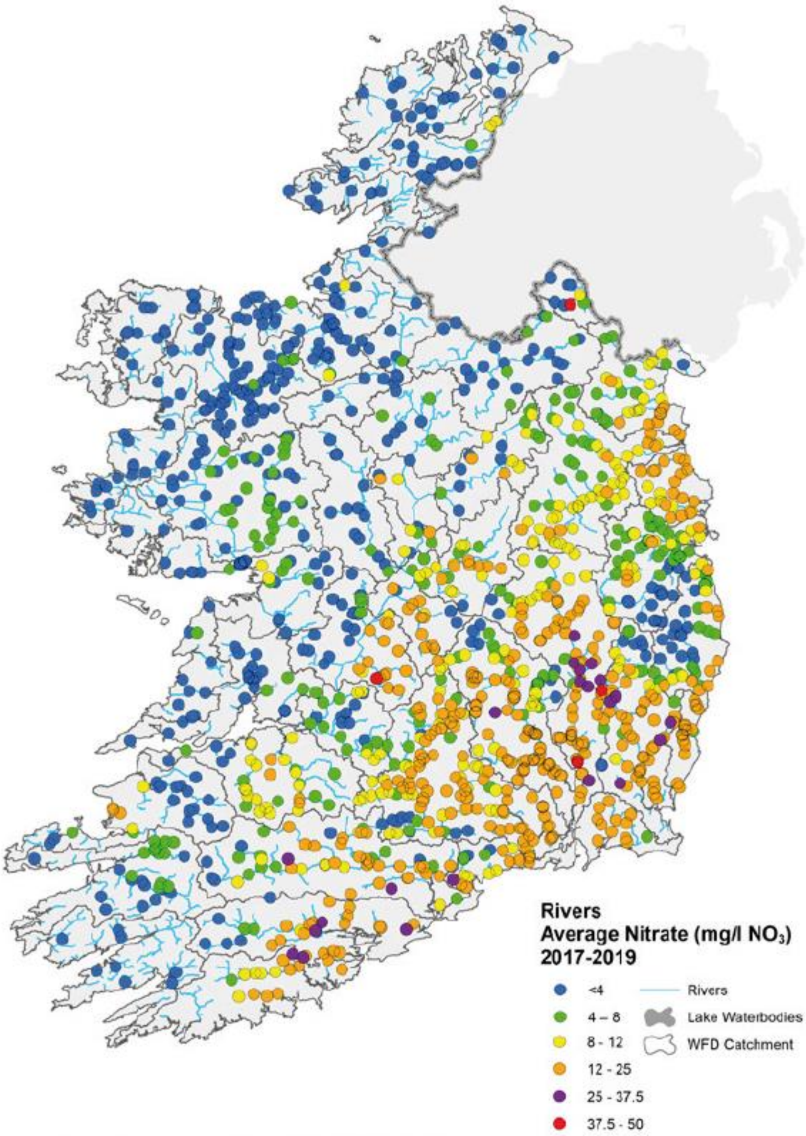


Figure 1. Average nitrate concentrations in rivers for the period 2017-2019, showing elevated concentrations in the catchments in the south, southeast and east of the country.

Nitrogen in our waterways comes mainly come from agriculture, from chemical fertiliser and organic fertiliser (manures and urine) from livestock. Excess nitrogen is leached down through freely draining soils, into groundwater, and then into our rivers and streams. Nitrogen also comes from urban and domestic waste water, although the relative contribution from human sources is much smaller overall than from agriculture. At the national scale, there is a broad relationship between the numbers of livestock on land, the amount of nitrogen fertiliser used, and nitrogen emissions in waters (Appendix 1). However, at the local scale, the soils and the climate are also very important driving factors that dictate how much of the nitrogen used on land ends up in waters from any given farm, in any given year. Measures therefore need to be targeted to achieve the most effective environmental outcomes.

The latest EPA Water Quality Indicators report for 2019 highlighted the following specific concerns in relation to nitrogen in waters:

- Over a fifth (22%) of estuarine and coastal water bodies have unsatisfactory dissolved inorganic nitrogen (DIN) concentrations.
- The loads of total nitrogen and total phosphorus to the marine environment from our rivers have increased by 24% (13,559 tonnes) and 31% (338 tonnes) respectively since 2012-2014.
- Over a fifth (22%) of all groundwater monitoring sites had high nitrate concentrations (>25mg/l NO_3), and three sites exceeded the drinking water standard (50 mg/l NO_3). Almost half (49%) of all groundwater monitoring sites had mean nitrate concentrations increasing by more than 1 mg/l NO_3 for the period 2013-2019.
- 44% of river monitoring sites are showing an increasing nitrate trend for the period 2013-2019.
- There is a strong regional pattern in all waters that have high nitrogen concentrations and there are increasing trends. The areas of greatest concern are the south and south east of the country.

The EPA reports on drinking water quality in public and private supplies in 2019 note that one public supply and one public group water scheme, and four private group water schemes and 20 small private supplies respectively, which were monitored for nitrate in 2019, had samples that failed to meet the drinking water standard for nitrate.

Nitrogen standards for achieving water quality objectives

The Nitrate Directive requires member states to set controls in place to prevent pollution of surface waters and groundwaters from agricultural sources, and to protect and improve water quality for aquatic ecosystem health and drinking water purposes. In Ireland the Nitrates Directive is implemented through regulations to manage the nitrogen source inputs to the environment, and regulations that set nitrogen limits in the receiving waters.

The Good Agricultural Practice for Protection of Waters Regulations (S.I. No. 605 of 2017, as amended in S.I. No. 65 of 2018) establishes nutrient management source controls on farm, such as maximum stocking rates, requirements for slurry storage, and the closed season for application of fertilisers. These regulations provide a basic level of protection from source inputs for all waters.

The Surface Water Regulations (S.I. No. 272 of 2009, as amended in S.I. No. 386 of 2015 and S.I. No. 77 of 2019) sets out the environmental quality standards that are required to maintain healthy aquatic ecosystems. The Drinking Water Regulations (S.I. No. 122 of 2014) sets out the maximum concentrations of nitrate in drinking water to protect public health. The most stringent statutory environmental quality standard in place is the dissolved inorganic nitrogen concentration in coastal waters (Appendix 2), which is <2.6 mg/l as N, as measured in the upper reaches of estuarine waters that discharge into the marine environment. It is assumed for the purposes of this nitrogen reduction assessment, that if the nitrate concentrations in streams and rivers throughout the contributing catchment are maintained at less than 2.6 mg/l as N, that the statutory dissolved inorganic nitrogen standard will be achieved in the marine waters.

Due to the large variability in farming practices, soils and climatic conditions across Ireland, the source input controls may not be sufficient in some places to achieve the nitrogen limits set in waters. In these situations supplementary measures may be needed to protect an improve water quality.

Catchments with elevated nitrogen concentrations

An analysis has been carried out for 18 major river catchments in Ireland that discharge to monitored coastal waters. The average annual nitrate concentrations of these rivers for the period 2009 to 2019 is shown in Table 1. The annual average concentrations are calculated based on monthly sample data at Ireland's long established OSPAR[2] monitoring stations. Thirteen of these catchments have elevated nitrogen concentrations and are key catchments of concern, all of which are located along the south, southeast and east coasts and include: the Maigue/Deel, Bandon, Lee, Blackwater, Suir, Nore, Barrow, Slaney, Tolka/Liffey (including the Dodder) and the Boyne (Figure 2). Nitrogen concentrations in these catchments were at their lowest in the early 2010s, and have risen during the subsequent years; the 2019 concentrations were higher than the 2009 concentrations in all but two of the 18 catchments. Actions to reduce nitrogen concentrations in these catchments are required to ensure that Ireland can support good water quality, and healthy aquatic ecosystems[3] and meet its statutory obligations.

Table 1. Mean annual flow weighted nitrogen concentrations (mg/l N) in major river catchments discharging to marine waters. Shading highlights catchments and years where the statutory dissolved inorganic nitrogen EQS for low salinity marine waters (2.6 mg/l as N) was exceeded.

River catchment	Area km2	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
AVOCA	652	1.7	1.7	1.6	1.4	2.4	1.8	1.5	1.3	1.4	1.9	1.7
BANDON	608	2.8	2.3	2.8	3.1	2.9	2.7	3.1	2.8	3.3	3.3	3.4
BARROW	3067	4.6	6.0	4.0	4.1	3.9	4.1	4.0	4.0	5.4	8.1	5.5
BLACKWATER	3324	2.5	3.0	2.2	2.4	2.2	2.8	2.7	3.5	3.0	3.2	3.2
BOYNE	2695	2.6	3.6	3.1	3.2	2.7	3.4	3.3	2.7	2.9	4.1	3.8
CORRIB	3138	0.9	1.2	1.0	0.8	0.8	0.7	0.9	0.7	0.9	0.8	1.0
DEEL	486	1.8	2.1	2.7	2.3	1.7	2.3	3.0	2.0	3.1	4.2	3.5
DODDER	113	1.5	1.8	1.7	1.5	1.8	1.9	1.6	1.4	3.4	1.5	1.7
ERNE	4372	1.0	1.0	1.2	1.1	1.0	1.2	1.2	1.0	1.2	1.6	1.8
FERGUS	1042	1.0	0.9	1.3	0.9	0.9	0.8	0.9	0.7	1.0	0.9	1.1
LEE	1253	2.0	2.1	2.0	2.3	1.9	2.1	2.1	2.0	2.6	2.6	2.7
LIFFEY	1256	2.4	2.3	2.6	2.3	2.7	2.7	3.0	2.3	2.4	3.8	2.9
MAIGUE	1052	1.9	1.6	2.5	2.2	1.6	2.2	2.5	2.2	2.6	2.9	3.2
MOY	2086	1.1	0.9	1.6	0.9	0.8	1.0	0.9	0.7	1.0	1.0	1.2
NORE	2530	2.9	2.8	3.3	2.9	2.9	3.3	3.2	3.0	3.2	4.0	4.3
SLANEY	1762	6.1	4.8	4.7	4.2	4.7	4.3	4.0	4.5	4.8	6.6	5.5
SUIR	3610	3.4	4.0	3.1	2.4	2.4	2.5	2.6	2.7	2.8	2.9	2.8
TOLKA	146	2.1	2.1	2.3	1.9	1.9	2.8	2.4	2.5	2.1	3.0	3.2

[2] Ireland is one of 15 signatory members to the OSPAR convention (Convention for the Protection of the Marine Environment of the Northeast Atlantic) which was signed in 1992 and came into force in March 1998. OSPAR monitoring sites were established to deliver comparable data from across the OSPAR maritime area. Many of these sites were later incorporated into the Water framework Directive monitoring programme.

[3] Some catchments may also need additional water quality measures such as reductions in phosphorus, chemicals and sediment, or improvements in hydromorphology or some of the biological elements, but for the purposes of this assessment, the focus is on nitrogen.

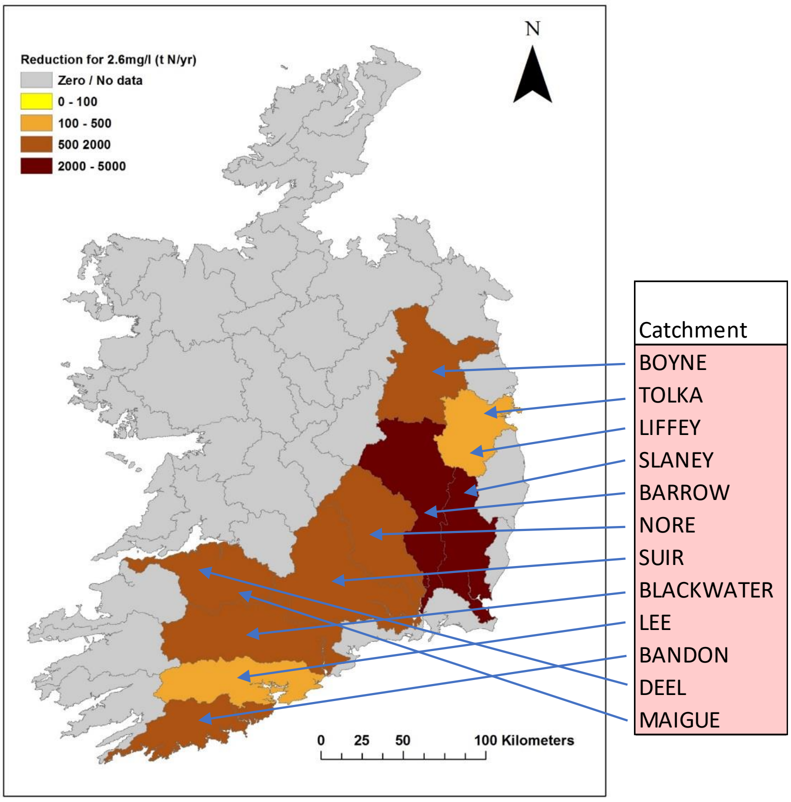


Figure 2. Catchments of concern with elevated nitrogen concentrations. Catchment shading shows the relative scale of nitrogen reductions needed to achieve the Environmental Water Quality Standard of 2.6 mg/l N in the downstream estuary, based on the peak concentration period from 2017-2019. Note that the River Dodder is part of the Liffey catchment.

Annual nitrogen loads in the key catchments

The annual nitrogen load is the amount of nitrogen (in tonnes) that flows out of the catchment via the river to the sea. It is calculated by multiplying the concentration by the flow, summed up over the whole year (Table 2). The nitrogen load varies between catchments, and between years, and it is dependent on the amount of excess nitrogen available for leaching in the catchment, and the effective rainfall that delivers it through the landscape and dilutes it in the river. Concentrations and loads are both useful metrics for understanding the scale of the problem – the concentration is the important metric for measuring the environmental harm, but the load is the means of making that understandable for the purposes of deciding on measures. Some large catchments may have large nitrogen loads for example, but the concentrations may be sufficiently dilute that the environmental harm is much reduced.

The lowest total loads of nitrogen discharged from these catchments in 2013, and all but one of the catchments of concern has had an increasing trend between 2013 and 2019. The highest total loads were discharged in 2009, 2018 and 2019. The role of climate is particularly evident in the 2018-19 figures: the relatively dry summer conditions in 2018 in many parts of the country led to higher levels of mineralisation in the soils. Farmers also applied additional fertiliser to try to encourage grass to grow. This was followed by a wet Autumn, Winter and early Spring, when the rainfall and rising groundwater levels pushed the excess nitrogen stored in the soils out into rivers and streams. This led to above average concentrations in waters in 2018 and 2019. The Suir, the Blackwater, the Slaney and the Barrow have had substantially larger nitrogen loads discharging from their catchments over the whole period than the other catchments.

Table 2. Estimated total annual loads (tonnes) of nitrogen discharging from a selection of large river catchments[4]. Shading highlights the key catchments of concern from Table 1 where the statutory dissolved inorganic nitrogen EQS for low salinity marine waters (2.6 mg/l as N) was exceeded in at least one year.

River catchment	Area km2	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	Total
AVOCA	652	1,656	1,164	945	1,184	1,750	1,668	1,129	854	784	1,398	1,252	13,784
BANDON	608	2,595	1,214	2,070	2,047	2,221	2,547	3,135	1,904	2,117	2,662	2,503	25,016
BARROW	3067	9,059	8,554	4,876	6,664	4,742	7,802	5,273	5,219	5,680	11,977	7,320	77,166
BLACKWATER	3324	8,458	5,269	4,628	7,000	5,339	9,120	7,812	9,443	6,323	9,009	8,206	80,606
BOYNE	2695	4,336	4,604	3,631	4,727	3,523	6,316	5,598	3,798	3,169	5,071	7,188	51,962
CORRIB	3138	3,542	2,498	2,785	2,707	2,586	2,292	3,080	2,140	2,337	2,696	3,697	30,362
DEEL	486	661	499	727	807	488	882	1,115	427	879	1,397	1,381	9,263
DODDER	113	143	148	116	141	126	195	119	105	213	131	140	1,577
ERNE	4372	4,138	2,487	4,515	3,859	3,091	5,082	5,199	3,440	3,842	5,322	7,262	48,239
FERGUS	1042	1,047	446	1,050	538	627	830	915	617	921	771	1,022	8,784
LEE	1253	3,888	2,671	2,767	2,689	2,992	2,717	3,062	5,837	5,578	4,132	4,328	40,660
LIFFEY	1256	1,658	1,230	1,106	1,407	861	1,944	1,367	1,603	875	3,652	1,387	17,091
MAIGUE	1052	1,436	647	1,147	1,473	687	1,550	1,460	1,039	1,319	1,676	2,215	14,648
MOY	2086	2,359	1,502	3,766	1,892	1,474	2,356	2,384	1,411	1,906	1,993	2,725	23,767
NORE	2530	5,535	3,385	3,560	4,230	3,287	6,100	4,222	3,475	3,572	5,803	5,514	48,683
SLANEY	1762	11,505	5,610	4,619	7,353	6,443	8,503	6,536	4,889	5,201	9,867	6,280	76,806
SUIR	3610	11,977	7,413	7,248	6,037	5,160	8,640	6,582	6,212	6,115	8,142	7,669	81,194
TOLKA	146	176	117	113	137	105	213	162	129	96	160	228	1,635
Total	11628	80,467	53,222	57,335	61,476	48,068	75,674	65,503	61,264	54,077	78,591	79,847	715,524

Load reductions needed in catchments with elevated nitrogen concentrations

The range and relative reductions in nitrogen loads needed in each catchment is shown in Table 3. This is determined by calculating the annual nitrogen load reductions that would have been required to maintain the concentration below 2.6 mg/l as N, for each catchment, in each of the 11 years. The Barrow and the Slaney catchments needed the highest levels of N reduction in most years, both in absolute terms, and as an average per unit area. The scale of the reductions needed ranged from zero in some years to just over 8,000 tonnes of nitrogen in the Barrow catchment in 2018. In the majority of catchments, the reductions needed increased towards the end of the decade, reflecting the increases in concentrations in waters – most catchments recorded the maximum reductions needed during the period 2017-2019.

The main factors driving the variability in agricultural catchments between years are changes in the weather, especially temperature and rainfall which affect growing conditions, uptake of nutrients, and nutrient transport and dilution; and changes in farm practice including the farming system, intensity, day to day management practices, and management of soil fertility, for example. At the farm scale, the soil conditions are an important factor in dictating the level of influence the farm has an on the overall catchment water quality – the most freely draining soils are the most favourable for nitrogen leaching.

[4] The loads presented in Tables 2 and 3 are the loads and load reductions at the most downstream monitoring station in each catchment, and they therefore represent only part of the catchment, albeit the majority. These loads are scaled up on a pro-rata basis to provide an estimate of the total national load reduction needed.

Table 3. Annual nitrogen load reductions (tonnes) needed to achieve the Environmental Water Quality Standard of 2.6 mg/l N in the downstream estuary. The mean, minimum and maximum load reductions needed across the 11-year period, plus the year in which the maximum load reduction was required, are also shown for reference.

River catchment	Area km2	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	Mean	Min	Max	Max year
AVOCA	652	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
BANDON	608	168	0	158	329	231	124	531	124	424	579	616	299	0	616	2019
BARROW	3067	3968	4856	1732	2455	1579	2848	1839	1868	2928	8114	3835	3275	1579	8114	2018
BLACKWATER	3324	0	751	0	0	0	759	170	2438	862	1638	1629	750	0	2438	2016
BOYNE	2695	56	1284	594	917	89	1544	1124	142	351	1847	2310	933	56	2310	2019
CORRIB	3138	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
DEEL	486	0	0	33	0	0	0	150	0	136	537	361	111	0	537	2018
DODDER	113	0	0	0	0	0	0	0	0	50	0	0	5	0	50	2017
ERNE	4372	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
FERGUS	1042	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
LEE	1253	0	0	0	0	0	0	0	0	5	0	183	17	0	183	2019
LIFFEY	1256	0	0	0	0	23	48	165	0	0	1123	135	136	0	1123	2018
MAIGUE	1052	0	0	0	0	0	0	0	0	0	160	437	54	0	437	2019
MOY	2086	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
NORE	2530	623	277	755	419	385	1286	743	470	690	2054	2168	897	277	2168	2019
SLANEY	1762	6561	2593	2040	2824	2877	3371	2288	2088	2366	5995	3290	3299	2040	6561	2009
SUIR	3610	2778	2633	1255	0	0	0	0	216	445	742	545	783	0	2778	2009
TOLKA	146	0	0	0	0	0	12	0	0	0	22	43	7	0	43	2019

The load reductions presented provide an indication of the relative scale and range of actions needed in different catchments to achieve water quality targets. They are not management or activity reduction targets which would be dependent on policy choices, including for example, which year to select as a baseline, and which farms and which practices to target for measures. The variability due to the weather is likely to increase in the future with climate change, as temperatures increase, rainfall becomes more intense and seasonal patterns change. It is important therefore that sufficient resilience is built in to the policy choices, that will keep the nitrate concentrations within sustainable limits for good ecosystem health at all times, whatever the weather.

Sources of nitrogen in each catchment

The main sources of nitrogen in Irish catchments are from agriculture and urban waste water (Figure 3). The EPA has developed a Source Load Apportionment Model (SLAM) which estimates the proportion of the nitrogen inputs to waters in each catchment that comes from each sector (Mockler et al, 2017[5]). The agricultural contribution can be further broken down into nitrogen from arable landuses versus nitrogen from pasture. The main data inputs for the model for agriculture are the 2018 land parcel (LPIS) and animal (AIMs) data from the Department of Agriculture Food and the Marine. The Urban Waste Water (UWW) data comes from Irish Water's discharge monitoring data. The model also calculates the inputs from a range of other sectors, including for example, forestry, septic tanks, peat, urban runoff and atmospheric deposition, however as these make up a very small proportion of the overall total, they are grouped here for simplicity as 'other'.

The data show that in the predominantly rural catchments, more than 85% of the sources of nitrogen in the catchment are from agriculture. In contrast, the majority of the nitrogen in Liffey/Tolka catchment, which incorporates Dublin City, is from urban waste water. The proportion of the nitrogen coming from arable farming was relatively high in the Barrow (28%) and Slaney (27%) catchments, however the majority of the nitrogen from agriculture across all catchments was from pasture.

[5] https://doi.org/10.1016/j.scitotenv.2017.05.186

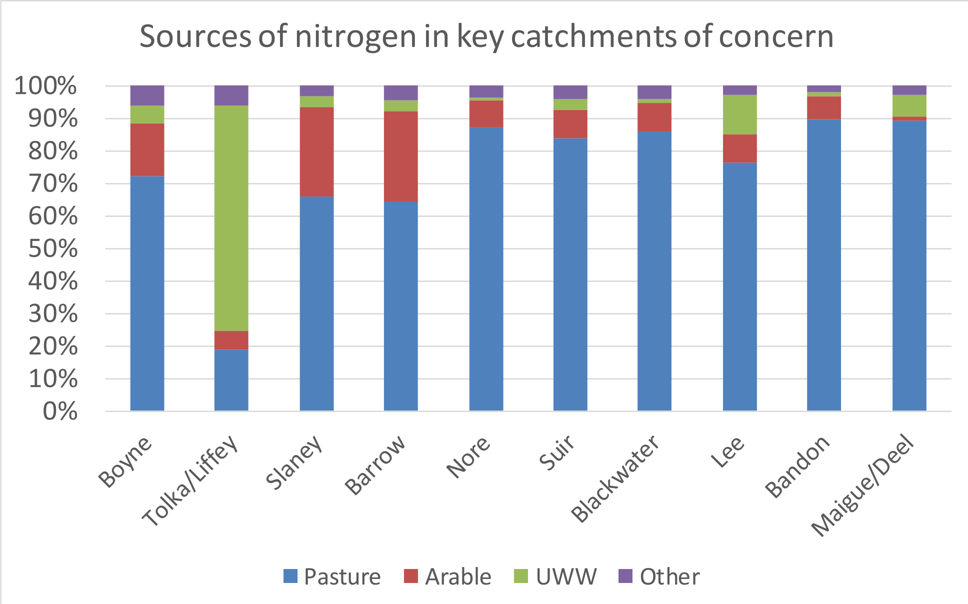


Figure 3. Sources of nitrogen in the catchments of concern. UWW means urban wastewater. Other includes forestry, septic tanks, peat, urban runoff and atmospheric deposition.

Targeting nitrogen measures in catchments

Within catchments, the freely draining soils with higher intensity farming are the highest risk areas for nitrogen leaching from agriculture. As soils and farming practice are highly variable across the Irish landscape, these areas are not evenly distributed. The EPA has developed Pollution Impact Potential (PIP) maps[6], or critical source area maps, which combine the soils and the DAFM farm data to show, on a relative risk basis, where these hotspots, or critical source areas, are within the landscape. The critical source areas are the locations where the risk of nitrogen leaching occurring is the highest, and where the quickest response will likely be seen in the river if measures are implemented. These maps can be used to target and prioritise actions in the catchments that need nitrogen reductions, and as a preventative measure in catchments that currently have satisfactory nitrogen concentrations. Some areas may need more actions than others depending on farm practices.

The proportion and the area of each of the catchments of concern that are higher risk and lower risk for nitrogen leaching from agriculture is provided in Table 4. There is approximately 6,900 km^2 of the highest risk areas across the catchments of concern. This represents 40% of the total combined areas of the catchments.

[6] https://www.catchments.ie/next-generation-pollution-impact-potential-maps-launched/

Table 4. Proportion of the catchments of concern that are located in the highest risk critical source areas for nitrogen leaching, and lower risk areas[7].

WFD Catchment Name	Land in highest risk critical source areas for nitrogen*		Land in lower risk areas for nitrogen	
	%	km²	%	km²
Boyne	23%	450	77%	1480
Liffey/Tolka/Dublin Bay	13%	103	87%	679
Slaney & Wexford Harbour	43%	617	57%	824
Barrow	37%	757	63%	1305
Nore	36%	687	64%	1210
Suir	39%	1006	61%	1575
Blackwater (Munster)	42%	985	58%	1338
Lee, Cork Harbour and Youghal Bay	64%	945	36%	521
Bandon-Ilen	67%	857	33%	413
Shannon Estuary South (Maigue/Deel)	30%	480	70%	1100
Total	**40%**	**6887**	**60%**	**10445**

*The highest risk critical source areas for nitrogen include the land parcels in the top 3 categories on the Pollution Impact Potential (PIP-N) maps

In the Blackwater catchment for example (Figure 4), many of the subcatchments in the headwaters to the west are less susceptible to nitrogen leaching (as shown in the beige colours). As such, the load reductions needed in these subcatchments (as represented by the size of the solid discs), are relatively small. The greatest load reductions are needed in the mid and lower parts of the catchment (purple colours) where the soils are more freely draining and the farming more intensive. The scale of the nitrogen reductions needed in the main river channel increases moving down the catchment, as the contributions coming in from each of the major tributaries is added. This is shown by the increasing size of the solid discs moving downstream.

This evidence base can be used by the policy makers to help prioritise measures. These risk maps should be considered together with the load reductions needed for the waters in each catchment, to provide an overall sense of the likely level of effort needed. For example, the total load reduction needed in the Lee catchment is relatively small, and the proportion of the critical source areas within the catchment is relatively large. As a result, a relatively small effort in terms of improvements or measures could be spread thinly over a relatively large area. In contrast, the scale of load reduction needed in the Barrow is relatively high, and the highest risk critical source areas cover only one third of the catchment. The most effective environmental outcomes will be achieved in the Barrow catchment by prioritising measures into that one third of the catchment. This will require a higher level of effort in these areas when compared to the Lee catchment.

[7] Areas in this assessment relate to the portion of the catchment for which PIP-N assessments have been carried out. Some areas are excluded because they have no source (i.e urbanised areas, roads etc.) and therefore the full catchment area does not directly equate to the full PIP-N mapped area for the same catchment.

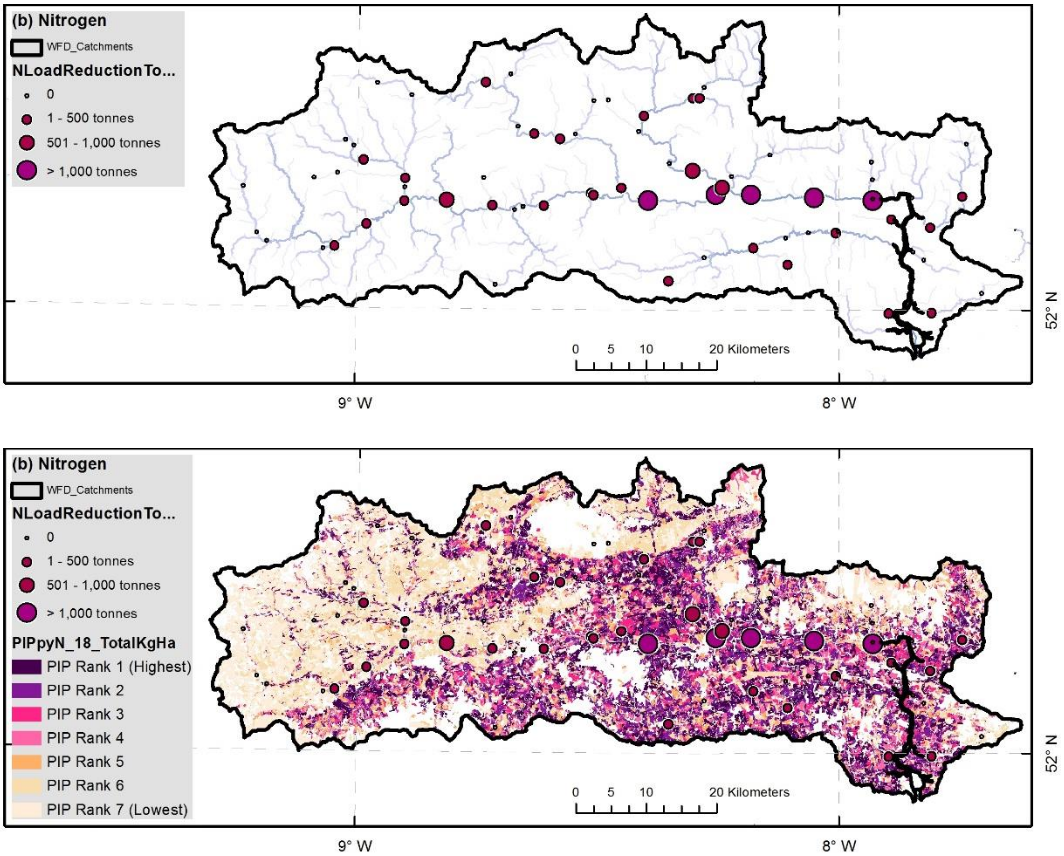


Figure 4. Spatial distribution and scale of nitrogen load reductions (top) and critical source areas (bottom) needed in the Blackwater catchment in North Cork.

Measures needed on farm

There are many variables that determine how much of the nitrogen used in farming ends up in our waterways, including farm practice, soils, climate and losses to air. The Teagasc National Farm Survey Sustainability report[8] shows that average nitrogen use efficiencies in Ireland's predominantly grass based farming systems are of the order of 25%, meaning in simple terms that 25% of the amount used on land is captured in the food that is produced and the remainder is either available for losses to the environment, whether to air or to water, or is stored in the soil organic matter. Preliminary crude estimates using the national inventory data suggest that for every 1 tonne of fertiliser purchased in Ireland, 0.29 tonnes of nitrogen is discharged out to sea in our rivers. Further modelling work is being carried out by Teagasc and EPA to better link management of nitrogen on farm, to nitrogen emissions in waters.

In 2012, when nitrogen emissions to water were at their lowest but further load reductions in waters were still needed in some catchments, the annual chemical fertiliser sales in Ireland were just under 300,000 tonnes. Over the next 10 years, the Ag Climatise roadmap has set a target of an absolute reduction in the overall level of nitrogen fertiliser being used on Irish farms from a high of 408,000 tonnes in 2018 to 325,000 tonnes in 2030, with an interim target of 350,000 tonnes in 2025. While significant changes in farm practices have been implemented since 2012, and there will be further

[8]Nitrogen use efficiencies are typically higher for tillage at 68%, and would be expected to be higher where animals are kept indoors. The Teagasc roadmap aims to increase grassland nitrogen use efficiency over the coming years. The National Farm Survey Sustainability report is available at the following link: https://www.teagasc.ie/media/website/publications/2020/NFS-2019-Sustainability-Report.pdf

measures including a focus on improving nitrogen use efficiency between now and 2030, as set out in the Teagasc dairy roadmap for example, this nevertheless highlights the scale of the national challenge. It will be important for achieving water quality outcomes that the nitrogen reduction measures as set out in Ag Climatise for climate mitigation purposes are implemented in the critical source areas for water, so that multiple environmental benefits can be achieved with the same measures.

Conclusions

Excess nitrogen in waters contributes to an increase in the growth of algae and aquatics plants, which in turn impacts on aquatic ecosystem health. This analysis has highlighted that there are a number of catchments of concern in which nitrogen concentrations are too high and are above the sustainable limits. Reductions in nitrogen loads in waters in these catchments are needed to achieve good water quality outcomes to support healthy aquatic ecosystems. This is important not only for the purposes of meeting our statutory obligations, but also to support our livelihoods, health and wellbeing, and the production of healthy food.

The majority of the nitrogen in most catchments comes from agricultural activities, from leaching of excess nitrogen from chemical fertilisers and organic fertilisers (manure and urine) from livestock. Maps of the critical source areas have been developed which show where the highest risk areas are in the landscape for nitrogen leaching. The most effective catchment scale water quality improvements can be achieved by targeting measures to reduce nitrogen leaching into these critical source areas. Further consideration should be given to identifying appropriate actions on farm that can achieve this aim. This work will feed into the 5th Nitrates Action Programme and the 3rd cycle river basin management plan, both of which are in preparation.

Appendix 1 – Relationship between herd size, gross nitrogen balance and nitrogen emissions to waters, from 1990 to 2019.

At the national scale, there is a broad relationship between the herd size, the gross nitrogen balance and the nitrogen emissions to waters, as monitored at the outlets to Irelands largest river catchments at our OSPAR sites[9] (Figure A1). The gross nitrogen balance estimates the potential nitrogen surplus on agricultural land and it is used as an indicator of risk to the environment. It is calculated as the balance between the nitrogen inputs to the agricultural system, and the nitrogen outputs (in milk and meat for example), per hectare of agricultural land.

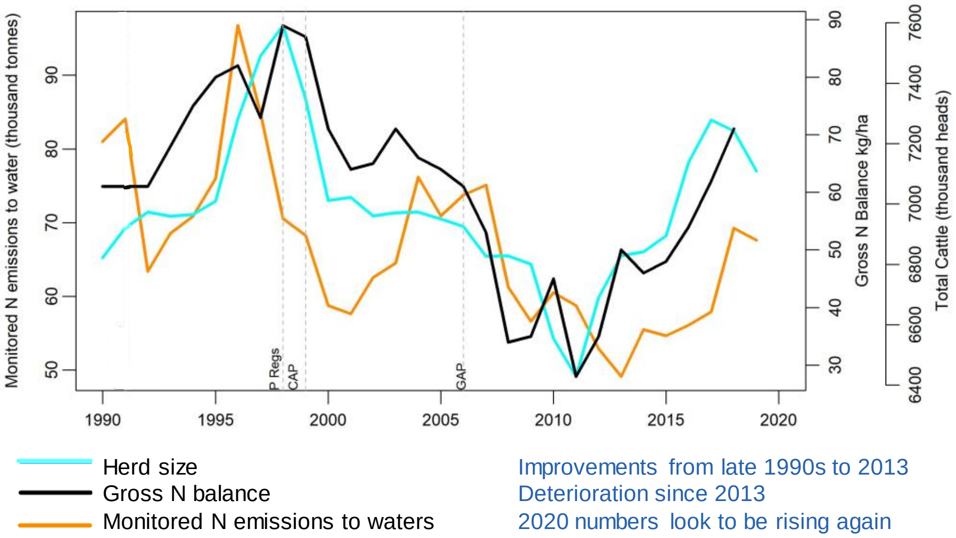


Figure A1. Relationship between herd size, gross nitrogen balance and monitored emissions to waters from 1990 to 2020, at the national scale.

The data highlight that in the past, at the national scale, the higher the number of animals, and the higher the gross nitrogen balance, the higher the emissions to water. Significant reductions in nitrogen emissions were achieved between the late 1990s and 2013, and since then emissions have started to rise once more. The emissions to water however, does not track the herd size or the nitrogen balance exactly, and can deviate in particular years. This reflects the important contribution of climate and changes in weather, farm practice, and various policy drivers such as the Phosphorus Regulations and the Good Agricultural Practice regulations, to the overall relationship.

Research being carried out Teagasc in the Agricultural Catchments Programme is showing that at the local scale, the role of soils is an important factor. Catchments with predominantly poorly draining soils with a relatively high stocking rate can maintain relatively low nitrate concentrations in waters. Catchments with relatively intensive farming on freely draining soils deliver the highest concentrations of nitrate to streams and rivers. These are the critical source areas, and they tend to dominate the overall water quality outcomes at the larger catchment scale. The relationship between practices on

[9] Ireland is one of 15 signatory members to the OSPAR convention, which is the Convention for the Protection of the Marine Environment of the Northeast Atlantic. The convention was signed in 1992 and came into force in March 1998. OSPAR monitoring sites were established to deliver comparable data from across the OSPAR maritime area. Many of these sites were later incorporated into the WFD monitoring programme.

individual farms and catchment scale water quality outcomes is therefore complex. To achieve the most effective environmental outcomes at the catchment scale, it will be important that measures are prioritised into the critical source areas. This will help to further decouple the national scale, historical relationships between animal numbers, fertiliser use and emissions to waters.

Appendix 2 – Nitrogen standards for achieving water quality objectives

An environmental quality standard (EQS) has been established under S.I. No. 77 of 2019 for dissolved inorganic nitrogen[10] concentrations in Irish coastal waters to support healthy ecosystems. The effect of nitrogen on marine ecosystems depends on the salinity of the water, so the EQS is presented as a sliding scale that varies depending on the salinity – the target for supporting Good Ecological Status ranges from a mean of 2.6 mg/l as N in fresh (low salinity) waters[11] that discharge from rivers into estuaries and coastal waters, to ≤0.25 mg/l as N in fully saline waters. For catchment management purposes, the freshwater (low salinity) end of the range is applied as a standard in the transitional waters where the freshwater from the river meets the saline waters in the estuary (Table A1).

Ireland does not have a statutory nitrogen EQS for rivers or lakes, but the EPA considers that Good Ecological Status is unlikely to be supported in rivers when nitrate concentrations are higher than 1.8 mg/l as N[12]. This guideline rivers value is used, together with statutory phosphorus and ammonium standards, to assess the nutrient conditions in rivers. When two of the three nutrients fail to reach their respective standards or guideline values, with a high level of statistical confidence, good nutrient status are deemed to have not been met. Nitrate is not used in the lakes assessment.

In groundwaters, a mean concentration threshold value of 37.5 mg/l NO_3 is applied to protect public health by ensuring that the drinking water standard, which is a maximum of 50 mg/l as NO_3 (equivalent to 11.3 mg/l as N), is not exceeded. This is substantially higher than the concentrations needed to support Good Ecological status.

Table A1. Standards for nitrogen to support water quality outcomes

Water type	Standard	Purpose	Source
Rivers	1.8 mg/l NO_3 as N	Guideline value to support Good Ecological Status	EPA
Coastal waters • Low salinity waters (freshwater)	2.6 mg/l DIN as N	Statutory limit to support Good Ecological Status	SI No 77 2019
• Fully saline water	≤0.25 mg/l DIN as N	Statutory limit to support Good Ecological Status	SI No 77 2019
Groundwater	37.5 mg/l NO_3 as NO_3	Threshold value (as a mean) to ensure maximum concentrations do not exceed the statutory Drinking Water Limit of 50 mg/l as NO_3.	EPA, as the basis for implementing S.I. No. 122 of 2014

[10] Dissolved inorganic nitrogen is comprised of nitrate, plus nitrite and ammonium. Nitrite and ammonium concentrations are proportionately relatively low in Irish waters, so the dissolved inorganic nitrogen concentrations are often considered to roughly equate to nitrate concentrations.

[11] The DIN EQS for high status objective waters (low salinity) is 1 mg/l as N.

[12] High status objectives are unlikely to be supported in rivers when the mean nitrate concentration is >0.9 mg/ls as N.