Department for Environment Food & Rural Affairs

Water targets

Detailed Evidence report

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Contents

Statement of Interests

Conflicts of Interest

No conflicts of interest present.

Statement of transparency for statistical robustness

The targets proposed below are based upon a wide range of data, including data from the Environment Agency that is statistically robust, and expert advice supported by peer-reviewed articles, amongst other sources. Where there are limitations with data, these are explained. Indicators are based on objectively measurable metrics, which are quantitative where possible. Statistical data below are represented from the original sources, with links to the original publications. Data from Defra and the Environment Agency are quality assured before publication, to ensure methodological quality and robustness. Metrics for water targets are anticipated to be based largely on publicly available and openly accessible data, which ensures transparency.

Changing status of evidence

The evidence base for the proposed water targets is not expected to change significantly before October 2022. The currently running consultation on the River Basin Management Plans (RBMPs) is expected to contribute to planning for the updated RMBPs and targets affecting water companies.

Introduction

Target topic summary

Water keeps us alive, drives our economy and sustains wildlife. Good water quality with sufficient quantity is essential to meet the health, business and leisure needs of society, while underpinning ecosystems on which the whole environment relies.

As part of maintaining and improving our water quality and managing water sustainably, the government has set out goals in the 25 Year Environment Plan to achieve clean and plentiful water. We have an overarching goal through the Water Environment Regulations [1,2] to achieve and maintain good ecological status in 75% of our water bodies by 2027. The River Basin Management Plans set statutory objectives to deliver this, setting out the actions required to prevent deterioration and the measures that will be taken in each river basin district to reach good status. The new targets proposed under the Environment Act 2021 aim to build on these existing commitments and work alongside them by addressing the key pressures that are preventing us from reaching existing goals.

Since the mid-1990s there has been great progress on improving our waters but in recent years overall ecological results have plateaued. In 2020 the Environment Agency (EA) released the latest classification results showing the health of our waters. These showed that surface waters are largely in moderate ecological status with only 16% of surface water bodies meeting the criteria for good ecological status and no surface water bodies having met the criteria for achieving good chemical status.

Ecosystems naturally change through the year, but additional pollutants and a changing environment (e.g., temperature, flow) exacerbate changes to these systems. Plants and animals need to cope with these changes to survive and thrive. This causes additional pressure on the ecosystem, making it less likely to function as normal, less likely to provide clean water or beneficial ecosystem functions and less likely to be used for commercial or leisure purposes. A water environment in near natural state and a heavily degraded water environment that is unable to function are two ends of a spectrum. Very few water bodies are at either of these extremes in the UK. Climate change is also negatively affecting the water environment. It is affecting river basin districts through changes to weather patterns, sea level rise, and increased frequency of natural hazards, extreme rainfall, heat waves and drought. By reducing direct pressures due to human activity, systems will be better able to respond to climate change in future.

This government has ambitious goals on the environment and has already taken steps to improve water quality, but we are not seeing the step change we need. These new targets seek to further drive that ambition in the long term, to ensure that investment and policy is sufficient to deliver clean and plentiful water. Government, water industry, the voluntary sector, land managers and the public at large all have a vital role to play if we want to make a real change. We are therefore proposing additional water targets under the Environment Act 2021 that focus on specific pressures on the water environment, to address obstacles preventing us from restoring water bodies to close to their natural state. This will drive outcomes in some of the more difficult to address areas that put additional pressure on the water environment. They will complement and help us achieve our existing overarching goals for water.

Methodology

Identifying target areas started with gathering evidence on the water environment and water quality. Some of this evidence is chemical and ecological measures of water quality, alongside reports by various organisations on water quality and quantity in the UK. These were used to identify pressures on water ecosystems, and areas to target to reduce negative pressures and increase water quality. These were combined with policy input on the feasibility and achievability of different target options, before reaching the currently proposed targets. Emerging issues have also been considered and are detailed more at the end of this document.

Approach to target setting

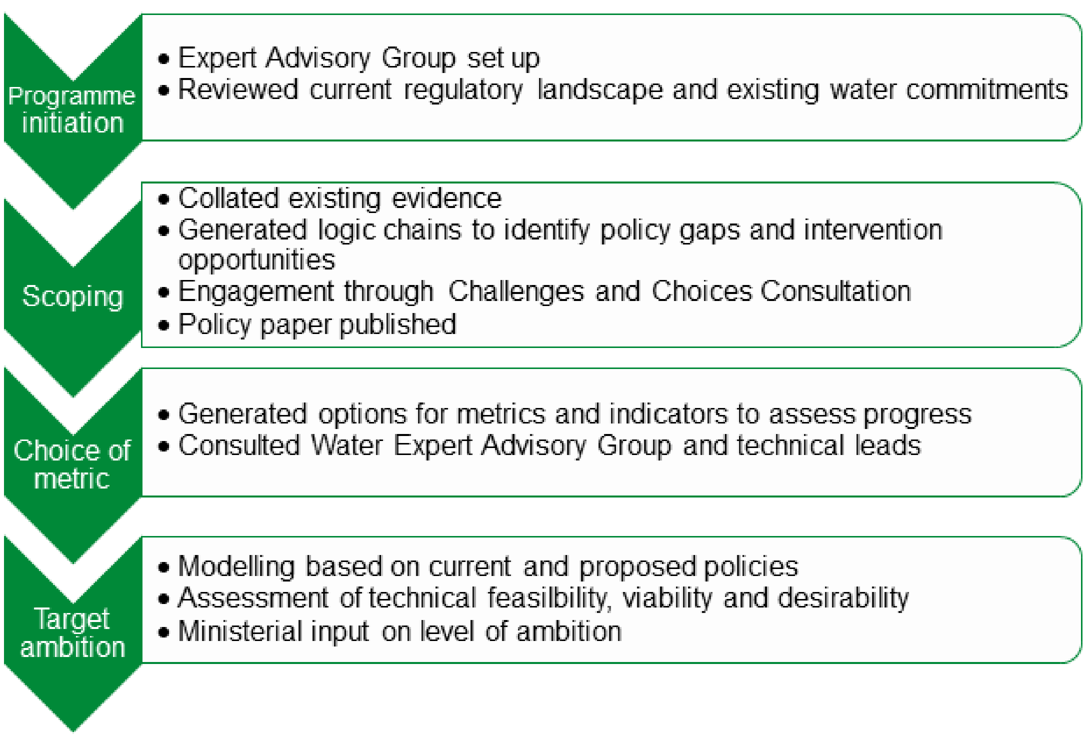
- The Environment Act 2021 mandates that at least one long-term water target must be set. Draft targets were initially proposed, with multiple targets based upon the evidence base highlighting pressures on the water system and informed by previous consultations.
- The Water Expert Advisory Group was set up to provide advice and evidence to help us reach the currently proposed targets from the draft targets.
- The currently proposed targets were then directed by Ministerial decisions, based upon their viability, feasibility, and desirability.
- More detail on each step can be found in the 25 Year Environment Plan Targets Policy Paper[1].

[1] Defra 2021, At a glance: summary of targets in our 25 year environment plan - GOV.UK (www.gov.uk)

- Targets were proposed using the following criteria, and are;
    - Based on the evidence base showing which areas need action to reduce the impact of negative pressures on the system, which is informed by expert advice and recent evidence.
    - To be enacted for England, as the Environment Act 2021 is England-specific in this area.
    - To show achievability, feasibility, and desirability in implementation.
    - Using SMART criteria - being specific, measurable, achievable, realistic, and time-bound.
    - In order to be measurable, an appropriate baseline is required to include a target. In some cases, additional evidence was gathered during target proposal and/or is included in planned future evidence gathering work.
    - To provide a long-term target that helps in improving the water environment, targets set under the Environment Act 2021 will have a minimum 15-year period.

An overview of the approach taken to setting targets for water as part of the Environment Act 2021 is shown below in Figure 1.

Figure 1: Overview of evidence process



Underlying pressures on water environment

The EA undertakes regular water quality monitoring of various chemical and ecological indicators [3]. These measurements are done on various water body locations covering a range of water body types (e.g., rivers, lakes, estuaries, coastal waters and groundwaters). Results are compared to near natural conditions, with all assessments (ecological or chemical) needing to show good quality or quantity for a water body to achieve good status. This approach underpins other water management strategies, such as the River Basin Management Plans [4].

When water bodies are assessed at being below the objective set for that water body, investigations are undertaken to identify the activities and sectors preventing the waters reaching a good status using a variety of methods, including monitoring, modelling, professional judgement, and catchment inspections. These are summarised in a dataset that describes the Reasons for Not Achieving Good Status (RNAGS). Determining the contributing sectors helps inform policy and management of river catchments to improve our water environment [5].

The RNAGS information shown here is based on the number of water bodies, from the total, affected by each pressure. Each water body could be affected by a combination of pressures at once (or none), and percentages do not add to 100%. Key pressures identified from the RNAGS database include;

- Pollution from rural areas, largely originating from agriculture and rural land management affecting 40% of water bodies.
- Pollution from abandoned metal mines, affecting 3% of water bodies.
- Pollution from wastewater affecting 36% of water bodies, largely related to the water industry, but occasionally also affected by the general public and urban areas.
- Physical modifications to the water environment affecting 41% of water bodies. For thousands of years the water environment has been physically modified to support farming, industry, transport, and by building places to live. Some of these changes have damaged habitats for wildlife and changed the natural functioning of catchments.
- Other pressures include pollution from towns, cities and transport affecting 18% of water bodies, non-native invasive species affecting 23% of water bodies and changes to natural flow and levels of water affecting 15% of water bodies.

The sectors and challenges preventing good water quality in England are shown in Table 1 below. This shows issues that are preventing water bodies in England reaching good status (ecological status/potential, chemical status and groundwater status) and the sectors whose activities are causing those issues. The percentages are based on the total number of water bodies in England. Multiple factors can affect one water body, so the totals do not add to 100%. The complete set of information is present in the State of the Water Environment, indicator B3 supporting evidence [5], from which this section is taken.

Table 1: Key issues and sectors affecting water bodies in England, replicated from State of the Water Environment, indicator B3 supporting evidence [6][2]. This shows the percentage of total water bodies affected by each combination of sector and effect.

Sector	Physical modifica-tions	Pollution from waste-water	Pollution from towns, cities and transport	Changes to natural flow and levels of water	Non-native invasive species	Pollution from rural areas	Pollution from abandon ed mines
Agriculture	12.9%	0.1%	0.1%	1.3%		40%	
Industry	1.9%	0.5%	3.4%	0.4%			
Mining and quarrying	0.1%		0.1%				3.2%
Navigation	1.9%			0.1%			
Urban and transport	10.9%	0.6%	10.1%				
Water industry	7.9%	35%	0.8%	9.8%			

[2] Defra 2021, State of the water environment indicator B3: supporting evidence, available at https://www.gov.uk/government/publications/state-of-the-water-environment-indicator-b3-supporting-evidence/state-of-the-water-environment-indicator-b3-supporting-evidence

Local and central government	14.3%	0.2%		0.2%			
Domestic general public	0.3%	1.1%	6.4%				
Recreation	2.9%		0.2%	0.1%			
Waste treatment and disposal		0.1%	0.3%				
No sector responsible	0.1%		0.1%		23%		

Data sources: Most of the data used to produce the tables within indicator B3 of the State of the Water Environment is taken from the 2019 set of probable and confirmed reasons for not achieving good status (RNAGS) linked to 2016 classifications, with the exception of the following two areas[3].

1. Changes to the natural flows and levels of water. The data is for those water bodies that do not have sustainable levels of abstractions. The sector contributions include suspected, probable and confirmed RNAGS.
2. Invasive non-native species. This uses EA monitoring data and is for water bodies that have specific invasive non-native species present which are considered to be contributing to the water body not achieving good ecological status.

'No sector responsible' covers those situations where it is not possible to assign the failure to achieve good status to the activities of a specific sector. This category has been mainly used

[3] This database has since been updated, and can be found online at WFD RBMP2 Reasons for Not Achieving Good Status - data.gov.uk

for invasive non-native species. Whilst the speed of their spread can be increased by poor practice, it is not possible to say whether their presence in a particular water body is ‘natural’ or due to someone’s actions. In addition, around 6% of water bodies have one or more RNAGS where the sector responsible is still under investigation. Around 5% of water bodies have one or more RNAGS caused by a different sector to those listed in the table. These are mainly where the issue is physical modification.

Evidence obtained overview

Various sources of evidence have been used to inform the proposed targets. These include evidence gathered by the EA, recent public consultations on water issues (such as EA's "Challenges and Choices” consultation [6]) and relevant academic information including through the involvement of expert advisory groups. The sections below cover the types of data used. The areas focused on were identified after assessment of the RNAGS data shown in Table 1.

Research obtained – datasets and reports

This is a brief overview of some key underlying evidence and data sources used to inform the targets affecting water.

Evidence for multiple water target areas:

- Phosphorus: challenges for the water environment [7]
- Nitrate: challenges for the water environment [8]
- Fine sediment: challenges for the water environment [9]
- Environmental Audit Committee inquiry into nitrate pollution in the UK [10]
- Defra’s Demonstration Test Catchment Programme (summarised in (i) Evidence Compendium [11] and (ii) Rapid Evidence Assessment - Defra project WT15115 [12])
- 2021 River Basin Management Plan - Pollution from Abandoned Mines challenge (2021) [13]
- Environment Agency – The state of the environment: water quality [14] (2018)
- The evidence summary supporting the 25 Year Environment Plan [5].

Agriculture specific:

- Agriculture and rural land management: challenges for the water environment [15].
- Agriculture's Impacts on water quality (Global Food Security Programme) [16].
- Catchment Sensitive Farming Evaluation Report – Water Quality Phases 1 to 4 (2006-2018) (NE731) [17].
- WT1594 Report [18] - Project WT1594 was commissioned to improve Defra's understanding of the most effective ways to support farmers in protecting the water environment. WT1594 comprised: an evidence review; a telephone survey including follow up site-visits; the generation of a measure vs mechanism matrix to categorise measures by both geographical spread and by policy mechanism (e.g., voluntary vs regulatory obligation); and modelling using FARMSCOPER to demonstrate the current (2018) baseline and the future impact on national annual average agricultural pollution loads for a series of future scenarios.

Metal mines specific:

- Monitoring of water quality by the EA [19]. This shows that approximately 1,500km of rivers and estuaries is currently polluted by cadmium, lead, nickel, zinc, copper and/or arsenic from abandoned metal mines. Rivers are polluted if measured concentrations are higher than the statutory Environmental Quality Standards (EQS) which are set by Government to protect aquatic life.
- Previous research commissioned by Defra and the EA with published outputs including Mayes et al. (2009) [20] and Mayes, Potter and Jarvis (2013) [21].
- In 2020/21, an independent consultancy was commissioned to review the EA's approach to quantifying the length of rivers polluted by abandoned metal mines, identify any knowledge gaps and evidence needs, and recommend future monitoring to strengthen the baseline evidence and allow progress against the potential metric to be measured. The review concluded that the approach and evidence base was robust whilst recommending some additional data collection and analysis by the EA. These recommendations are being implemented.

Wastewater specific:

- Water industry wastewater challenge [22].
- Water quality in rivers - Environmental Audit Committee (parliament.uk) [23].
- Data published by the EA that on annual phosphorus (P)loads discharged from water company sewage treatment works STWs to rivers. The basis of the calculations is the

final effluent monitoring data from STWs which is held on EA's WIMS database. These data are collected by the water companies under Operator Self-Monitoring and are a permitted requirement where there is a numeric phosphorus limit on the permit.
- Information on effluent load discharged containing phosphorus. This has been informed by water company reports to the EA on phosphorus compliance as well as datasets from EA monitoring under the Water Environment Regulations.

Water demand specific:

- Environment Agency – Water Levels and flow Challenge[4], October 2019 [24].
- Reporting and water resources management plans by water companies and Ofwat.

Research obtained – recent water environment consultations

There have been a few recent consultations on the state of the water environment and related issues. The responses from these consultations were considered as part of the research for the Environment Act 2021 targets for water.

As part of the process of updating the River Basin Management Plans [25], three statutory public consultations were planned. These cover all the river basin districts that are entirely in England, and the Severn and Northumbria River Basin Districts which lie partly in Wales and Scotland, respectively.

The first consultation [26], called 'Working Together' ran for six months between 22 June 2018 and 22 December 2018, and requested input on the steps, consultation measures and proposed timeframe for updating the river basin management plans.

The second consultation 'River basin planning: Challenges and Choices' consultation [27] ran between 24th October 2019 and 24th September 2020, with the original statutory 6 months consultation period extended due to the coronavirus outbreak. The Environment Agency sought public views on the challenges waters face (including a question on potential targets) and the choices and changes needed to help tackle those challenges. As the challenges facing the water environment have not changed significantly since this recent consultation, this

[4] https://prdldnrbm-data-sharing.s3.eu-west-2.amazonaws.com/Challenge+narratives/Water+Levels+and+flow+Challenge+RBMP+2021.pdf

consultation was used to help develop the water targets proposed within the Environment Act 2021.

The third consultation on draft river basin management plans started on 22nd October 2021 and runs until 22nd April 2022. The consultation has been published on the gov.uk website and makes use of data and map viewers and allows consultees to focus on specific catchment partnership pages.

The development of the proposed water demand target was also aided by responses to the 2019 Consultation on Measures to Reduce Personal Water Use and the 2021 Consultation on Updating the Determination of Water Stressed Areas in England.

Research obtained – Water Expert Advisory Group

A Water Expert Advisory Group was created to gain expert advice on target areas. The expert group was used to gather evidence and give expert feedback on the proposed targets, to assist in setting proposed targets in the most appropriate area/s, and obtain expert advice on target indicators, feasibility, and viability.

Research obtained – Stakeholder meetings

A number of stakeholder workshops and forums were held during the target development process. These were to aid in assessing the viability and feasibility of the proposed target areas.

- Stakeholder Forum: This group, representing the regulators, water industry, agriculture industry, water environment groups and academic experts, met in September 2020. The Forum introduced the reasoning for the new water targets and the project timeline and requested input for the initial scoping of the water targets.
- A Stakeholder Workshop was held in April 2021 with more than 30 stakeholders representing water companies and agricultural businesses, environmental NGOs and other groups. The aim of this workshop was to share progress on the water targets and to gather inputs, experience and perspectives from different groups to help inform target development in advance of formal consultation in 2022.
- We presented high-level proposals for water targets to the Biodiversity Targets stakeholder group in September 2021, and the Water Leaders Group hosted by the Environment Agency in October 2021.

Results and Discussion

The sources of information and approach described above were used to develop the proposed targets. This followed the approach outlined in the methodology.

Expert group findings

A Water Expert Advisory Group (WEAG) was set up to advise on the proposed targets during development. Various meetings took place with the expert group during the work on targets for the Environment Act 2021. These covered different topics areas and involved various policy teams.

Evidence summary

In their recent river basin planning progress report [37], the EA assesses the changes in the state of the water environment, providing a summary of progress towards achieving the environmental objectives in the 2015 plans, a summary of the measures implemented since 2015, and identifies some of the main changes in the evidence used in river basin planning. 16% of surface waters were found to be in good ecological status[5] or potential in England in 2019, similar to the previous assessment of 17% in 2015.

Although the overall results have shown little change, there is some movement between status classes for individual water bodies. In England, 151 water bodies improved from moderate or worse ecological status in 2015, to good or better ecological status in 2019. In contrast, 171 water bodies dropped from good or better ecological status in 2015, to moderate or worse ecological status in 2019.

Nutrient pollution represents a significant pressure on the water environment. 55% of river water bodies and 73% of lake water bodies exceed phosphorus standards for "close to natural" and similar proportions exceed the phosphorus targets for favourable condition of water-dependent Habitats Sites. These waters are affected by or at risk from eutrophication, meaning that elevated nutrient levels cause excessive algal and plant growth, damaging the ecology, water quality and uses of the water [31]. Nitrogen exists in many different forms, including both inorganic (e.g., ammonia, nitrate) and organic (e.g., amino and nucleic acids) [32]. It

[5] The ecological status of a water body is derived from the status of multiple individual tests or quality elements.

undergoes many different transformations in the environment, changing from one form to another as organisms use it for growth and, in some cases, energy [33]. Some nitrogen compounds pose a risk to human health and/or to the environment. Nitrate may pose a risk to human health in water bodies used for drinking water abstraction. In groundwater, 69% of water bodies are at risk of failing and 37% are classed at poor chemical status (or have rising trends) due to nitrate [34]. Nearly 30% of groundwater used for public water supply must be blended or treated to remove nitrate and meet drinking water standards, which is costly [34]. In eutrophic standing freshwaters nitrogen can be a factor limiting or co-limiting biological production and reducing both nitrogen and phosphorus loads is often needed to restore ecological quality.

Some waters are formally designated as affected by freshwater eutrophication (5164 km of rivers, 96 lakes and reservoirs in England) [31]. The EA has reviewed the extent of eutrophication impacts in river and lakes more generally, showing that eutrophication is a substantial issue for freshwaters in England [31].

As set out above, the reasons for water bodies not achieving good status are varied but many water bodies fail due to pressures from wastewater and rural pollution, alone or in combination. As mentioned above, a single water body could be affected by multiple sectors at once. The latest indicators on the state of the water environment (assessed in 2019) reports that 40% of all water bodies are affected by pollution from rural areas (the majority of which comes from diffuse agricultural pollution) and 36% are affected by pollution from wastewater [5]. Furthermore, through additional pressures such as physical modification or changes to flow and water level, the agricultural sector is identified as affecting 45% of water bodies with the water industry affecting 44% of water bodies (table 2 below). Here, “affected” indicates that this pressure or sector is a probable or confirmed reason for not achieving good status and gives a conservative estimate of the number of water bodies affected to some extent by each issue.

Table 2 taken from the State of the water environment indicator B3: supporting evidence[6], showing percentage of water bodies affected by each sector. Around 5% of water bodies have one or more RNAGs caused by a different sector to those listed in the table. These are mainly where the issue is physical modification.

Sector	Percentage of water bodies affected by each sector
Agriculture	45%
Water industry	44%
Urban and transport	18%
Local and central government	14%
Domestic general public	8%
Industry	6%
Mining and quarrying	3%
Recreation	3%
Navigation	2%
Waste treatment and disposal	0.30%
No sector responsible	23%

[6] https://www.gov.uk/government/publications/state-of-the-water-environment-indicator-b3-supporting-evidence/state-of-the-water-environment-indicator-b3-supporting-evidence

Target area proposals based on gathered information

Agriculture target

Proposed target - Reduce nitrogen, phosphorus, and sediment pollution load from agriculture to the water environment by 40% by 2037.

Target background

Nutrient and sediment pollution enters the water environment through run-off and leaching from agricultural land which makes up around 70% of our land area [29]. It is estimated that 50% of nitrate pollution, 25% of phosphorus in the water environment and 75% of sediment pollution comes from agriculture [30] and the relative contribution of agricultural pollution to water quality pressures is increasing. As shown above, pressure from agriculture affects 40% of our water bodies.

Excess fine sediment can have a negative impact on aquatic ecology and the quality of water abstracted for drinking water supply. It can also transport other pollutants, inhibit navigation, and block water industry infrastructure. Phosphorus in particular is often bound to sediment. Fine sediment pressure in England is responsible for around 5% of reasons for not achieving good status [35].

There is no ecological in-river sediment standard and so there are no official compliance statistics. Sediment can impact directly upon river biology (invertebrates and fish) or indirectly through links to other pressures (e.g., pesticides, chemicals and nutrients). In addition, around 80 drinking water protected areas are at risk from colour problems, mainly caused by loss of dissolved organic carbon from peat uplands, which may be exacerbated by sediment erosion [35].

The loss of valuable soil from land is of concern for individual farms and for the future of productive farming across the country. Each year, farmers in England and Wales lose an estimated 2.9 million tonnes of soil to erosion [36]. Soil erosion is a natural phenomenon, but the rate of soil erosion varies. It is influenced by several factors including the intensity, duration, and timing of rainfall events (erosivity); the physical, biological and chemical properties of soils (erodibility); the length, gradient and form of slope; the type of vegetation/crop on the land and its stage of development; and the type and timing of singular or combined land management practices.

Current actions in this area

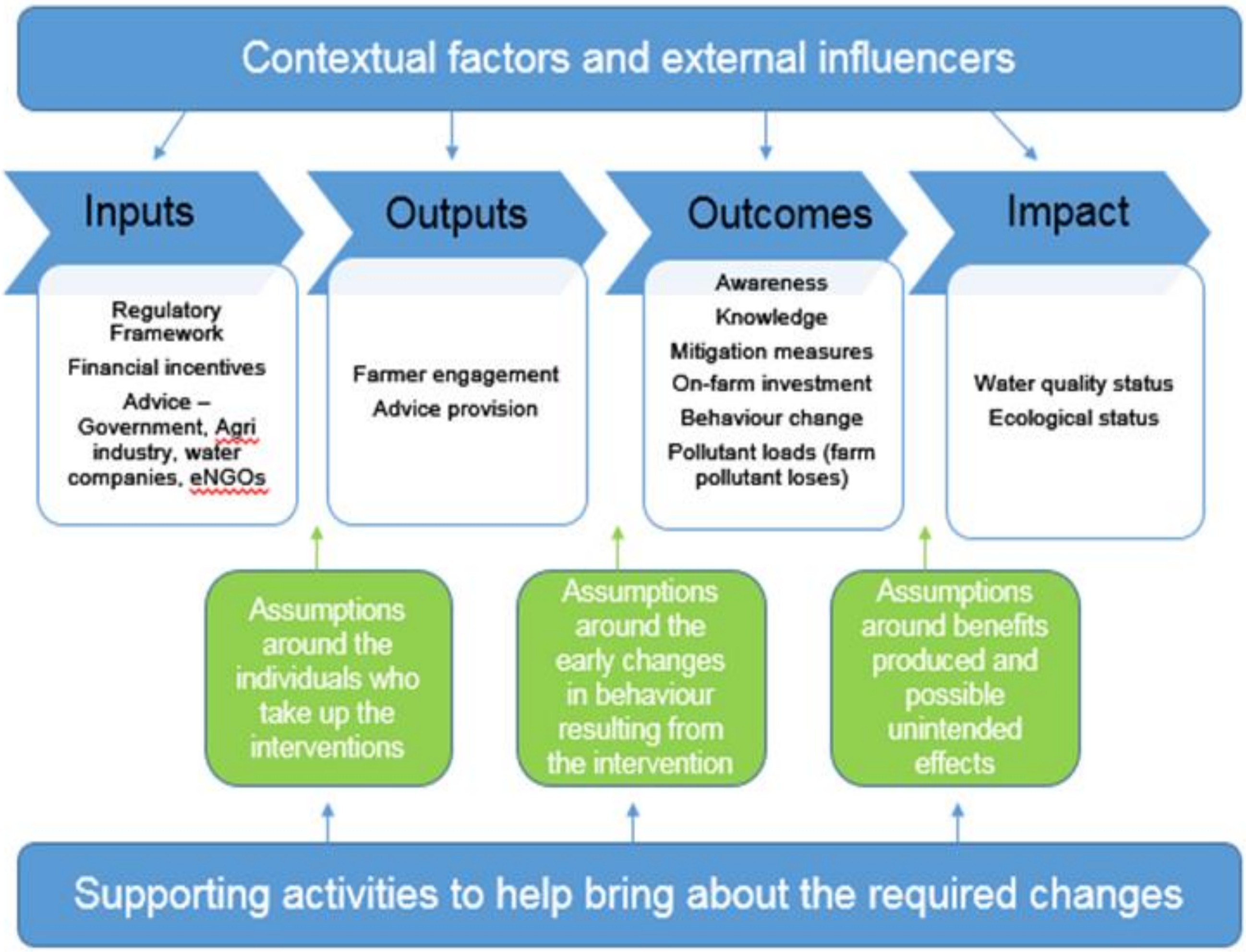
A variety of strategies and measures are currently implemented through voluntary, incentivised and regulatory policy mechanisms to reduce agricultural pollution. Current voluntary schemes and initiatives include Catchment Sensitive Farming (CSF), Championing the Farmed Environment, water company catchment-based schemes, LEAF, Red Tractor and the Courtauld commitment [38]. Reports vary on levels of compliance with water regulations. In response, we have almost doubled the CSF budget to ensure the service covers all the farmed area of England and allocated the Environment Agency additional funding to increase more than eightfold the number of farm inspections conducted annually. We are also in the process of introducing new environmental land management schemes as part of the agricultural transition. These schemes will be crucial to incentivising the actions to reduce nutrient pollution but have not been included in the baseline scenario as they are still being rolled out.

Target area and ambition

Logic models were constructed to provide a framework for the development of targets (see Figure 2). The proposed target focusses on reducing the nutrient loads (losses) from agricultural sources which will help to deliver improved water quality and ecological status of water bodies. Based on the evidence and models available the target will deliver a significant reduction of nitrogen, phosphorus, and sediment in the water environment from agricultural sources.

Modelling has been carried out to inform decision making on the target development, including illustrative potential policy pathways. However, no decisions have yet been made on the delivery approach. The 40% reduction is predicted to be achieved through very high (85%-100%) uptake of regulatory measures and future farming schemes such as the Sustainable Farming Incentive, with incentives for precisely targeted habitat creation and changes to the way land is used and managed to achieve maximum reductions in pollution. This means, for example, incentivising farmers to maximise the potential for riparian habitat and rewarding the more precise and efficient use of nutrients (especially manures) in the farmed landscape. Technological innovation will also contribute to the delivery of the target by reducing the proportion of nutrients lost from agricultural systems, maximising yields with reduced inputs and increasing crop production using smaller areas of land. As noted by the WEAG, a 50% reduction of phosphorus, nitrogen and sediment loads from agriculture would get us closer to achieving good ecological outcomes in many waterways. However, we decided not to take this option forward as the widespread changes in agricultural practices and alterations in land use needed to achieve this high ambition would not be feasible and the impacts on the sector would be too great.

Figure 2: A logic model developed during target development.



Abandoned metal mines target

Proposed target - By 2037, reduce by 50% the length of rivers and estuaries polluted by target substances cadmium, nickel, lead, copper, zinc and arsenic (Cd, Ni, Pb, Cu, Zn, As) from abandoned metal mines.

Target background

Metal mines are the most significant source of metal pollution in rivers. Impacted rivers are polluted by high concentrations of at least one of the following substances: cadmium, nickel, lead, copper, zinc or arsenic. Mine operators cannot be held liable for permitting water pollution from mines abandoned before 2000. As most mines were abandoned before the 20th Century, environmental damage will continue unless government acts. Defra holds departmental liability on behalf of government. Without further action, the metal concentrations in rivers, of the target substances, will remain above the statutory Environmental Quality Standards (EQS) that are set by government to prevent harm to aquatic wildlife.

Current actions in this area

Published research estimates a minimum of 150 tonnes of the target substances are discharged each year to rivers [21]. Further mine water discharges have been discovered by the EA since 2013. The Water Environment Regulations aim to reduce pollution from priority substances (including nickel, lead) and to cease or phase out discharges of priority hazardous substances (including cadmium) as a step towards improving all water bodies to good status. The existing Defra-funded Water and Abandoned Metal Mines Programme was set up to address this type of pollution. Increased funding over the financial year 2022/2023 will speed up progress. Without the proposed target, capital and revenue funding will still be required to operate the three existing mine water treatment plants (plus one currently in construction), maintain diffuse measures and evaluate performance. This obligation is required in perpetuity and is accounted for in Defra’s financial provisions over a 100-year accounting period.

Target area and ambition

Following review by the EA and discussion at the WEAG in July, this is considered to be the best metric for the proposed target. This metric would also contribute to statutory River Basin Management Plan objectives and 25 Year Environment Plan environmental indicators (B1: Riverine inputs of selected metals and nutrients into tidal waters, and H4: Exposure and Adverse effects of chemicals on wildlife in the environment) [39].

The EA estimates that to achieve the proposed target, up to forty new mine water treatment schemes need to be built to capture metals before they can pollute rivers. These schemes would need to be operated in perpetuity.

Alternative levels of ambition were considered on the suggested target option.

- 40% reduction in polluted river length: whilst this was felt to be more achievable as less funding from government is required, analysis showed we could go further and make a greater positive impact in river quality.
- 60% reduction in polluted river length: this would require significantly more funding from government. The EA and Coal Authority have low confidence that they would be able to accelerate the WAMM programme to achieve this target by 2037.
- 75% reduction in polluted river length: this was considered to be unachievable in practice at present.

An alternative metric that was considered was to base the target on reducing the mass flux (tonnes per year) of metals (Cd, Ni, Pb, Cu, Zn, As) discharged to rivers and estuaries from abandoned mines by 2037.

- This metric would also contribute to the 25 Year Environment Plan environmental indicators B1 and H4, and indirectly to statutory River Basin Management Plan objectives.
- Following review by the EA and discussion at the WEAG in July this option was rejected due to low confidence in the baseline mass flux discharged to rivers by abandoned mines. Considerable additional monitoring resources would be required for the EA to establish an accurate baseline against which progress could be measured. The existing EA monitoring data used for the 25 Year Environment Plan B1 indicator and international treaty obligations under the OSPAR Convention reports mass flux of various contaminants to estuaries. However, there is considerable natural seasonal variability dependent largely on river flows, and particularly whether the EA collect samples at low, medium, or high flows.
- EA monitoring data show that the most severe pollution (how much the Environmental Quality Standards are exceeded) occurs at lower river flows when there is less dilution of mine waters containing high concentrations of metals, whilst the highest metal mass flux discharged to rivers and estuaries is at higher river flows. Due to this it was considered that currently mass flux is a less useful and reliable metric for assessing environmental harm than the length of polluted rivers.

Wastewater target

Proposed target - An 80% reduction in phosphorus by 2037 against a 2020 baseline.

Target background

The largest source of phosphorus pollution within English rivers is sewage effluent, making up between 60-80% of the total (although this contribution has decreased significantly since 1990). Population growth and climate change are placing increasing pressure on wastewater treatment and the water environment. There is more treated wastewater being discharged into the water environment, resulting in more phosphorus entering water bodies. Although there has been great progress in reducing phosphorus discharges from treated wastewater, monitoring shows that there is still far too much phosphorus entering the water environment, and that water companies are still the largest source of this nutrient pollution.

Current actions in this area

Water companies are committed in the current Asset Management Plan 7 (AMP7) period to reducing phosphorus levels by around 50% by 2027 against a 2020 baseline. We are creating a more ambitious, long-term target to reduce phosphorus by 80% by 2037 to ensure we continue to make progress beyond the next AMP cycle towards our ambition of clean and plentiful water.

Target area and ambition

We have considered different levels of ambition for the phosphorus target, ultimately deciding on an 80% reduction as a feasible and effective target. This level of ambition will build on a large programme of phosphorus reduction taking place in Asset Management Plan 7 (AMP7) which will be concluded by 2027. The 2020 baseline phosphorus load was around 9,220 tonnes per year. The AMP7 period is projected to deliver a reduction of around 50% by 2027.

A low ambition scenario would require a 50% reduction of phosphorus from wastewater, representing no additional progress from the current commitments made in the AMP7 period. Beyond 2027, we are assuming that a number of wastewater treatment works serving a population greater than 2,000 will have phosphorus reduction to current Technically Achievable Limit (TAL) of 0.25 mg/l. This is tightest limit that the EA currently permit at if they are not already at TAL. We are making an allowance for future growth and development adding an additional 200 tonnes per year back into the environment. This results in an overall predicted phosphorus load of around 2,000 tonnes per year by 2037, which is a decrease of

80% against the 2020 baseline. This means tackling projects that were previously deemed not to be cost beneficial, showing a strong commitment to delivering improvements to the water environment.

A more ambitious target for reducing phosphorous emissions will require additional investment by water companies, and this will have an impact on customer water bills. In line with their duties, water companies and Ofwat will need to ensure that new investments agreed through the price review process represent value for money over the long-term. Water companies will need to innovate to deliver the most efficient solutions possible, whilst delivering against their statutory obligations and environmental commitments.

The inclusion of nitrogen was considered for this wastewater target, but ultimately was not included, as agriculture is a much larger contributor of nitrogen to the water environment. This means that nitrogen concentrations in rivers are unlikely to fall enough to control eutrophication, even if additional measures are introduced at sewage treatment works. We also know that these treatment work upgrades would bear significant financial costs, which would be passed onto customer water bills, for low environmental benefit. Nitrogen reduction measures at sewage treatment works can already be put in place in saline waters and lakes affected by eutrophication, rivers where drinking water abstraction points fail nitrogen standards, and river or lake Drinking Water Protected Areas are at risk from nitrogen concentrations. There is the ability under existing regulations to address nitrogen pollution from wastewater where it is the biggest contributor to eutrophication (and nutrient pollution) under the Habitats Regulations and the Urban Waste Water Treatment Regulations.

As the share of nitrogen from agriculture entering the water environment starts to fall, we will continue to review the case for setting a nitrogen target for wastewater in accordance with the recommendations made by the UK Technical Advisory Group, in line with polluter pays and fair share principles.

Water demand target

Proposed target – To reduce Distribution Input (DI) over population by 20% from the 2019/2020 reporting year figures, by 2037/2038.

Target background

We need a secure supply of water to support a growing economy and population and reduce the strain we put on our water environment. We expect our population to grow and climate to change in the years ahead, which will place additional pressure on water resources. We also need to make public water supplies more resilient to droughts. In 2018, the National Infrastructure Commission (NIC) recommended that government should plan to deliver an additional 4,000 Ml/day by 2050 (30% on top of the current volume put into our public supply) to ensure resilience to extreme drought [40]. The NIC report suggested that two thirds of the additional capacity be met by demand reduction and a third by increasing supply by investing in new infrastructure.

Current actions in this area

Efforts to address water demand have been ongoing for a number of years with rapidly growing interest. Water companies are already working to reduce leakage by 50% on 2017-18 levels by 2050. The non-household sector has published a collective action plan for achieving water efficiency, however there is currently no agreed target for reducing water demand from the sector. In the 25 Year Environment Plan, Defra pledged to set a non-statutory target for personal water consumption (per capita consumption (PCC)). The government has announced new policies to reduce household water consumption to achieve this.

We need a secure supply of water to support a growing economy and population and reduce the strain we put on our water environment. Without investment in additional water capacity we would see households and businesses experiencing more frequent interruptions to water supply. These could include water use restrictions, bans and standpipes in the street. The environment would also be put under greater pressure from water abstraction. The NIC predicts that the cost of relying on emergency options to tackle drought occurrence would be around £40bn over the next thirty years. A study presented to the government in 2012 estimated that the impact of a severe drought on London's economy would be in excess of £250million per day. In 2016, Water UK's long-term planning framework also estimated that there is a 12% chance of seeing a drought event with standpipes or similar in place for 2 to 3 months over a 25-year planning period. There is a lesser risk (circa 5% in 25 years) that such an event could turn into an 'extreme' drought with drought restrictions lasting for 4 to 6 months.

Target area and ambition

The Water Demand target formalises and draws together water efficiency commitments, made by government, regulators and industry. This includes the Written Ministerial Statement on Reducing Demand for Water published in July 2021. The target would add value by setting the level of ambition for the new policies to reduce household consumption and introducing a statutory target that includes non-household (NHH) consumption. It also links demand and leakage reduction.

This target could be met through achieving a DI per population of 195.7 l/p/d, which equates to approximately a 10% reduction in DI, and a DI volume of 12556 Ml/d (Mega litres per day). The target is based on a trajectory for achieving the following figures calculated for 2050: PCC of 110 l/p/d, a 50% leakage reduction from 2017/18 levels, a 15% reduction in NHH water use.

Alternative levels of ambition based on the metrics mentioned above were considered. These included less ambitious targets for PCC of 116 l/p/d, a 37.5% leakage reduction and a 12% reduction in NHH demand by 2050. A more ambitious target was also discussed, however stakeholders advised that compulsory metering would be key to delivering a higher water efficiency ambition than the target option which may result in unmetered family homes facing unexpected large increases in bills. The government doesn't plan to make changes to existing rules around when people can be charged for their water use through water meters. Water companies in seriously water stressed areas may implement wider water metering programmes where it is shown within their Water Resources Management Plans that there is customer support and it is cost effective to do so. Metering programmes must nevertheless be justified by water companies and achieve customer support. This strikes the right balance between the need to protect water supplies and the importance of water companies reducing leakage before expanding the use of water meters. The target's proposed metric is DI over population, as this indicates the level of water used per person in England, making it relatable to water users, and will help to measure and improve water efficiency trends over time. Including population would ensure that the target does not have the unintended consequence of restricting growth and will remain achievable despite unexpected population changes. This type of target has been successful internationally. For example, in Western Australia a target consumption level of 155 thousand litres per person per year for consumers was implemented[7] and achieved within 4 years from a high of 185 kilolitres a year[8]. The 20x2020 Water Conservation Plan for California used a similar approach setting a baseline urban water use expressed in gallons per capita per day (GPCD) with a target of minus 20% by 2020[9].

Government and its regulatory bodies, including Ofwat, have a role in setting ambition for water companies and determining the funds they can raise to deliver it. A statutory target would give government leverage to influence water efficiency through channels such as the Price Review process and water resources management plans (WRMPs). By demonstrating

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[7] https://www.water.wa.gov.au/__data/assets/pdf_file/0012/4314/82417.pdf

[8] https://www.newwaterways.org.au/downloads/Resources%20-%20Policy%20and%20Guidelines/Government/State%20Water%20Plan.pdf

[9] https://www.waterboards.ca.gov/water_issues/hot_topics/20x2020/docs/20x2020plan.pdf

the government's expectations on water demand reduction, and embedding this objective in the Price Review process, we will ensure that appropriate actions are taken to meet the water demand target. Without government intervention water companies will have little incentive to reduce leakage or demand as works to reduce leakage are costly and business has a shorter planning horizon than government. This means they may make different investment decisions.

Modelling levels of ambition for the targets

Differing levels of ambition have been modelled for the targets. The amount and type of modelling varied depending on the type of target, metric used, related evidence and modelling already available.

Agriculture modelling

To help inform the level of ambition for this target, a number of possible future policy pathways were considered using information from Defra project WT1594. These are indicative assessments; in practice a number of different considerations would be taken into account when developing different measures and determining where these should be applied. These assessments consider the degree to which nutrient concentrations can be reduced and not the individual policies that could be used to deliver such reductions.

Defra project WT1594 investigated the future impact on agricultural pollution loads of potential policy scenarios (in which there was an increasing level of action and investment on the part of the farmer) at increasing levels of uptake: current, 50% and 85%. No decisions have yet been made regarding policy pathways and these were purely illustrative policy options to inform target decisions. From the illustrative potential policy pathways modelled in WT1594, the most ambitious scenario has been used as a representation of a potential indicative policy path to deliver the proposed agriculture target.

The percentage reductions, relative to a 2018 baseline (scenario 7), are shown in Table 3 (taken from WT1594 Table 3-6). The estimated pollution reductions were calculated at the Operational Catchment scale, but aggregated to give a national average figure. There are assumptions and caveats present in all modelling, including in this project, and these are explained in detail in the impact assessment[10]

[10] The impact assessment can be viewed at https://consult.defra.gov.uk/natural-environment-policy/consultation-on-environmental-targets

Table 3. Percentage reduction in annual average agricultural nitrate (Nit.), phosphorus (P) and sediment (Sed.) loads- taken from WT1594

	Scenario 7 (Current uptake of regulatory and voluntary measures)			Scenario 9 (85% uptake of regulatory and voluntary measures plus habitat creation)			Potential improvement (Scenario 9 minus scenario 7)		
Farm Type	**Nit.**	**P**	**Sed.**	**Nit.**	**P**	**Sed.**	**Nit.**	**P**	**Sed.**
Cereals	6.3	5.4	6.6	38.8	38.4	41.2	32.5	33.0	34.6
Dairy	7.9	10.1	8.3	22.8	43.8	31.8	14.9	33.7	23.5
General Cropping	10.7	6.9	8.8	42.1	40.5	44.0	31.4	33.6	35.2
Horticulture	9.2	6.7	8.8	39.8	38.4	41.1	30.6	31.7	32.3
Pig	8.5	8.7	7.7	27.8	42.1	38.7	19.3	33.4	31.0
LFA Grazing	5.4	5.9	5.0	19.6	26.1	18.9	14.2	20.2	13.9
Lowland Grazing	7.5	13.3	9.1	23.7	36.9	28.1	16.2	23.6	19.0
Mixed	7.0	7.6	7.9	33.6	38.8	40.9	26.6	31.2	33.0
Poultry	10.2	10	6.9	29.3	44.0	41.7	19.1	34	34.8
National	**7.9**	**8.0**	**7.2**	**32.2**	**37.2**	**35.7**	**24.3**	**29.2**	**28.5**

A maximum uptake rate of 85% in WT1594 was assumed because there are cases where sections of the farming industry do not comply with regulation (or take up voluntary advice), however a reasonable planning assumption is 100% for regulatory measures. WT1594 scenario 3 (regulatory measures with uptake rates of 85%) have been uplifted from 85% to 100% by carrying out a comparison of these two uptake rates and a national average increase of 2.5% (nitrate), 3.9% (phosphorus) and 4.2% (sediment) is predicted.

Spatially targeted Land Use Change (LUC), aimed at the highest risk land in terms of pollutant load (such as sloping land near water courses), with conversion from agricultural land to semi-natural habitat or woodland, will always provide greater pollutant reductions than implementing land management measures. However, any proposed land use change would need to be considered alongside any potential impact on agricultural production and food security. The land use change component of Defra project WT1594 was not spatially targeted, therefore greater reductions than predicted in WT1594 can be achieved through targeted changes. Recent EA work suggests implementing a similar scale of LUC to that in WT1594 (20%) by 2037 (by converting agricultural land to semi-natural habitat or woodland) would achieve a maximum potential national average load reduction of 31% (nitrate), 28% (phosphorus) and 30% (sediment).

Further EA analysis, replacing the LUC component of WT1594 scenario 9 with EA LUC scenarios (and reducing the available agricultural area by 20% over which measures can be applied), and with an uplift from 85% to 100% for regulatory compliance measures, suggests a maximum 43% reduction in nitrate load, 46% reduction in TP load and 48% reduction in sediment load can be achieved by 2037, relative to current (2018) baseline (Table 4). It is important to note that the EA modelling shows the maximum possible change under the LUC scenario as the targeting converts the highest risk agricultural land. In practice it will not always be possible or desirable to incentivise land use changes in all the highest impact locations, so we are likely to achieve less progress than modelled, so the pollutant reductions achievable will be lower than this modelling shows.

Table 4. Percentage reduction in annual average agricultural nitrate, phosphorus and sediment loads by 2037, relative to 2018, using WT1594 and further EA analysis

	Nitrate	Phosphorus	Sediment
WT1594 scenario 9 relative to scenario 7 (as published including land use change averaged over land)	24	29	29
EA analysis relative to WT1594 scenario 7 (accounting for WT1594 land management impacts (85% uptake) plus uplift to 100% for regulatory measures plus EA targeted LUC to 20% highest risk agricultural land)	43	46	48

Abandoned metal mines modelling

The proposed ambition level relates to the proportion of affected rivers that can be restored. The degree of restoration that can be achieved within a given budget will also be determined by what is feasible within the context of each remediation project, depending on the nature of the site and the pollutants involved. Levels of ambition also rely on the budget and feasibility of implementing schemes in the proposed timeframe. Costs were estimated against 3 scenarios:

1. 40% of affected rivers restored to a good condition
   Whilst this was felt to be more achievable as less funding from government is required, analysis showed we could go further and make a greater positive impact in river quality.
2. 50% of affected rivers restored to a good condition
   The Environment Agency estimates that to achieve the proposed target, up to forty new mine water treatment schemes need to be built to capture metals before they can pollute rivers. These schemes would need to be operated in perpetuity.
3. 60% of affected rivers restored to a good condition
   Approximately 50 mine water treatment schemes would need to be built and operated in perpetuity. The Environment Agency and Coal Authority have low confidence that they could accelerate the programme to achieve this target. Higher levels of ambition than this were considered un-feasible by the Environment Agency and Coal Authority as it was not

considered feasible to accelerate the programme from the current level to achieve this target by 2037.

Water Demand modelling

Distribution input (DI), or public water supply (PWS) is made up of several components. These can all be addressed to reduce water demand. The components are listed below in Table 5, with the percentage of overall water supply that they make up.

Table 5. The 2019/2020 water usage returns from water companies, split by public water supply component.

PWS component	Distribution input (Ml / d)	Percentage of PWS (%)
Leakage	2771.29	20.2
Household	7726.66	56.3
Non-household	2790.80	20.3
Other	441.42	3.2
PWS total	13730.17	100

The 2019/2020 annual water usage returns from water companies in England is shown in Table 5, which will form the baseline against which this water demand target will be measured. In the 2019/20 reporting year the DI/population was 241 litres per head of population. Leakage had reduced by 7% from 2017/18 and PCC was 140 (l/p/day).

The analysis looked at the change in Distribution input relative to population as well as the change in distribution input over time by reducing individual components (listed above). Scenarios were modelled, projected to 2050, in line with the targets included in the EA's framework for water resources, this was then worked back to establish a target value for 2037. Three overall scenarios were modelled:

- The Low scenario (2050: PCC of 120 l/p/d, 40% leakage reduction and NHH reduced by 10%) in 2037 they become; a PCC of 128 (l/p/d), 25% leakage reduction and 6% in NHH demand. This gives a DI/population of 206 l/p/day which is a 14.1% reduction.
- Medium target (2050: PCC 110 l/p/d, 50% leakage reduction, 15% reduction in NHH) in 2037 they become 122 PCC l/p/d, 31.3% reduction in leakage and 9% reduction in NHH. This gives a DI/population of 195.7 which is a 20% reduction.
- The High scenario (2050: PCC of 100 (l/p/d), 60% leakage reduction and NHH reduced by 20%) in 2037 they become; a PCC of 116 (l/p/d), 37.5% leakage reduction and 12% in NHH demand. This gives a DI/population of 185.4 l/p/d which is a 22.75% reduction.

Recommended metrics

Agriculture

Levels of water pollution can be measured through water quality monitoring and a long-term agriculture-focused *Enhanced Water Quality Monitoring Programme* has been in place since 2006, through the Catchment Sensitive Farming Partnership. However, the rural water environment is subject to multiple pressures including both point and diffuse sources, and monitoring alone may not, therefore, form a robust basis for setting sector-specific environmental outcome-based targets for agriculture.

Most evaluation of intervention impacts on agricultural pollutant losses has been conducted using modelling approaches, with FARMSCOPER being the leading policy tool for diffuse agricultural pollution management in England. FARMSCOPER integrates multiple pollutant, emission and erosion processes, at a range of spatial scales in order to estimate agricultural pollutant loadings. Where modelling approaches are used, field verification of model predictions is important. Water quality changes resulting from changes to agricultural pressures have been successfully modelled by combining pollution load modelling with statistical water quality modelling (e.g. EA, 2019).

A combined modelling/monitoring approach is proposed, using modelled predictions of progress against the target validated through water quality monitoring data. The most recent version of the FARMSCOPER model will need to be updated to model total nitrogen and include the most recent survey of farming practices. Current monitoring to support the CSF which provides targeted sampling to assess the impact of farming on water bodies will need to be expanded to validate the updated FARMSCOPER model. Incorporating data from the new Natural Capital Ecosystem Assessment (NCEA) monitoring programmes (which use randomly selected sites) will also help to provide the baseline condition of catchments and understand how they change over time due to different interventions.

Abandoned metal mines

EA analysis has determined that approximately 1,500km of English rivers are polluted by the substances specified in the target (adapted from published research [20]). To be included in this baseline the substance concentrations in rivers must have been recorded above the Environmental Quality Standard (EQS) when assessed as an annual average, and the source of those pollutants must have been confirmed as abandoned metal mines by the EA. There is good confidence in the baseline length of polluted rivers. Analysis completed by an independent consultancy in early 2021 recommended the EA should carry out a further review of the polluted rivers, including gathering additional water quality data to decrease uncertainty in the length of rivers affected and provide a more robust baseline. This work is in progress and will be completed in 2022.

The metric proposed can be measured using the existing monitoring and evaluation framework of the EA, adapted by the WAMM programme to the river catchments known to be polluted by abandoned metal mines. The monitoring for this is well established, and the scientific method of measuring metal concentrations in water is robust. The proposed metric does not change the current monitoring approach by the EA but will require sampling at increased frequency and locations to demonstrate whether mitigation measures such as mine water treatment schemes are decreasing metal concentrations so that the target is achieved.

Wastewater

The proposed target can be measured using the existing monitoring and evaluation framework of the EA using data collected from both monitoring and modelling. The target is based on effluent load discharged. It will be monitored by water companies under operator self-monitoring and the Urban Waste Water Treatment Regulations (1994) [41] requirements, and reported to the EA. The EA also monitors water bodies as part of their work on River Basin Management Plans. Outcomes will be visible from water company actions under the target from outflow phosphorus concentrations, with a reduced P concentration in the receiving water. The factors driving catchment failures are also modelled accordingly for River Basin Management Planning purposes. There are procedures currently in place to provide the monitoring for the target.

Water demand

The WEAG proposed the metric of Distribution Input. We considered this but decided the proposed target will be measured through distribution input per population (DI/pop). Population is included as this indicates the level of water used per person in England, making it relatable to water users and will help to measure and improve water efficiency trends over time. Including population would ensure that the target does not have the unintended consequence of restricting growth and will remain achievable despite unexpected population changes. This type of target has been successful internationally. Distribution input is already regularly reported by water companies to both the EA and Ofwat on an annual basis. This data can also be broken down further to its component uses, household consumption, leakage and non-household consumption. Distribution input is already in use in well-established reporting processes that water companies use in relation to the Water Resource Management Plan (WRMP) processes and performance reports, and the reporting of these are not expected to change. The proposed metric would not need additional monitoring to the current annual reporting. There are also agreed approaches to how the measurements for the distribution input value are recorded, which add to reliability of this data. Population data can be gathered from the Office for National statistics (ONS).

Target balance between desirability, feasibility, and viability

Agriculture

The approach proposed for the target is nutrient and sediment load reduction estimates using modelled predictions validated through water quality monitoring data (e.g., Catchment Sensitive Farming Enhanced Water Quality Monitoring programme). This approach has previously been proved effective for evaluating Catchment Sensitive Farming [42]. The target will be set as a national average, and we are consulting on the potential to set ambitions at a catchment level in future.

Desirability: The agriculture target is required to address one of the most significant sources of pollution in the water environment. Action taken by farmers will be a significant contributor towards achieving our ambitions in the 25 Year Environment Plan and also achieving the Environment Act biodiversity targets. However, domestic food production continues to be a high priority and it’s important to consider any potential impacts the targets may have on it, particularly as policy pathways are considered.

Feasibility: The proposed level of ambition for a 40% reduction in pollutants is highly ambitious. The delivery of the agriculture target will be supported by other Defra and cross-government policy programmes such as net zero and the environmental land management schemes. Technology is also becoming ever more precise. However, achieving 40% reductions will require policy mechanisms going beyond existing regulation, schemes, and advice. Alongside high compliance with regulations (supported by increased advice and enforcement), uptake of voluntary measures and the delivery of government commitments on habitat creation, the new environmental land management schemes will be crucial to supporting a shift towards more sustainable nutrient management. This is particularly relevant for the nutrient management standard in the Sustainable Farming Incentive which is under development.

Viability: Funding schemes such as the Sustainable Farming Incentive, Local Nature Recovery, Landscape Recovery and the Farm Investment Fund, and advice schemes such as CSF will contribute to the target by incentivising farmers to improve their practices and protect the water environment.

Abandoned metal mines

Desirability: Pollution from abandoned metal mines is the single largest source of metal pollution in rivers in England and causes the most severe EQS failures. The target would encourage a step-change in cleaning up this long-standing chronic pollution of rivers that is a legacy of Britain's industrial revolution. Government has a high degree of control since no change to societal or business behaviour is required. Government intervention through the WAMM programme is the only way to tackle this, as all these mines were abandoned before 2000 and so the former mine operators are not liable for knowingly permitting the ongoing water pollution. The target supports the levelling up agenda and identifying sustainable low-cost treatment options to treat pollution will also help to develop a world leading programme that sells UK scientific expertise.

Feasibility: This target is technologically feasible, and the WAMM programme has established mechanisms for prioritising funding and targeting action to deliver environmental improvements. The delivery of the target is dependent on government funding as this is a government liability, although subsequent co-funding can then be secured in some cases. Each site has unique characteristics, however there is a growing body of transferable knowledge and examples of successful projects. The three mine water treatment schemes that have been built to date treated over 7.5 million m^3 of water last year removing over 140 tonnes of the target pollutants and improving 20km of rivers in Cornwall, the North-East, Cumbria and Bassenthwaite Lake in the Lake District. The EA estimates that to achieve the proposed target, up to forty new mine water treatment schemes need to be built to capture contaminants before they can pollute rivers.

Viability: The target is dependent on long-term government funding. Achieving the target has been assessed to be cost-beneficial.

Wastewater target

Desirability: High levels of phosphorus within water bodies is the most common reason a water body fails to achieve good status. Most of phosphorus in the water environment comes from continuous discharges of treated wastewater from the water industry.

Feasibility: Water companies are already employing treatment methods and technologies to remove phosphorus from sewage. The legislative drivers also already exist for ensuring the delivery of this target (wastewater treatment works permitting, statutory Drainage Wastewater Management Plans). There are different methods available to water companies for achieving the reduction and emerging technologies will increase the feasibility of delivering the target such as those which allow for phosphorus recovery.

Viability: The target is currently assessed to be cost-beneficial and a viable target. Future development of novel technologies and a potential market for phosphorus recovery may further improve the cost benefit ratio and bring wider environmental benefits.

Water demand

Desirability: The water demand target aligns with our wider climate change and adaptation ambitions. Reducing water demand is an essential step for achieving a sustainable and resilient supply of water in the face of a changing climate and ensuring sufficient flow levels in the water environment to support vital ecosystems.

Feasibility: We expect to achieve the proposed level of ambition by pursuing policy commitments in the Written Ministerial Statement on Reducing Demand for Water. Data on Distribution Input is readily available, however there are gaps in our evidence for the non-household sector. Regulators and industry are working to resolve this.

Viability: The target aligns with policies announced by government on water efficiency, including the government’s response to the 2019 consultation on personal water consumption.

This includes policy on leakage and water company adoption of customer pipes, water efficiency in building regs, and water efficiency labelling.

Assumptions

Agriculture

The FARMSCOPER model includes assumptions regarding farm practices such as the timing of fertiliser and manure applications, duration of livestock grazing and the storage of manure, although the data used is from national annual surveys.

An accurate and comprehensive assessment of uptake of mitigation measures across all policies is required to determine progress against the target – scaling up of the results will use assumptions of farmer behaviour.

Policies and time lags are indicative. It is assumed that the gradual introduction of policies and the adoption of measures by farmers will result in a linear increase in uptake and hence costs from an initial baseline in 2022 to reach the modelled scenario in full by 2037. CSF evidence indicates a lag of around three years from farm advice delivery on mitigation measures until there is a detectable water quality improvement. The lag is a combination of the time taken to implement mitigation measures (and hence incur the main costs) and the time for the mitigations to deliver reductions in pollution. It is assumed that the lag between costs and benefits is two years. This is a major simplification because some environmental effects are almost immediate whilst other lags could be far longer, particularly for responses in groundwater dominated catchments or those with legacy nutrient stores.

Assumed modelling baseline (with no interventions) is an unchanged structure of agricultural land use (cropping and stocking), management systems and technologies. All additional actions on farm are modelled assuming no changes to land use and management other than those specified in modelling. This modelling was undertaken before the current volatility in the prices of agricultural commodities therefore prices of all agricultural inputs and outputs are assumed constant in real terms throughout.

With regards to the modelled potential policy pathways, it is assumed that a combination of better targeted action, market-driven changes and action primarily aimed at other targets (including net zero) will contribute extra pollution reductions. Further modelling work is under way to confirm this.

Abandoned metal mines

Benefits begin two years after the construction date (i.e., when operation begins) and last until 2100. Benefits have been calculated using National Water Environment Benefits Survey values supplemented by the EA's benefit assessment guidance (BAG) assessments where available. Benefits have been assessed at a management catchment scale rather than the individual water bodies or estimated number of interventions. It is assumed all schemes and diffuse measures within a catchment are technically and practically feasible.

Assumptions made when calculating costs: Diffuse measures take one year to build. Operating costs for diffuse measures begin in the year of construction. They are incurred annually until 2100. Treatment schemes take three years to develop and two years to construct. Operating costs for mine water treatment schemes begin when construction has finished. Operating costs are then incurred annually until 2100. Operating costs increase by £30k per scheme from year 7 as it is assumed increased operating costs are a better reflection of cost than periodic capital investment. Costs were provided by the Coal Authority based on their experience building and operating more than 75 coal and metal mine water treatment schemes. The majority of the capital costs for new schemes is in earthworks and pipelines which have a long lifetime, and replacement is generally less than initial earthworks. Costs have been assessed at a management catchment scale based on the estimated number of interventions rather than the individual water bodies.

It is assumed all schemes and diffuse measures within a catchment are technically and practically feasible. Current technology to remove pollutants will be used until 2100 although R&D is likely to decrease operating costs.

Risks: Delivery of the target is entirely dependent on government funding. Some schemes do attract financial contributions from other catchment partners and beneficiaries, but government funding is required for the vast majority of the investment required and to act as match funding to attract the non-government contributions.

Gaps in the evidence base: There is uncertainty around future technological improvements and the outcomes from investment in research and development to decrease costs. Future changes to the evaluation of benefits may increase their value.

Wastewater

This was costed using a standard model drawing upon EA experience with modelling costs of similar schemes over a long period of time.

EA’s initial modelled costs are replaced in subsequent appraisal by water company estimates of the cost of each individual works enhancement, that are subject to Ofwat scrutiny. This ensures that EA initial costings are now broadly in line with typical outturns.

Alternative technologies, including phosphorus recovery for reuse as fertiliser, are currently not economically viable at scale but may become so in future with innovation and depending on world prices of phosphate rock, delivering better environmental outcomes.

Water Demand

Assumptions have been made about some of the factors which are likely to affect water demand, such as climate change which will have an unpredictable impact on water consumption requirements, and water availability. Any large divergence from modelling used could have an impact on the achievability of the target. However, climate change is also a driver for demand reduction.

The proposed target includes household consumption and leakage, as well as the additional element of non-household consumption. Whilst there are industry commitments and plans to address leakage and household consumption, these cannot be considered guaranteed and there are risks that climate change and social factors could affect the deliverability of these commitments.

There is a minor risk that climate change could lead to some abstractors (industrial water users who self-supply from their own reservoirs, wells, or river abstractions) shifting in drought periods to the public water supply.

There is limited data on water consumption practices in the non-household sector, leaving a degree of uncertainty over exactly what issues might arise.

Future evidence plans and evidence gathering

The water environment is continually changing, as is our relationship with it. To ensure the full range of impacts on water are captured in the evidence base, as well as noting emerging issues, our evidence base is continually improved. An overview of some of these areas is given below.

Evidence gathering in near future

Our proposed agriculture target requires further development of models and datasets in order to accurately estimate nutrient loads and report these, and we plan to work with academics, researchers and others to undertake the following:

- We will continue to develop our modelling capability which will be used to monitor against our proposed agriculture target, for example by development of FARMSCOPER to expand its estimates of nitrogen-bearing nutrient loads from nitrate to total nitrogen.
- Following advice from the WEAG, we also hope to add other models to our approach, building an ensemble of models which will allow more accurate estimates of nutrient loads.
- The proposed agriculture target will also require new sources of data relating to uptake of on-farm measures to allow accurate modelling of annual loads and we are exploring whether new sources of data could be used to improve these estimates.
- We will also develop new methodologies for reporting nutrient losses. We are also working with the EA to improve the way that we estimate the monetised benefits of improving water quality to near natural state which is currently assessed using the National Water Environment Benefits Survey (NWEBS). Further details of this and all our research, including final reports, will be published on the EA or Defra Science pages.
- We will continue to obtain evidence on the impact of agriculture on the water environment through the CSF monitoring programme which was expanded beyond high priority catchments at the start of 2022. In addition to this, the Natural Capital Ecosystem Assessment (NCEA) River Surveillance Network will provide a new nationally representative dataset of river condition which will allow longer term detection of trends across a range of water quality and ecosystem health parameters. Finally, the NCEA Small Streams Network should provide data on smaller water courses.

Water Expert Advisory Group discussions on proposed targets

This section summarises the expert advice and conversations with the WEAG[11]. We would like to thank the group for their contribution. The proposed targets discussed with the WEAG is shown below at each section. This is the wording they were asked to give advice on and is not necessarily the wording of the target recommended by WEAG. The target discussed with the WEAG may differ from that currently proposed in the consultation, in response to advice from experts, other governmental departments and Ministerial decisions.

Water Experts Advisory Group- Detailed notes on an Agriculture water quality target

Proposed target during initial WEAG discussions – "Reduce nitrate and phosphorus pollution load from agriculture to the water environment by 40% by 2037".

Background system information from experts

Agricultural sources of total nitrogen and total phosphorus

The sources of nutrient pollution[12] (nitrogen and phosphorus) were discussed, with WEAG noting that some of the most negatively impacted rivers in terms of ecological function are in livestock farming regions. This is not always captured by measuring only nitrate concentrations, as in such systems the organic nitrogen fractions contribution can be up to 50% of the total nitrogen (N) load. These compounds are highly bioavailable to aquatic biota. A focus on inorganic nitrogen alone (nitrate, nitrite and ammonium) in river systems can underestimate the impact of livestock farming on freshwater ecosystems. Defra acknowledged this and agreed that the target should address total nitrogen and total phosphorus (P). Important sources of organic nitrogen and phosphorus from agriculture include sheep farming

[11] A different font will used to show separation of the sections

[12] Although the term contamination may be technically more appropriate where impact is on the environment rather than human health, we use the term pollution to align with our 25 Year Environment Plan and other key documents.

in upland areas, and more widely geographically dairy, beef cattle farming, outdoor pig farming and poultry farming.

The WEAG explained how the use of fertilisers and crop growth interacted with the natural nitrogen cycle. Common nitrogen fertilisers include ammonia, ammonium nitrate and urea, and slurry and manures from livestock farms which all replace nitrogen in soils following removal during plant growth and losses though denitrification in soils. Denitrification processes may be offset by nitrogen deposition from the atmosphere, particularly in the immediate vicinity of intensive livestock production units, in addition to nitrogen deposition from fossil fuel combustion. The WEAG also pointed to the over-estimation of denitrification rates in wetland systems, where assumptions are often made that whole systems would support denitrification. They noted that in reality, the process occurs patchily in only the wettest areas of wetlands and highlighted that needs to be accounted for when modelling denitrification rates.

Alongside the addition of nitrogen or phosphorus to soils, other compounds affect plant growth and nutrient use. One example the WEAG noted was that a lack of potassium (K) or sulphur (S) can reduce overall nutrient use efficiency[13] in some agricultural systems. This reduces uptake of nitrogen by plants with the excess at risk of leaking to the water environment. This is also affected by different sources of nitrogen (farmyard manure, etc). Similar issues have been noted by the Nutrient Management Expert Group (NMEG) currently advising Defra and we will continue to engage with the NMEG secretariat to ensure that we consider advice from this group as it is drafted.

Reductions in nutrient loads associated with advice and on-farm mitigation measures incentivised through the Catchment Sensitive Farming programme (CSF) are estimated at an average 10% reduction, which the WEAG advised is not sufficient to generate significant benefits for freshwater ecosystems. The WEAG noted this would be partly due to time lags in the system response to current mitigation efforts, but also due to low uptake rates/poor targeting of mitigation measures that reduce nutrient loads and suggested that a significantly higher level of ambition is required to achieve the goals of the 25 Year Environment Plan.

There are generally low livestock numbers in the 'arable east' so reductions in inorganic nitrogen fertiliser applications (or land use change) could decrease NO_3 concentrations in

[13] The ability for crops to efficiently take up and use nutrients for increased yields.

water bodies[14]. However, the WEAG noted that geographical land uses are changing, and will continue to change, due to climate change and policy and market drivers, and that it should not be presumed that current farm structures and locations will stay the same. They also highlighted that there is intensive indoor pig and poultry rearing in the east that may not take place on arable land, and that nitrogen and phosphorus flux to waters resulting from disposal of the pig and poultry litter to land, landfill or incinerators from these sources need to be taken into account in any mitigation efforts.

Methods for assessing nitrogen and phosphorus pollution from agriculture

Defra have used the FARMSCOPER decision support tool to assess nitrate and phosphorus (dissolved and particulate) losses from agricultural systems. The WEAG recommended that multiple (and ensemble) models of total N and total P loads delivered to waters from agriculture should be compared to gain a more accurate picture of current nutrient pollution problems. An inter-model comparison would be helpful to inform Defra of the different patterns and loading rates simulated by different models. An export[15] coefficient model (ECM) [43] output was presented, showing total nitrogen and phosphorus loads delivered to UK waters, for the period 2000-2010 (Figure 3). Models that focus on nitrate, and not total nitrogen, do not capture the whole nitrogen system and show a different geographic spread of nutrient pressures (showing the most acute problems in East Anglia), as they are largely driven by inorganic fertiliser application practices. Models such as the ECM[5] which consider total nitrogen and total phosphorus also account for organic nutrient fractions derived from livestock production and particulate nutrient fractions attached to eroded soils from agricultural fields. Existing policy support models used for Defra work do include consideration of particulate and dissolved fractions for phosphorus pollution.

The ECM showed that the highest rates of total nitrogen flux (movement in mass or kilograms) to waters tend to be where there is intensive agriculture and downstream of urban areas. The highest areas of total nitrogen flux from agriculture were found in the west of the UK. This is due to a combination of factors including higher livestock densities, application of manures and slurries at times applied in excess of crop requirements, and the presence of naturally heavier, wetter soils on steeper sloping land. In comparison, the highest rates of total phosphorus flux are associated with treated wastewater sources so occur in areas with larger populations, though significant fluxes of particulate phosphorus also occur as a result of sediment and soil

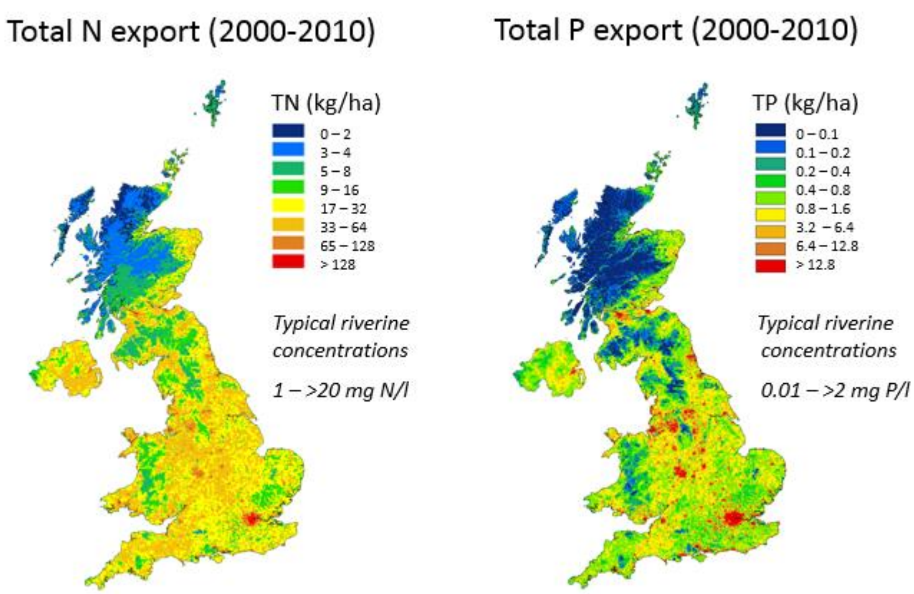
[14] As noted above, in areas where livestock farming is more prevalent, organic N and P fractions may contribute more to nutrient pollution.

[15] Nutrient movements from one system to another are often termed ‘exports’, in this case from the terrestrial to aquatic environment.

erosion from arable land and overgrazed land in rural catchments where agriculture is the dominant source. Fluxes of dissolved bioavailable phosphorus can also be high in grassland systems in livestock-dominated areas.

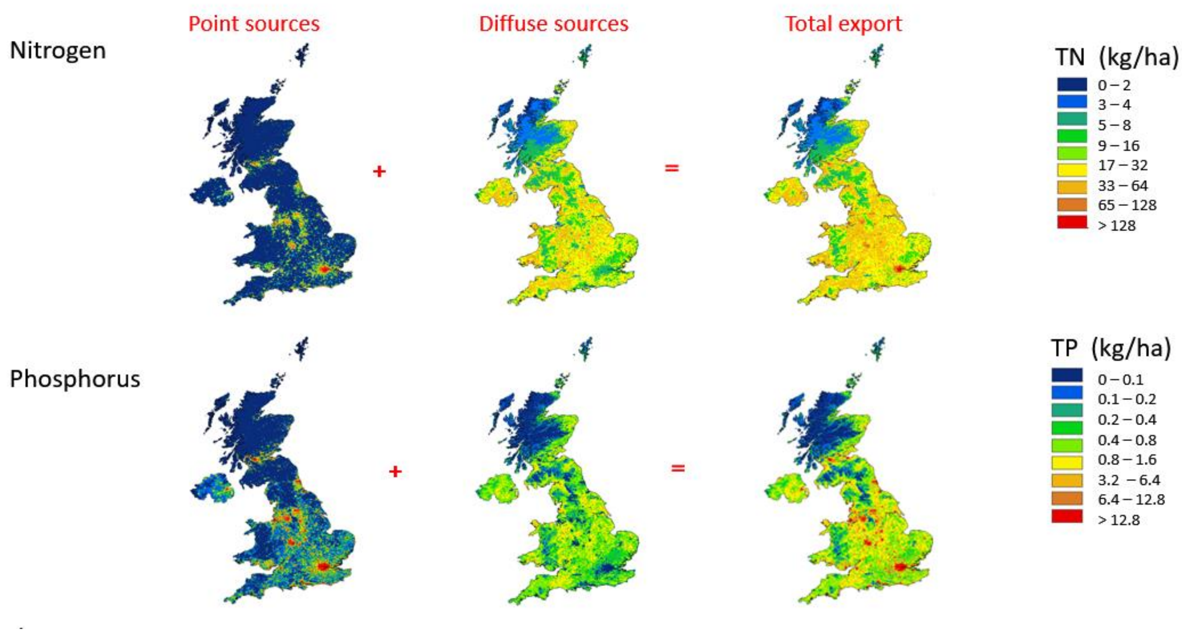
The WEAG noted that the ECM includes non-agricultural sources such as septic tanks, small sewage treatment works, large wastewater treatment works. Inclusion of multiple sources and assessing total nitrogen and phosphorus fluxes allows the ECM to more accurately capture both the spatial variability and the full scale of the problem, especially when compared to some other models. A breakdown of the fraction of the total nitrogen and total phosphorus loads delivered by agriculture, versus from point sources (see our Wastewater Target chapter) from the same research programme is shown in Figure 4.

Figure 3; Modelled total nitrogen (N) and total phosphorus (P) loads ECM from Krueger et al. 2015 [43]



The potential to compare the ECM and the Sagis-Simcat model used by the EA was then discussed. Experts highlighted that the ECM had previously been compared with models developed by other groups in Europe, as part of the European Nitrogen Assessment programme [44, 45] and with global models developed by teams in the USA. There may be merit in doing an inter-model comparison to assess if there are similar patterns between the highlighted model and Sagis-Simcat. Defra is considering ways to improve modelling capability on this topic and this would fit with the ensemble modelling approach recommended by the WEAG.

Figure 4: Modelled total nitrogen (TN) and total phosphorus (TP) loads to UK waters, 2000-2010 by contributing sector, where point sources refer to combined export from all sewerage systems, and diffuse sources refer to export from agriculture [43].



Experts highlighted several academic papers describing modelling on how to spatially target mitigation measures for reducing nitrogen or nitrate, P and sediment [46, 47]. They include analysis of trade-offs by looking simultaneously at the emissions of nitrogen, phosphorus and sediment to water bodies as well as the emissions of ammonia, NOx and methane, investigating whether nutrient pollution is being measurably reduced overall or whether a portion is being shifted to some other pollution pathway. Experts also showed a national nitrogen budget for the UK that has been developed for the UNECE task force for reactive N [48].

Experts also highlighted a project in progress producing evidence and recommendations for farming sectors on nitrogen losses [49], with official outputs anticipated at the end of 2022. Experts suggested that a key point is that while national budgeting of nutrient fluxes to air and water linked to environmental and human health impacts is needed, finer scale monitoring and modelling is also needed to inform design of mitigation on the ground on individual farms and within catchments. Links to current governmental strategies and policies were also raised including net zero, Farming Rules for Water and the Clean Air Strategy.

Current understanding of nitrogen and phosphorus compounds impact on water bodies

Ongoing work assessing the relative importance of different nutrient species or fractions (different nutrient compounds comprising total N and P) globally was discussed. This work shows data for N species in freshwaters collated from 83 sites around the EU [50], for >2000 sites globally [51] as well as a range of sites in the UK [52, 53]. In waters generally described as being in good or high ecological status, the proportion of N loading in the form of nitrate was typically <10-20% of the total N loading. In the UK and across temperate and boreal regions of the world, N loading in unpolluted waters is dominated by dissolved organic N rather than nitrate.

The ecological impact of nutrient pollution at different levels was then discussed. The WEAG highlighted that the global data set for temperate and boreal regions published by Wymore et. al. [54] showed a clear change point in N load composition at around 1.5-2 milligrams N per litre (mg N/L) with waterbodies shifting from being predominantly dissolved organic nitrogen (DON) to predominantly nitrate as total N concentrations increased [55]. A similar change point is also evident in the work on UK catchments [50] and in the work on 83 European catchments in the work of Durand et al. (2011) in the European Nitrogen Assessment programme. Above 1.5-2 mg N/L, freshwater ecosystems cannot access or process the additional N fast enough to incorporate it into biological material and subsequently into the dissolved or particulate organic nitrogen (DON/PON) in these environments. Inorganic N then starts to accumulate within the water body, generating the switch from organic- to inorganic-N dominated chemistry. A large review of ecological evidence of the N thresholds at which shallow lakes shifted from clear water and plant-dominated systems to clouded, algal-dominated systems (James et al., 2009) found that the richest UK lake communities were associated with winter nitrate-N concentrations of up to ~1–2 mg N/L [55]. This indicates this threshold might correspond with ‘good’ ecological quality under the Water Environment Regulations. Several studies using both chemical and ecological evidence have suggested a threshold in the same range and national N thresholds established for waters across the EU, based on this evidence, are reviewed by Poikane et al (2019 [56]).

Phosphorus measurement methodology

Experts suggested that Defra use the opportunity of setting a target on phosphorus from agriculture to consider updating monitoring practices in England in line with current international standard water quality monitoring practices by adopting measurement of Soluble Reactive P (SRP) alongside Total P (TP). SRP is measured on a filtered sample, rather than the current TRP (Total Reactive P) which is measured on an unfiltered sample. It was noted that there is variability between different datasets, with some showing no major difference between SRP and TRP measurements, and others showing a divergence of these measures in areas dominated by livestock farming where colloidal P compounds are present which are not measured by SRP.

Including total nitrogen in the target and not nitrate

The WEAG suggested it was essential to use TN to represent the total N loading driving freshwater ecosystems, and to additionally report nitrate (as TON – total oxidisable nitrogen) concentrations. This will allow the UK to continue reporting against the baseline monitoring dataset originally established under the EU Nitrate Directive to continue. Experts explained that TN is best determined following a well-established process of sample digestion by persulphate oxidation followed by colorimetric analysis that allows for simultaneous determination of both Total N and Total P [57]. This would provide a robust and comprehensive measurement of the N and P pools that drive freshwater ecosystems and biodiversity loss in nutrient enriched freshwaters.

The WEAG advised that by focusing on inorganic fractions alone, measures might be introduced which generated pollutant swapping from inorganic to organic and particulate nutrient fractions without decreasing the overall nutrient pressures on freshwater ecosystems. Measuring the whole N and P system also has the additional benefit of supporting measures seeking to move to a more circular economy on farms, as recommended during discussions with Defra's Nutrient Management Expert Group. Experts highlighted a number of publications which would be helpful when moving to include TN in our target [58, 59, 60].

The WEAG stated that the academic community widely measures TON (total oxidisable nitrogen, includes nitrate and nitrite) to report the nitrate data. Experts suggested that using TON as a proxy for nitrate is acceptable because in rivers nitrite makes up less than 0.01% of the TON fraction and is generally only detected when a water body has very low oxygen conditions. The technical methodology of determining TN, TP, and the various inorganic and organic fractions of each was discussed.

Target feasibility, achievability and ambition

The proposed target of a 40% reduction in nutrient (nitrogen and phosphorus) and sediment loads from agriculture by 2037 is based upon modelling undertaken in Defra project WT1594 [61] which used FARMSCOPER to assess the load reductions which could be achieved through a range of policy scenarios. With high uptake of on farm measures and high compliance with regulations up to 25% load reductions could be achieved against the current baseline. Defra recognise that a 40% reduction is therefore very ambitious.

The WEAG stressed that there needs to be explicit consideration of intrinsic or background risks being built into the targets, and an assessment of the intrinsic loading and losses of nutrients and sediment present within farming systems and catchments, so that the excess of losses is targeted without trying to reduce all losses to almost zero, which is not practicable [62, 63].

The WEAG also highlighted the long lag times for instream water quality improvement in many catchments due to legacy stores within the water environment. They highlighted the need to ensure this is fully communicated to public and stakeholders as part of targets for improving water quality in the long term, to keep communities and environmental managers engaged and properly resourced to continue mitigation and monitoring efforts over the longer time period in which some systems might respond. They noted that catchments which are wet, steeply sloping and less intensively farmed are likely to respond more quickly to mitigation efforts than those with deep aquifers (chalk regions), low topography, little rainfall, and intensive agriculture [64].

Target Scope

The scope of the proposed target was discussed, and particularly whether this target addresses the right point of the logic chain between input of fertilisers on farm, losses and mobilisation, pollutant transport within the landscape and pollutant pathways to the receiving water bodies. Experts suggested that the proposed target does focus on the right point of the logic chain but highlighted that other indicators of progress may be required alongside load estimates, e.g. indicators measuring uptake of farming practices.

Defra asked if there are resilient actions we can take within the logic framework to deal with significant pressures on water bodies. Experts set out the importance of setting nutrient targets nationally, regionally and within catchments, so that individual farmers are not unduly targeted, while devolving decisions about how to reach nutrient load reductions at the individual farm level. Reducing nutrient loads is a multi-scale activity that begins with multi-industry actions to reduce the nutrient input pressures and improve efficiency, but social science inputs will be critical to help engage farmers and industry stakeholders in achieving these targets. Again, significant synergies between the target setting process and the advice of Defra’s Nutrient Management Expert Group were highlighted.

Experts also cautioned that a Defra focus on individual mechanisms and practices applied across all agricultural sectors will not be enough, as mitigation options and efficacies will differ between arable and livestock systems, and between differing types of arable or livestock production system: there are marked difference in practices and business models between beef versus dairy farming, sheep versus indoor pig or poultry rearing, for example. They suggested that there needs to be a focus on helping all farmers and the wider industry stakeholders to implement nutrient loading reductions and that targeting of these should be based on detailed and robust process-based or empirical understanding of different landscapes and farm types [65]. Experts suggested that significant reductions in nutrient pressures from agriculture would require wider changes within the food chain.

Metric

Defra proposed that this target should be measured by modelling nutrient and sediment loads from agriculture using existing decision support tools and models (e.g., FARMSCOPER) with input data on agricultural practice and uptake of on farm mitigation measures and validated using water chemistry data from the Catchment Sensitive Farming Enhanced Water Quality Monitoring Programme.

FARMSCOPER

The technical capabilities and limitations of FARMSCOPER [66] were discussed. This model has provided the baseline, along with additional evidence, for Defra's current understanding and assessment of agricultural loads of nutrients and sediment to water bodies (although only nitrate is modelled in the current version). The WEAG noted that FARMSCOPER was designed initially as a policy tool to assist decision making. It has subsequently been used to support farmer decision making on the most appropriate mitigation methods to reduce nutrient losses from farms to water bodies. The WEAG explained that the underpinning process-based models are mean (average) climate driven, whereas in reality, the progress towards load reductions will be affected by natural inter-annual variability in rainfall and runoff and by climate change [67]. In wet years, many mitigation measures may be overridden with 'perfect storms' reducing efficacy of interventions, while warmer wetter winters under a changing climate are likely to exacerbate nutrient (N and P) and sediment loss from agriculture to water. The WEAG also highlighted that the model/s need to be aligned with wider inventories of nutrient use, across the agricultural sector and across the whole food system. Some references for recent work on this were provided in previous sections (UNECE project). The potential use of scaling factors to correct FARMSCOPER outputs for effects (e.g., lag effects across scales) not currently within the model was discussed. The WEAG noted that technically this was possible but were uncertain such an approach would be accurate for N and P, and that the spatial sensitivity may not be accurate enough for catchment specific areas.

The WEAG advised that all models only represent the model builders' conception of how the environment works, unless they have compared it against another independent data set. The ability of a model alone being used as monitoring of progress towards the metric was challenged; some alternative approaches suggested are shown later, including use of an ensemble of multiple models or a robust water quality monitoring programme to including total N, total P and suspended sediment, at a high enough sampling frequency to generate robust pollutant load estimates for multiple catchments.

Experts highlighted the challenges of validating modelled pollutant loads using the expanded Catchment Sensitive Farming Enhanced Water Quality Monitoring Programme. Confidently linking concentrations of pollutants in water bodies with changes in long term inputs will require an understanding or modelling of hydrology within catchments (e.g., lags between mobilisation of pollutants and arrival in receiving water body), in stream processing of N, P and sediment and source apportionment of these pollutants. As above, experts highlighted the need to measure TN and TP and to carefully consider the number and frequency of sampling needed in order to detect long term trends in N and P plus sediment concentrations or loads and to assign any identified reductions to the agricultural sector.

Experts agreed overall that the proposed metric is likely the right metric to use, but that it is a slow-moving metric and will need to be supplemented with other metrics behind the scenes in order to assess progress in the short to medium term. For example, it would be unreasonable to have a P load reduction target when we are still accumulating phosphorus in the landscape and so we need to address the P input pressure and ensure there are ways of assessing or measuring that [68].

On timescales, it was noted that Defra would need to confirm set targets by Easter 2022 for an initial review of evidence. However, the WEAG agreed that an updated version of FARMSCOPER (to include TN) does not necessarily need to be in place by then. The WEAG's view was that this could be a 3-year timescale and would involve significant investment to build upon the initial evidence base.

Catchment specific ability of FARMSCOPER and other tools

It was noted that for the three prominent pressures from agriculture on water quality (N, P and sediment), it would be disadvantageous to measure progress for agriculture as one unit due to the variability of the pressure and mechanisms of loss in catchments and within sectors. The feasibility of having a catchment and/or sector specific approach and impacts on uptake of mitigation measures was discussed.

The WEAG highlighted published research from the EEA and other countries on more basic or simple indicators of nutrient balances in agriculture, usually calculated at regional level, to indicate the intensity of loading. Regional loading (at catchment or river basin level) was noted as important during delivery in explaining nutrient flows across sectors to multiple stakeholders, as issues are often not clear until there is cross-scale focus. There was discussion about the appropriate level of detail, and the potential advantages of linking to a farm payment system or other mechanisms.

As mentioned above, the WEAG explained that the dominant species or fractions of N pollution will differ depending on the dominant land use, with loads from arable land likely to be dominated by nitrate whereas in livestock dominated areas, N pollution is balanced more evenly between nitrate and organic nitrogen fractions. Combined with the differing character of soils, geology and climate between different areas of the UK, this will generate location-specific nutrient loading rates, pathways, sinks and response times to mitigation methods. Therefore, the pathway/mobilisation of nutrients in relation to these geoclimatic controls seems to be the driving factor which affects the composition of the total N pool. The WEAG then discussed the benefits of taking different approaches to different agricultural sectors to best reduce total N and total P delivery to water bodies. Examples included the suggestion that pollution from intensive poultry farming could be reduced by requiring a transition from manure use on land to energy use such as anaerobic digestion and incineration, with the caveat that this should not result in increasing greenhouse gas or ammonia emission to the atmosphere (pollutant swapping) followed by nutrient recovery. Experts also highlighted how different approaches should be taken to tackle different nutrient sources, for example how a little and often approach to applying farmyard manure may reduce risk of over application at certain times or leakage from storage [69], whereas closed periods with no spreading are appropriate for more mobile slurries and inorganic fertilisers.

The data underlying some areas of the metric was noted as being prone to bias, e.g., response rates of surveys. It was highlighted by the WEAG that having an objective high-level target does not preclude the use of explicitly biased data at a lower or more detailed level if this is accounted for statistically. If there were indicators to assess how farm practice has changed, these could include sources like farmer self-recording, balanced by other sources like regulatory breaches, to triangulate and thus achieve objectivity from comparing data from multiple sources. WEAG members explained this through their work on policy evaluation using mixed methods and triangulation to enable explicit recognition of bias in evidence, which is unavoidable but not a problem if accounted for.

Building up modelling capacity

Building on the advice to set a target for nitrogen rather than nitrate, the WEAG were asked to consider short, medium, and long-term options for developing our modelling capacity for understanding N, P and sediment losses from agriculture and subsequent water pollutant loads. The WEAG stated that the evidence needed to expand FARMSCOPER (and the mitigation measures included in its library) to predict TN loads may currently be incomplete, and this may be an area for additional investment and research. They suggested further developing the concept of a 'Biogeochemical Modelling Framework' using work similar to that in the Environmental Virtual Observatory [70] to allow nutrient fluxes in different landscape types to be robustly estimated, with similar landscapes behaving in a similar way. The WEAG noted that not all landscapes behave in the same way, and not all catchments have sufficiently robust and complete data under current routine monitoring programmes to accurately quantify and apportion nutrient loading to different sources in the catchment using monitoring data alone [71].

The WEAG recommended taking an ensemble approach to modelling, including the use of an ECM+ (Export Coefficient Model) [72] to sense-check the outputs from models such as FARMSCOPER. A review of all usable models, by Defra or a group of impartial experts, along with an analysis of model accuracy or validation with robust data would help build a more accurate picture of nutrient and sediment losses and how they are changing over time. It was noted that unless models are calibrated or validated with independent monitoring data, outputs should be treated with caution and might agree but still not accurately reflect the nutrient pressures generated by agriculture on waters and experienced by the biota.

The WEAG stated that one robust model or ideally an ensemble of models for water quality could be used to assess progress against the target and suggested that obtaining a robust review of these models would be important. It would be important to consider whether outputs can be used appropriately. A new model or ensemble that can only be run by a certain expert or group would be counter intuitive. A number of easily accessible, open access models were noted by the WEAG, and specifically the UKRI funded Virtual Observatory [73] and a subsequent geospatial framework for integrated biogeochemical modelling in the UK [74].

Discussion on alternative design for the target and metric

Target load versus concentration limit

The differences between a target focused on percentage load reduction as presented, or whether it should focus on an absolute concentration threshold for total N and total P concentration in a water body was noted as needing more discussion. The WEAG stressed that biology within rivers responds to the local concentrations, not the load. However, load is easier to calculate at farm scale if farm nutrient budgeting is being looked at to reduce nutrient flux to waters and can be readily converted to a mean concentration and range of concentrations using discharge monitoring data (or simulations) for the water body. The decision between a load target or a concentration-based target would need to be taken carefully and coordination with the advice coming from Defra's Nutrient Management Expert Group was recommended.

Based on the evidence, the WEAG stressed that 1.5-2 mg N/l is the absolute baseline for good ecological status in waters. This raised the question of whether Defra should prioritise preserving water bodies that are in a good state or invest in mitigation to improve those that are highly damaged. This is because for many sites, a 50% reduction in total N would still not meet the 1.5-2 mg N/l goal. However, some improvement in biodiversity could be expected even if an interim threshold in excess of the 1.5-2 mg N/l were to be achieved. Experts also highlighted research analysing all N targets set in European waters by Poikane et. al. (2019) showing that 50-60% of countries have a total N target between 1 and 4 mg N/L [75].

Monitoring

The WEAG suggested that investment and adequate resourcing is needed to bring the approach to monitoring up to date with current science thinking, particularly as agriculture moves towards using new sources of nutrient additions on farm, for example the recycling of organic wastes to soils in preference to applying inorganic fertilisers. They advised that this was increasingly likely to happen given looming challenges in the global phosphorus markets, and the move towards establishing a circular and sustainable economy with multiple anticipated environmental and societal benefits. The WEAG advised that the robust and statistically representative data needed to validate a modelling approach, whether a single model or ensemble is used, would need an expansion of current sampling locations alongside more frequent sampling.

Using a water monitoring based metric instead of a modelling-based estimation of loads was discussed. The WEAG explained that it is expensive to collect data through manual monitoring and that although in-stream sensors can give continuous real time water chemistry data, these are not perfect systems (they require upkeep, calibration and validation through sampling) and sensors and bankside monitors currently available do not measure TN. Sensor data also has a higher degree of uncertainty associated with them, as the data streams cannot be quality assured in the same way as a laboratory analysis [76]. The WEAG advised that to keep results as accurate as possible, sample collection and analysis for Total N and Total P would ideally be done daily at one site in each catchment, which would provide the evidence needed to measure progress against a water quality target expressed as mean annual Total N or Total P concentration. Separately, sensor systems deployed at the same sites could provide further evidence of extreme rainfall events, flow variations and the flux of other important fractions of the nutrient and sediment load delivered to waters from agricultural sources in their catchments. Combining concentration data (in mg/L = g/m^3) and discharge data (measured in m^3/s) would then allow robust load calculation for each site ($g/m^3 \times m^3/s = g/s$), upscaled to annual load estimates from the daily monitoring record.

The WEAG advised that to use monitoring data alone to measure this target, around 1000 representative sites may needed to be sampled at daily resolution. These could be fitted with telemetered sensor systems, as tested extensively under Defra's Demonstration Test Catchments programme for the data to be robust. Daily sampling does not happen routinely and several academic studies have illustrated the uncertainties associated with weekly/monthly sampling frequencies [77]. The WEAG also argued that monitoring alone would not differentiate between the pollution from agricultural land and other sources in the catchment (see our Wastewater note) and that source apportionment modelling would be needed in tandem, together with targeted monitoring of discharges from sewerage systems. Source apportionment modelling was considered central to setting a statutory target using monitoring data on one sector where multiple sectors contribute to the issue (e.g., septic tanks, rural wastewater treatment plants).

Other metric points discussed

The WEAG highlighted that framing water targets in terms of ecological improvement does not work well for groundwater where progress against a natural baseline condition is more appropriate. It was noted that the natural baseline from academic estimates is substantially lower for P than in existing UKTAG targets under WER, or under the HABS Directive. It was also noted that the water quality targets will need to address pollutant loading but that there is a substantial excess of nutrients already in the environment which will also need to be addressed. The current influence of agriculture on groundwater quality should be measured and predicted by reference to nutrient loading.

National targets for TN, TP and sediment

There was discussion on whether Defra advice on national targets should be at farm level (e.g., outputs from FARMSCOPER or other farm decision support tool) or if it should be more high-level, giving catchment managers and local stakeholders more authority to decide what the feasible actions and subsequent total nutrient and sediment reduction targets should be. Approaches used to spatially distribute targets in other countries e.g., Germany were noted. The WEAG stressed that national targets would still require farm-level advice and suggested that the most effective approach to delivering change could be to provide a network of independent farm advisors to work with farmers to develop nutrient management plans at farm scale. This would be built with a regional focus (river basin, catchment area, etc.) that can then drive structural change across industry sectors. They noted that this was in line with advice emerging from Defra's Nutrient Management Expert Group currently, where there is considerable expertise in working with farming groups to deliver change. Experts suggested that landscape-scale planning and coordination is also required to move activities with high risk of N and P losses to landscapes more able to retain nutrients (e.g., low topography land, land that is less well-connected to the flow network). Defra agreed that even though the overall target that is set would be at a national level, this is an averaged target that would then be applied to the water body/operational catchment scale. A question is included in the consultation asking for views on setting ambitions for reducing nutrient pollution for individual catchments to gather further evidence on this.

The WEAG noted that diffuse agricultural pollution is one of the most challenging areas for water quality improvement, but that Defra has already invested in R&D in this area which should be utilised where possible. They referred to the work by a consortium of researchers and advisors under Defra's 10-year long Demonstration Test Catchments programme [78], including work on the elaboration and development of evidence in FARMSCOPER. This work provides collated advice, based on testing of the impacts and time-windows for response of river chemistry and ecology to a suite of on-farm mitigation measures, from multiple farming 'types' in the English landscape. It encapsulates these findings and provides advice on what the science team think is the best way forward in a physical, natural environmental and social science context. Work undertaken under other Defra projects, including under Defra's Sustainable Intensification of Farming programme was suggested as particularly useful in this respect. A number of UKRI-funded projects were also highly relevant.

Future R&D and evidence gaps

Defra suggested that publishing a national inventory could be a way of reporting against the national target but larger emission factors would need to be applied currently to understand enough about the system to do so. The WEAG were supportive and highlighted that a lot of this work has already been done. There are a series of expert groups for nitrogen currently, that have already produced a national N budget for the UK. This now needs to be updated with current data. A detailed up-to-date national P budget has just been produced for the UK under the RePhoKUs project, though a comparison of the relative methods, data sources, and time periods for the two budgets could be useful to ensure they are capturing comparable information. The WEAG also stressed the value of looking into local knowledge and involving the farming sector at an early stage, as farmers often know their land well and can easily tell you where the issues are and come up with creative and effective solutions. There is particular expertise in Defra's Nutrient Management Expert Group on the best approaches to working with the farming community, so that solutions can be co-created. The value of drawing on this expertise was stressed by experts and previous modelling work using FARMCOPER has illustrated the technically feasible benefits of mitigation strategies co-designed with farmers on the basis of their attitudes towards individual on-farm measures.

Additional gaps and R&D areas include modelling total nitrogen from agriculture, national load calculations of N, P and sediment, and source apportionment that were mentioned as part of previously explained topics.

Water Experts Advisory Group – Detailed notes on Abandoned Metal Mines water quality target

Proposed target during initial WEAG discussions – "By 2037, reduce by 50% the length of rivers and estuaries polluted above EQS by target substances (Cd, Ni, Pb, Cu, Zn, As)."

Background system information from experts

Alongside recommendations on the target and metric, experts provided background information during discussions. These are shown to give context to later discussions and expert suggestions.

Point vs diffuse sources of pollution from abandoned metal mines

Contaminants in the water environment can come from various sources. These are often categorised into those originating from a point source (e.g., a single pipe or spring) or a diffuse source (e.g., widespread runoff from soil or roads). Experts in the WEAG noted that there is some evidence that diffuse metalloid sources are more significant than point metalloid sources, depending on site location. However, diffuse sources are more difficult to evaluate, remedy and monitor. As such, quantification of diffuse and point sources will be important for this target. This will also be important in prioritising interventions that would be difficult without quantification of contaminant input sources.

The Environment Agency (EA) stated that their evidence suggests the most severe metalloid contamination is caused by point sources (drainage tunnels or adits/ mine entrances). The WEAG pointed out that each catchment is different, and in some seepage from diffuse sources would be the dominant source, with the optimum interventions only determined following monitoring. The EA has ongoing research looking into quantifying impacts from shallow groundwater seepage and mine wastes. There are current simple source apportionment tools to assist balancing input impacts, alongside monitoring results, to support decisions on the best interventions.

Sediment release and metalloid cycling

Sediment cycling and metalloid cycling are linked. Experts highlighted that decreasing the input or flux from abandoned metal mines may cause increased metalloid release from sediments that are already in the river system. This would be through the re-equilibration processes, causing metal(loid)s bound in sediment to be released to the water column. Due to this there could be long lag effects before water quality improvements occur. The extent of re-equilibration release may not be fully known in advance. A potential knowledge gap was discussed relating to system response during high flux periods, and whether there is a desorption of metalloids from sediments into the water column. Some evidence from global systems suggests that the onset of heavy rainfall after prolonged dry weather facilitates high metalloid flux, with high metalloid output from efflorescent salt dissolution, followed by decreasing concentrations after the first flush through the system. Evidence was highlighted in estuaries where there is an impact from tidal cycles on metalloid flux, where the flux between sediments and water column is on a daily (hourly) time frame, which may have implications for the monitoring programme for the target [79, 80].

The reservoir of metalloids within fluvial and estuarine sediments was highlighted as a large potential source of contamination in waterbodies. These may be mobilised in the future, particularly in response to climate-change induced higher river flows and flooding that can cause reductive dissolution and increased mobility of contaminants. There are both long term and short-term sediment stores, and experts noted that the monitoring programme needs to include sedimentary stores of contaminants from the start, alongside water column concentrations.

Metalloid toxicity

Measures of acute metalloid toxicity and overall system metalloid toxicity were discussed. The expert group noted they were not aware of case studies showing systems that are fully remediated (metalloids completely removed from water). However, river improvements based on stopping metal inputs, and allowing dilution to reduce the toxicity of sediment bound metalloids that are re-released, as currently used in metal mine remediation, were noted as a suitable interim solution, alongside focusing investment into monitoring and identifying sources.

Both the EA and the WEAG noted that tin tends to remain in the solid phase, where it is not as biologically available and poses a much lower toxicity risk to surrounding biota. Though there are water quality failures (at EQS level) due to metalloids, tin is not involved as it does not enter the water column at toxicologically relevant concentrations. It is not included in the target for metalloids for that reason.

Measurement of metalloid concentrations in water column

The use of filtration in obtaining water column samples was discussed, with the WEAG noting caution is required in the choice of filtration system and specifically the size fraction filtered. The EA noted that as EQS is assessed in rivers, the target will be measured and set in rivers using EQS methodology. This involves a 0.45 µm filter, and liquid passing through it is considered equivalent to the dissolved fraction of a sample. However, it is acknowledged that very small (colloidal and nano-sized) particles containing attached metalloids will pass through and may be measured as part of the filtered/dissolved fraction. The EA noted that samples are measured for metalloids in filtered and unfiltered fractions, providing total metalloid concentrations alongside separate fractions.

In common with all pressures on water (not just metalloids), there is a simplification of a complicated whole water environment to enable management and control of environmental contamination within available budgets, including through environmental monitoring.

Metric

Meetings with the WEAG took place throughout target setting work, and the target was refined as additional evidence and expert input was obtained. The downstream impacts of contaminated sites were discussed. Discussion focused on sites which are 100 times the EQS level currently, and whether considering the zone of influence could be a more useful metric. This was taken on board by Defra, and aligns with the current approach, reflected in the suggested target option aimed at reducing the length of rivers contaminated by the target metalloids.

Variable flow data

River flow is variable, both seasonally and in response to weather events resulting in high and low flow conditions. The expert group discussed sampling for metalloid concentrations in the water column, and data required to support understanding the target at various flow conditions. Flows are currently measured at permanent hydrometric gauging stations and/or using the dilution salt gauging approach, with older data collected using velocity-area measurements. Most EA monitoring relevant to this target is completed 12 times a year, with comparable sampling programmes in place for some nutrient fractions. Due to this sampling frequency, there will be many significant flushing events (in response to sudden intense rainfall) which will be missing in the current EA monitoring programme, underestimating impacts and fluxes to downstream environments. Experts noted this is a common problem where monitoring is infrequent. The WEAG suggested that monitoring more frequently would be needed, ideally at daily frequency, or weekly and during peak flow events, and for a period of multiple years in order to capture inter-annual flow variation.

Defra noted that focusing on the narrow issue of metal mines has provided the opportunity to test monitoring and source apportionment methods, which could be applicable to other pressures in the water system.

Ecological monitoring

Alongside chemical measures of metalloid concentrations, ecological monitoring of metalloid contamination, particularly of bio-accumulatory contaminants generating ecotoxicological impacts was discussed as a potential metric. Recent work linking metal mine contamination and macroinvertebrate health was discussed, referencing literature in this area. Experts noted that macroinvertebrate indicators were generally developed for organic pollution, based on oxygen concentrations. Though there is macroinvertebrate sensitivity to pH, not all mine discharge is acidic. Macroinvertebrates are affected by metalloid concentrations but respond with a different order of sensitivities to that used in other macroinvertebrate indicators.

Defra highlighted focused monitoring ongoing in specific catchments (in the South-West and the North), focusing on the metalloid burden in fish and impact on the structure of the fish population. More evidence is needed for an ecologically based monitoring of metal mine river impacts, using fish, macroinvertebrates or other biota.

Experts talked through evidence gaps within the logic chain from interventions to first chemical then ecological recovery or improvements in water bodies and discussed the assumption that improvements to water column concentrations will decrease harm to wider aquatic biology, suggesting that more evidence is needed to support assumptions. Experts noted the importance of longer-term funding certainty to allow research to directly apportion causality and how metalloid concentrations harm biota, as opposed to a more monitoring based approach.

Use of EQS concentrations as metric

Current EQS levels are set for individual metalloids. The WEAG suggested a holistic multiple stressor approach is needed, including a portfolio of chemistries which are monitored and defined under EQS, and biota which are sensitive and declining. There is difficulty in pinpointing particular metalloids, or a mixture of metalloids, as the cause of negative ecological impact when multiple stressors are present. As such, the WEAG suggested load reduction at the source is considered, as it is both environmentally desirable and more achievable to target compounds in multi-stressor systems than concentration measurements. This could potentially be undertaken alongside EQS compliance and other chemical measurements down river (including conductivities and pH) from discharges.

Current use of a chemical metric and a water column metric, and the proposal to set a target based on this, is because it is a simple and accessible method with appropriate background data. As noted earlier, a baseline flux threshold, and measurement of exceedance of that threshold would need additional baseline monitoring to be considered an accurate and robust metric. Defra agreed with the ecological impact issues, and the challenge of monitoring ecology due to current definitions and multi-stressor systems and expressed a desire to keep options to incorporate this in the future under review.

International sediment quality guidelines for metalloid concentration were highlighted, and experts suggested using a combination of EQS water column concentrations and international sediments measurement methods as a metric. This could use priority metalloid removal sites for baseline studies, and enhanced monitoring to accumulate evidence on remediation.

Consideration of options discussed

Options proposed by Defra included A) a concentration-based target using EQS to determine ideal metal concentrations[16], and B) a metalloid flux or metalloid load target based on metal discharges to rivers[17].

The WEAG raised a concern that a target based on the reduction in river length affected by metalloid concentrations may incentivise the prioritisation of ‘low hanging fruit’ – i.e., the improvement of the least polluted lengths of rivers, rather than focussing on the worst pollution first. They recognised that the current approach was favoured for its simplicity and similarity with the current monitoring approach, building on existing processes and data. The WEAG recognised the need to start with this but noted that gathering data on alternative metrics would be useful.

Consideration of measuring metalloid concentrations in both water column and sediment are outlined above. Currently, EQS levels are set for water column concentrations, not for sediments. These are currently set at national (formerly EU) level based on toxicity for a wide range of aquatic biota. Defra highlighted that treating main mine water discharges will lead to predictable measurable decrease in metalloid concentrations, that will be most significant under lower river flow conditions when metalloid concentrations (and hence environmental harm) are highest in rivers. Metalloid concentrations have decreased downstream of the Force Crag treatment scheme, even though it is only treating some of the mine water. EA recognised that there is a challenge to demonstrate the time required for ecological recovery as there are very few examples (globally) of successful mine water interventions for these metalloids, although there are good examples for iron from coal mine water contamination [81, 82]. The WEAG noted that sediment is a more stable medium, combining change in metalloid concentrations over longer time periods and long-term sources of metalloid contamination that could provide a better measure of metalloid concentrations for monitoring purposes.

The WEAG advised that a mass-based target using sediment sampling to measure metalloid loads (e.g., in kg per year) would be preferable to concentration (e.g., mg per litre), as it is interlinked with reducing water column concentrations (see earlier points on sediment flux).

[16] Option A: “By 2037, reduce by 50/60/75% the length of rivers and estuaries polluted above EQS by target substances (Cd, Ni, Pb, Cu, Zn, As).”

[17] Option B: “Reduce the mass flux (tonnes per year) of metals (Cd, Ni, Pb, Cu, Zn, As) discharged to rivers and estuaries from abandoned mines.”

However, as previously noted, the accuracy of the metric and baseline for sediments needs improvement to be used as a metric. Both groups agreed action is needed to improve this dataset. An initial target may need to use a water column concentration metric, but the WEAG encouraged reviewing this, taking into consideration new baseline information on sediments in the future. Defra noted that mass flux will need to be decreased to achieve a concentration target, so improvements made to reduce metalloid concentrations will also reduce some metalloid flux and can be made while gathering additional sediment and loading information.

Data on EQS compliance from treated mine water for 80 mine water schemes and 60 diffuse treatment schemes was noted. The WEAG advised the target was measurable and suggested that a model of how this would reduce the length of rivers contaminated be developed. This could link both the concentration based option A, and flux/load based option B discussed in the initial WEAG meeting on this target area.

There are differences between catchments, and for all options discussed, the most important metal(loid) sources will be different in each catchment. An assessment of the risks in each catchment is needed to aid decisions on prioritising tackling mine waters or diffuse inputs with the most negative ecological impact. Defra noted this would be done to identify locations under this target, as is currently done through the WAMM programme.

Ambition

A range of ambitions was discussed. EA noted that these included ranges with varying levels of ambition and investment assumptions. Discussion also included source apportionment in locations negatively impacted by metalloid contamination. The background level of understanding is varied; for some rivers the sources of metalloids that need cleaning are known, whereas for others more investigations are needed. For areas with abandoned mine water contamination, the whole catchment needs to be considered to understand whether point source mine water inputs or diffuse source inputs are most significant, and this affects possible interventions and appropriate ambition in each catchment.

The baseline requirements for a metalloid flux metric were noted earlier. Experts and EA discussed the evidence available and reliability of pre-mining water quality and metalloid flux values, in relation to the ambition of the target. Measurements of both metalloid flux and water column concentrations are infrequently present pre-mining (e.g., for some areas, pre-1900) and are of varying accuracies. EA considered that a metalloid flux target could encourage a greater level of ambition by prioritising the largest volume inputs of metalloids. This could avoid the risk that a water column concentration target might encourage prioritisation of slightly contaminated rivers to achieve the target without cleaning the most contaminated. A focus on the most heavily contaminated rivers by using metalloid flux could enable dealing with the worst environmental harm, even if there is difficulty in achieving EQS concentrations. However, it was concluded that more robust data are needed for a baseline of metalloid flux as a national metric (see previous section) and so this is not a feasible metric currently. There are also high flow systems with little ecological impact from a relatively high metalloid load, and just using metalloid flux alone would not appropriately target areas at most ecological risk. For any metric, whole catchment specifics would need to be assessed to accurately prioritise the areas that need the most improvement for near-natural function of water bodies.

The target and chemical standard are based on current climatic conditions. With increasing impact from climate change (flooding events, rainfall changes, etc.) altering how water systems interact and how sediment mobilises, experts suggested that the target and chemical standard will need to be kept under review, and potentially made more stringent to deliver appropriate environmental benefits.

Achievability

It was noted that ecological recovery in water bodies has lagged behind chemical recovery, for example where river acidification has been dealt with. There are legacy effects that have accumulated in the system and inhibited ecological recovery, and a similar effect is likely to occur with removing metal mine inputs. The WEAG noted that the same legacy effect will cause delays in catchment and ecosystem responses to agricultural and wastewater mitigation efforts targeting nutrient reductions, with parallels between targets and similar lessons to be learned in the evidence of ecological and chemical responses to mitigation efforts for multiple pollutants. Experts suggested a ratcheted approach to targets over different years could be considered, with interventions focused at the start of the timeframe to allow time for ecological improvements to be seen, as well as decreasing metalloid contamination as soon as possible. Defra highlighted that using ecological improvement as the goal aims to target large systemic problems, such as metalloid contamination, and measure larger scale responses to interventions. It was recognised that a specific ecological improvement target is unfeasible at present, with the metric likely to be concentration based, linked to ecological impacts but not directly measuring ecological indicators. See earlier points on monitoring mentioning difficulty in using ecological responses as a metric and current unfeasibility.

The WEAG advised that a metalloid flux target is a more pragmatic way to tackle the whole system pressure, though more baseline data are needed, and this this needs to be balanced with scientific understanding of sediment, assessing more interventions and projected impact of related environmental changes. They noted that a water column, concentration-based target is easier to explain to a wider audience but will not be achieved without decreasing metalloid fluxes too. Improved communication and education, beyond immediately involved stakeholders, including the public, about pollution from abandoned metal mines could help achieve this target by maintaining community engagement over the long term as mitigation is put in place.

Case studies

Case studies were highlighted, including a project observing metals downstream which saw movement between solid and dissolved metal compounds. The Wheal Jane (Cornwall) passive treatment research project in the early 2000s was noted [83], and the problem of wetland remediation in extracting and disposing of metal containing sediment were discussed. In addition, see the earlier mention of Force Crag treatment.

Future R&D and evidence gaps

Topics for future research and development, including evidence gaps, were discussed as part of the meetings. These included:

- Acquiring additional high-resolution data in a selection of catchments, to enable the current, low frequency (monthly) EA monitoring outcomes to be put into context, and uncertainties in the resulting flux and concentration estimates to be calculated.
- There is an evidence gap in the estimation of the baseline for metal fluxes for each catchment and in sediment metal concentration monitoring. The WEAG noted that a single baseline year for each catchment is needed, though several years would enable a representation of long-term averages. It was noted that the depth of evidence gathering needs to be weighed against taking immediate action to decrease metal contamination, given limited resources, which suggests that a concentration-based target may need to be used initially. At present this information is not available.
- Multi-year evidence is needed on metal fluxes for robust long-term averages. These would benefit both of metric options discussed here and provide the option to add targets for metal contaminants in sediments at a later stage.
- Resource recovery is an option for economic return on investment in mitigation schemes, as it enables reuse of waste material, with potential business development opportunities in future. This remains under review. Challenges in separation or purification mean that there is not currently a viable business proposition for collection and re-use. However, the increasing importance of critical elements such as lithium, cobalt, nickel and copper (e.g., in electrical technology items) may mean this becomes more economically viable in future.

- As noted in the earlier monitoring section, more evidence is needed on the specifics of toxicity to biota. The order of impacts on freshwater biota, commonly measured using macroinvertebrate sampling, can differ between contaminants and may not be directly transferrable to monitor ecological impacts of metalloid concentrations.

Water Expert Advisory Group- Detailed notes on a Water target for Wastewater

Proposed target during initial WEAG discussions – "Reduce phosphorus loadings from treated wastewater by 80% by 2037.

Background system information

Excess Nutrients in water bodies from wastewater discharges

The proposed water targets are intended to focus on the two larger sectors and contributors to nutrient pollution in water bodies. Nutrient removal from wastewater is currently focused solely on phosphorus (P), with P removal from wastewater that are currently based on water company discharges. About 1,700 additional wastewater treatment works will have specific P removal by 2027 as scheduled under the current Asset Management Plans (AMP 7, 2020-2025). This applied to wastewater treatment works serving a population greater than 2,000, with the following investment round (AMP 8) looking at smaller works.

The inclusion of nitrogen (N) and of the particulate and organic fractions of both N and P were noted as important, contributing to ecological pressure. WEAG noted that in their experience of looking at the total load of both N and P exported from wastewater treatment facilities to adjacent waters, there is transformation from the routinely monitored inorganic fractions (i.e., ortho-phosphate, nitrate, ammonium) into other types of compounds (organic, particulate N and P), and not necessarily a significant net removal of N and P contaminants from the system. The knowledge base needs to be expanded on to understand what happens to organic N and P released to water bodies, and how much N could feasibly be removed from wastewater discharges to water bodies.

Input lags

The WEAG stated that winter flow dilution might reduce the immediate nutrient concentrations which the biota are exposed to, originating from sewage treatment works, storm overflows and other sewerage systems such as septic tanks (collectively 'point source discharges' from wastewater sources). By contrast, in summer concentrations lack the same levels of dilution. Nevertheless, summer convective storms could deliver substantial nutrient loading to adjacent waters. Some evidence points to a seasonal impact of point source inputs on smaller water bodies, and less seasonal impact on larger rivers, lakes, estuaries and coastal waters, as these receive the combined contributions of fresh nutrient loading from the catchment plus re-release of contaminants stored within the river reach upstream, the wider landscape, and sediments in the bed of the waterbody. The WEAG advised that therefore there is no one period of the year where wastewater nutrient reductions are a priority over other times, as the biota will be responding to nutrient loads delivered freshly to the water body alongside those released from upstream stores (in sediments or biota), or in the water body itself.

The WEAG noted that not all systems will react in the same way to the same mitigation measures. Some systems are more damaged and/or flush (move water and contaminants through) more slowly. The steeper the land, the higher the rate of rainfall, the more quickly a system will flush from source to sea. The higher the population density, the lower the gradient and drier the catchment, the more likely it would be to flow slowly, and continue to contribute nutrient and other contaminant fluxes to waters draining the catchment. Experts stated that this point needs to be communicated clearly so that people's expectations in terms of timescales of system response to mitigation measures and investment can be adjusted to reflect these functional realities.

The lag between contaminants from accumulated and fresh inputs reaching waterbodies means decreases in nutrient concentration and improvements to local ecology may not be seen immediately when nutrient inputs are decreased or stopped. Most waters beyond small headwater stream and ponds will be responding to cumulative fluxes over several seasons or years, depending on the scale of the catchment, and length of time over which such fluxes have been exported from sources in the catchment. In some systems, the time lag can be up to 40 years before contaminants contained in water make their way from source to waterbody.

Nature based solutions

Nature based solutions were discussed, how they would fit with the proposed metric, and how best to represent co-benefits alongside reducing multiple contaminants in water bodies. WEAG noted that integrated nature-based solutions can deliver multiple benefits alongside reducing contaminant inputs, though there is little control after nature-based solutions are designed and put in place, which makes it difficult to achieve specific concentration standards. Such systems can be effective as a 'polishing' stage, though their large-scale use is limited by risk of effluent failure under operational conditions, their finite capacity to store contaminants, leading to the leakage of further fresh or stored contaminants once they reach design capacity, and lack of suitable design data. The effectiveness of nature-based solutions in removing nutrients, their different nutrient removal efficiencies for N and P fractions, how much land is required to produce a constructed wetland and how nature-based solutions are climate dependent (and impacted by climate change) were discussed.

Metric

There were concerns about an annual load masking other inputs and not being an effective environmental protection measure, though it was noted as an easy way to administer the metric. The WEAG suggested annual total load reduction is right for the metric, but queried whether this considers seasonal changes, storm overflow changes, and whether an additional target which captures when sewage discharges from overflows occur was needed to help reduce the summer impact of wastewater systems. The EA noted that overflow discharges should be rainfall related, so would be more common in winter when it rains more. It is possible to set seasonal standards for overflows, as is currently done for overflows affecting designated bathing waters, which have standards set for the bathing season.

The cost-benefit for the proposed target was discussed, with the WEAG stating that river health may not be fully valued in the CBA if the approach is based on only a limited range of stressors included in the metric. If other, non-target, stressors (such as pathogens, pharmaceuticals and nitrogen) were also decreased in response to mitigation efforts and investments, there might be more benefit for river health than that valued in the CBA. Similarly, it was noted that unintended benefits or negatives for other parts of the environment (air quality, soil quality, terrestrial biodiversity) need to be built into the CBA, to ensure win-wins are identified, and perverse outcomes involving pollutant swapping from one environmental compartment to another are avoided. Defra noted that trying to separate the cost-benefit analysis (CBA) from the metric would prove difficult. Experts stressed the need for a focused decision on what the CBA does and does not include, alongside clear communication during the consultation process on the range of benefits and costs included.

The phrasing of the metric was discussed, with the WEAG suggesting referencing initial commitments and investments to set schemes up, alongside a longer-term target for delivery. They noted that the scientific basis and long-term objectives for ecosystem requirements should be defined independently of initial financial considerations. This provides an overall goal for nutrient contamination in water systems, even if currently unachievable for financial or other reasons. This is an approach to water quality guidelines and wastewater treatments recommended by WHO for various countries with differing investment abilities, defining objectives and long-term standards that can be achieved by stepwise interim targets. As such, the WEAG suggested Defra consider a longer-term metric with interim standards, described as a ratcheted approach to target setting, and the inclusion of both N and P as nutrient stressors delivered to waters from wastewater systems. The overall aim for nutrient reduction needs to be ambitious, and something this target and interim targets contribute to.

The WEAG asked about the particulate and organic fractions of nitrogen and why they are not described in the proposed target, with concerns that total nitrogen from wastewater was not being considered in this target (see section below). Experts highlighted that in their experience of looking at the total load for both N and P, there is primarily transformation not removal of compounds in treatment. They also stressed that the assumption that P was the key nutrient factor driving freshwater ecosystem decline was based on older science which is no longer supported by the research community. A range of evidence in the literature was highlighted confirming that both N and P may limit production in ecosystems, both cause ecosystem damage, and explained that a continued focus on driving down P alone was unlikely to deliver the anticipated benefits for freshwater, estuarine and coastal ecosystems. The WEAG also pointed out that in urban catchments, with a high population density, N flux to waters from wastewater discharges is likely to be the single biggest source of N for the local biota.

Experts noted wastewater treatment works are important sources of N loading in rivers and can have a locally significant impact before the load is diluted as it flows downstream. In some systems it can be the dominant source of N, and so experts suggested both P and N reductions should be included in the target, perhaps at the same 80% reduction as proposed for phosphorus. The EA noted that a high target is possible for phosphorus on a polluter pays principle, but not necessarily for nitrogen, and that an 80% reduction in nitrogen could not currently be achieved.

The WEAG asked if there are constraints in setting a target based on nitrogen due to remediation costs, while noting that nitrogen standards exist in most other EU countries and more widely globally. This includes using biological nutrient reduction (BNR) plants that remove N and P, with some countries using BNR at all new wastewater treatment plants. A Defra water quality research programme (project WT15115) was highlighted with a compendium output that reviewed evidence around nitrogen [84]. EA noted that large wastewater treatment works already have nitrogen removal and 70% of nitrogen in rivers comes from agriculture. The WEAG raised concerns that the national statistic figure attributing 70% of nitrogen to agriculture risks masking smaller and more urban catchments where a much higher proportion of N would come from sewage works.

This advice was considered, but ultimately nitrogen was not included in the target as agriculture is a much larger contributor of nitrogen to the water environment. This means that interventions on wastewater are unlikely to reduce nitrogen concentrations in rivers enough to control eutrophication, even if additional measures are introduced at sewage treatment works. These would incur significant financial costs which would be passed onto customer water bills. Nitrogen pollution from wastewater can already be addressed under existing regulations where it is the biggest contributor to eutrophication (and nutrient pollution) under the Habitats Regulations and the Urban Waste Water Treatment Regulations and nitrogen reduction measures at sewage treatment works can be put in place in saline waters and lakes affected by eutrophication, rivers where drinking water abstraction points fail nitrogen standards, and river or lake Drinking Water Protected Areas are at risk from nitrogen concentrations. As the share of nitrogen from agriculture entering the water environment starts to fall, we will continue to review the case for setting a nitrogen target for wastewater in accordance with the recommendations made by the UK Technical Advisory Group, in line with polluter pays and fair share principles.

Ambition

It was noted that the scientific evidence and technical feasibility should be the primary consideration for the level of ambition, and that any ambition level is possible, if appropriate levels of investment are made available. The rationale for the percentage reduction was discussed, and the WEAG noted that, based on technical feasibility, the target could be more ambitious. Experts also noted that a more ambitious target was likely to drive innovation in the water industry, where solutions that simultaneously drive down N and P fluxes while minimising carbon emissions could then emerge. They noted that a continued focus on P reduction alone would be unlikely to deliver the necessary step change in nutrient pollution and the associated loss of biodiversity in waters, and the anticipated levels of ambition in current government policy. As noted above, nitrogen has not been included in the target at this time, but as the share of nitrogen from agriculture entering the water environment starts to fall, we will continue to review the case for setting a nitrogen target for wastewater in accordance with the recommendations made by the UK Technical Advisory Group, in line with polluter pays and fair share principles. The ambition for the phosphorus target is in line with achieving the Technically Achievable Limit of 0.25 mg/l at many more treatment works. This limit was set by the EA based on a programme of phosphorous reduction trials by water companies to determine which technologies, suited to UK conditions, can reliably reduce phosphorous at sewage treatment works. This level of ambition goes beyond Water Environment Regulations requirements.

Achievability

The current AMP cycle was considered, and how the investment cycle affects or could constrain the ability of the target to be implemented. The current price review cycle is every 5 years, and WEAG questioned how this interacts with setting long-term and ambitious targets under the Environment Act 2021. The proposed target aim is 2037, which is only two AMP cycles from the targets being set. To have investment and construction in place to achieve the proposed target within that period is challenging. Defra noted the need to consider the practicalities of the 5-year AMP cycles, that are controlled by Ofwat, and highlighted that that the Environment Act 2021 targets provide scope for ambition to change things over a longer time-period than 5 years. Experts suggested that involving Ofwat in setting the level of ambition could be beneficial due to their role in the Price Review and Asset Management Plan cycle processes, to ensure that resource expenditure is sufficient to meet the more ambitious targets needed to protect and improve freshwater biodiversity and water quality.

Delivery mechanisms

The WEAG noted that water companies would need to come up with different solutions, and not have solutions prescribed, especially given the privatised nature of the water industry in England. Setting a target that has feasible solutions without stipulating exact solutions enables bespoke solutions by each water company and for each catchment or location and is likely to drive innovation.

The WEAG advised that targets should focus on load reduction relative to current loading rates, allowing water companies to develop bespoke combinations of technical or nature-based solutions, fitted to the specific system and catchment of interest. Reducing the total N and P loads to a waterbody will include action through treatment works, and in some locations reducing input from combined sewer outflows, to achieve the target phosphorus reduction.

Impact

The WEAG asked about circular economy and capturing phosphorus, specifically in a way that can be reused for food production (via fertiliser), given the substantial challenges to P resource availability internationally in the near future and the global drive towards sustainable phosphorus use. They suggested reviewing the willingness to pay to improve river water quality, which Defra will incorporate into upcoming research into improving our valuations of clean and plentiful water. It was mentioned that the wastewater industry needs to move towards material recovery for fertiliser (or other uses) and biological nutrient removal (BNR), but this does require huge changes in infrastructure and policy. WEAG advised that there is scope for a target that encompasses the circular economy and recovery of materials, which is endorsed for wastewater treatment by the UN. The WEAG asked whether there is a role for the water target/s to increase the number of sewage treatment works which have BNR. EA responded that BNR does allow for recovery of other nutrients in the future and new technology is focused on chemical dosage not BNR or recovery of phosphorus. However, this will require a change to water companies and involve high costs.

The WEAG suggested it would be useful to have a map of impact across the water companies of all the developing water targets. They noted this would also help in developing the evidence on feasibility. The WEAG stated that the impact is difficult to measure because of the volume of measurements required. Experts noted that monitoring would need to be adjusted to include the wider range of determinants recommended, rather than the focus mainly on P as currently proposed.

Scope (further scope/target areas)

There were several areas the WEAG strongly recommended should be considered as part of the target development, which Defra noted were not possible to include within the scope of this target at this stage. This advice will be incorporated into the development of future policies, evidence bases and targets in the future.

Septic tanks and other sources of nutrients in wastewater

Septic tanks are an additional source of N and P, are privately owned and currently regulated, although additional enforcement may be required to increase compliance. Although septic tanks are only a minor source of nutrient pollution nationally (contributing 3% to P loads), they can be significant sources in certain catchments, for example headwater streams. It was noted that reductions need to be appropriately targeted, as a small P load discharged to large, fast flowing rivers have lower environmental impact locally than the same load discharged to small, slowly flowing rivers. Experts noted that this still contributes to the cumulative loading of material cycled and flushed downstream from the headwaters to lakes, rivers, estuaries and the coastal zone. They highlighted that if biodiversity loss and poor water quality were to be addressed downstream and ambitious targets were to be met, then all such sources would need to be brought under control.

The WEAG suggested bringing septic tanks into the target scope perhaps through use of grants, since they can cause persistent and significant localised pollution of not just nutrients, but a range of other contaminants [85]. Experts highlighted the problem of septic tank systems, particularly in rural catchments and areas and especially in older properties or poorly maintained systems, that discharge throughout the year, with a large ecological impact cumulatively. Experts noted this as a particular problem in rural catchments, rather than in heavily urbanised regions, and often a key source in many areas with National Parks or nature conservation designation. There is a similar issue with small sewage treatment plants in rural villages and small towns, which discharge less efficiently treated effluent, though the proposed changes under AMP 8 (explained above) in a proportion of smaller works were noted.

Lack of adequate regulation of discharges from septic tanks currently was highlighted as a key challenge to meeting water targets due to their cumulative impact. Experts highlighted the target needs to be sensitive to the differing types of landscape, catchment, and sewerage systems in place across England, not just targeting large sewage and wastewater treatment works in large cities, if biodiversity loss in freshwaters was to be tackled with ambition.

This advice was considered, but ultimately septic tanks were not included in the target as they are a relatively minor component of pollution nationally and action is being taken to reduce their impact. Since 2015, a regime involving general binding rules for most septic tank and small package treatment plants has been in place, with permits required for higher risk situations. The WEAG noted that septic tanks may be complicated to address, as they are privately owned, but that new regulations recently introduced may help reduce their impact, if properly resourced and enforced. New regulations for septic tanks were introduced in 2020, with separate regulations for those discharging to a drainage field and those discharging directly to surface waters, regulating those with surface water discharges and distinguishing on volume. The regulations allow where possible connecting to a foul sewer, creating a drainage field, and installing a small treatment plant. The rules in each instance require the effluent to be "higher standard than a septic tank". Some small treatment systems provide a small reduction in ammonium but may not be able to decrease total nutrient concentrations sufficiently to drive down nutrient pollution in rural systems. The WEAG recommended that septic tank discharges continue to be tackled with further innovation and ambition.

Other areas

The WEAG suggested that while Defra may, for policy reasons, want to identify priority catchments within the proposed target, identifying these could be challenging and, depending on the criteria, not necessarily effective at delivering outcomes for biodiversity and environment. The relative contributions from different sources, including from agricultural, atmospheric deposition and sewerage discharges to the water body will vary between catchments and locations. Reducing one nutrient pollution from one source type nationally is unlikely to deliver the anticipated environmental benefits. There may be a communications challenge in explaining why certain catchments are not selected for prioritisation. The WEAG also pointed to social science evidence emerging from other Defra committees and previous research that indicate a blanket approach where all waters are managed to the same environmental standards is more likely to sustain community engagement in mitigation measures, investment of time and resources for long-term solutions, and deliver widespread benefits for ecosystems and society. Defra stated that for feasibility reasons and given the significant cost of action on some pollution sources, and potential corresponding impact on water bills, improvements need to be prioritised on an appropriate basis.

Experts noted that changes to reduce water demand (see the water demand proposed target evidence) will affect wastewater, for example changing current rates of dilution of treated effluent, and suggested more discussion is needed to ensure joined up thinking under this target and the proposed water target for Agriculture under a changing climate.

Case studies

The WEAG noted an integrated constructed wetland (ICW) where mean nitrate and phosphate concentrations were reduced by ~63% across the wetland, whilst nutrient loadings were reduced by ~57%. At a different ICW, mean nitrate and phosphate concentrations were reduced by ~30%, whilst nutrient loadings were reduced by ~70%. The total capital cost of both ICWs was comparable at £31-39 per person served. Experts noted concerns that much of this removal was likely to be transformation and export in a different chemical form and would not necessarily decrease total nitrogen and total phosphorus concentrations released from treatment wetlands to adjacent water bodies [86] highlighting that case studies need to include total nitrogen and total phosphorus measurements to be comparable. Another large ICW investigation currently underway suggests little to no P removal, but up to 30% reduction in N. Another example treatment system was noted that can reduce total nitrogen in waters discharged from ICW using the Tricel Novo treatment system. Experts noted that removal of both N and P is possible with these innovative approaches to wastewater treatment, with additional biodiversity benefits over and above what might accrue from a traditional chemical dosing technique, but that the removal rates are likely to vary between system types, year of operation and seasonal variability.

Future R&D and evidence gaps

Additional research is needed to develop a nitrogen standard for wastewater. An evidence gap was noted on alternative nutrient removal strategies for winter months, due to seasonal differences in nutrient movements within catchments.

Water Target Expert Advisory Group – Detailed notes on Water Demand target

Proposed target during initial WEAG discussions – To reduce Distribution Input per head of population by 19% by 2037/2038 from the baseline 2019/2020 reporting year figures.

Background

For reader clarity, some terms used to describe water demand topics include:

- Distributional Input (DI): the amount of water input into the water supply system
- Leakage: the water lost through faults in the supply system
- Per Capita Consumption (PCC): the average annual amount of water used in domestic locations per person, usually expressed in units of litres per person per day (l/p/d).

Demands on public water supply

Defra and the WEAG discussed the different demands on public water supply. The WEAG explained the different demands on public and non-public supply of water, and how climate change will impact upon this. They explained that the magnitude and duration of the peak demands during summer are generally what drive resilience problems, and that this picture was already worsening over time and across the whole of the UK. More frequent hot summer conditions will increase the demand and drive peaks. Experts noted that the right level of water efficiency is at a level that leaves enough water in the water environment for it to thrive, alongside meeting public supply needs. It was noted that water companies currently use the UK 2018 [87] climate projections when producing their Water Resource Management Plans (WRMPs). The WEAG highlighted that challenging demand reduction steps need to be taken as water resilience is essential, as is the overall aim of leaving more water in the environment, and that setting targets may lead to innovation.

The current levels of water input from desalination were discussed. It was noted that though desalination has risen up the agenda in water supply conversations, it is not currently contributing to the water supply. There is a Thames desalination plant, which was intended for use during times of high demand but has not been used to date. In the South-East there is very limited sustainable freshwater abstraction available, and reductions in licensed abstraction are likely to be required for sustainability reasons. At that point, water companies will then either have to reduce demand or look to alternative sources such as reuse, rainwater harvesting and potentially desalination. In order to address the predicted increase in water demand, the government released a Written Ministerial Statement [88], outlining policies to reduce water demand. The WEAG welcomed this announcement.

The WEAG referenced the Climate Change Committee's 3rd UK Climate Risk assessment[18], published in June 2021, which stated the urgency and positive cost benefit ratio of climate change adaptation actions, and listed water efficiency measures as having the highest cost benefit ratio of these [89]. The WEAG noted that all three elements of demand management - household water efficiency, non-household water efficiency and leakage - were currently not on track to meet current ambition, according to a draft dashboard produced by Defra for the Senior Water Demand Reduction Group[19] (SWDRG) [90].

Non-household water use

The WEAG agreed that tackling non-household (NHH) consumption is a challenge, including the difficulty of getting accurate information on NHH water demand due to lack of a consistent data, and having a robust national measure of NHH was highlighted as a key evidence gap. Experts noted that the figure proposed in the target represented only the gap between supply and demand on non-household water, with no additional ambition for improvements. The WEAG suggested using the market operator (MOSL [91] data on actual use by customer segment and region, rather than relying on wholesale water company demand predictions which have often had a poor evidence base, partly due to retail separation of the non-household water market in England.

Factors impacting per capita consumption (PCC)

The WEAG highlighted that per capita consumption is changing, for example due to hotter summers, more people wanting to have more showers, increases in water demand in gardens and tourist areas. Climate change also drives peak demand and a target with percentage reduction in Distributional Input (DI) related to PCC is challenging, in part because how climate change will affect peak demand is somewhat unknown.

It was noted that the mean PCC takes account of consumption across all domestic properties, but that the distribution of consumption tends to be uneven. Most people use less than the average (~140 l/p/d), with low numbers of high-use consumers inflating the average (e.g.,

[18] https://www.theccc.org.uk/publication/independent-assessment-of-uk-climate-risk/

[19] https://www.waterwise.org.uk/knowledge-base/senior-water-demand-reduction-group/

internal household losses through leaky loos has increased due to the current design and build quality of many dual flush toilet mechanisms). There could be water savings made through focusing on higher volume users and use of smart metering to help householders identify issues. The WEAG provided a report from consultancy Artesia on the long-term potential of reductions in household water demand [92].

The WEAG highlighted that new building regulations will help reduce water use. However, the number of people in a building, demographics, and the amount of retrofitting (e.g., water efficient taps, low flush toilets) may mean an older building is more water efficient than a newer building with no water use retrofitting. Care needs to be taken in generalising where water use improvements can be made across buildings of differing ages and locations.

Water companies are the suppliers of water to nearly all domestic properties, and there are some factors affecting water demand that are within their control, particularly company-side leakage. Alongside this, the WEAG noted that PCC is influenced by factors outside water companies' control, such as climate, weather, and pandemics.

The WEAG noted that population demographics need to be taken account of when considering water demand forecasting. There also are elements of uncertainty on behavioural changes and other disruptive events that will impact on future water demand.

The impact of changing work patterns and pandemic-enforced working from home on water demand were discussed. The WEAG noted there may be a displacement of water demand and sewage treatment if people are more geographically spread than previously. This would mean that smaller, more localised water supply and sewage treatments works might be under increased pressure that was not forecast during their construction, rather than the treatment plants and supply works that are set up to provide services to heavily populated cities (e.g., with high numbers of office workers). Experts noted that personal water consumption tends to occur more in a household location (e.g., washing clothes, bathing), and that estimates of population home working increased from ~27% in 2019 [93] to ~37% during 2020 [94] (of people reporting at least some home working). It was noted that household water consumption and total distribution input had both increased during the pandemic. Changes in patterns of water consumption across the UK will need to be kept in mind going forward.

Abstraction

It was noted that the proposed target covers public water supply, which is the water abstracted by water companies, to meet the demand from households and non-households uses, as well as leakage. It does not cover demands met by non-public water supplies, which is the water abstracted by others – e.g., businesses, agriculture. These are managed by a wider range of policies, including abstraction licencing and the 2017 Abstraction Plan, at the catchment level rather than nationally. The WEAG highlighted that irrigation can have a high impact on water use from the environment. For example, in the East Anglia area during dry weather, the spray irrigation water consumption can approach, if not exceed, the public water supply (PWS) demand on a summer's day [95]. It was noted that the public water supply will be protected by the Environment Agency stopping irrigation; however, it highlights the connections between public water supply and other water resources uses.

Metric

The metric proposed by Defra was DI/population (DI/pop), which gives a measure of public water supply input per unit population. The WEAG welcomed including DI as the basis for the metric as it was more holistic than current targets and would incorporate water efficiency in homes, leakage, and - for the first time – water efficiency in businesses and the public sector, which accounts for a third of public water supply in England. The WEAG, however, raised concerns about dividing DI by population, as the overall ambition of the demand target in the Environment Act 2021 was to leave more water in the environment – dividing the DI target by population could mean that the total DI could increase (i.e., due to an increasing population reducing the DI/pop metric) and not leave more water in the environment. They also raised concern at dividing the DI target per head of population as water companies use a range of population forecasts, from local authority trends, which provide an upper-range estimate to ONS forecasts, which tend to provide a lower-range estimate. Uncertainty will always exist until we know how many people are in the supply area at any one time. There are also large differences in impacts of per capita consumption, and how population affects non-household use (inc. different types of customers) and leakage metrics.

The WEAG agreed that household consumption is a better metric than per capita consumption as a potential sub indicator for household use, sitting beneath the overall Environment Act 2021 water resource target and alongside sub-indicators for non-household use and leakage.

The WEAG highlighted that a separate SWDRG meeting had also discussed improvements to water demand and suitable metrics and were supportive of a DI metric to ensure a positive impact on the water environment. Experts noted that the SWDRG also had concerns about the accuracy of population data that would underpin a per capita target (DI/population) and annual measures of DI/population.

The units and difference in target percentages for equivalent DI and DI/population metrics were discussed. Defra took this advice into consideration, as well as other factors including growth, achievability and international precedents, as set out in the previous section outlining the metric.

Ambition

The WEAG agreed that the overall outcome from the demand target should be to reduce the impact on the environment, by increasing total water left in the environment. They noted that the target should be set at a level which went beyond the ambition of current plans and policies – making the analogy with the carbon targets in the Climate Change Act, which set stretching targets for government and others to reach and did not merely reflect business as usual. The WEAG noted that the target being proposed was the equivalent of a 19% reduction by 2037, reflecting only current ambition and not the higher level of ambition they advise is required. WEAG suggested that the test for the demand target should be whether it was ambitious enough to improve the water environment, as per the aim set out in the government's 25 Year Environment Plan for England.

WEAG noted that, as a group of experts working in the environmental field, and given all the evidence cited in meetings, higher ambition was its logical recommendation to drive change.

On household demand, the WEAG noted that this had doubled over the last 5 or 6 decades and would need to be halved again in the next few decades to meet resilience of supply challenges and improve the water environment and suggested that the demand target should set an ambitious trajectory towards this. The WEAG warned that both total DI and per capita consumption had risen during the Covid pandemic, by 2.6% and 9 to 13% respectively and that water use trends related to new ways of working could continue. Given this increased pressure, the WEAG suggested the target currently proposed may not lead to protection or improvement of the water environment. However, the target proposed has been developed on the basis of delivering the demand reduction required by 2050 under the National Water Resources Framework, which considers demand reduction and new supply options to ensure there is enough water allocated to the environment.

Defra and the WEAG agreed that uncertainty over population growth may affect the target and projections for water demand. Experts highlighted that sufficient ambition was therefore necessary to ensure enough water was left in the environment, regardless of other uncertainties in projected water use.

The WEAG noted that the proposed target aims to fill the currently projected DI requirements by 2050, but that this does not allow for future proofing of the target, given future uncertainty around the effects of climate change, changes in water resource availability and alterations in patterns of water use. Experts suggested that this should be explicitly considered in increased ambition for the proposed target, and in updated cost-benefit projections for higher ambition levels.

The WEAG provided an example of one water company where for current metered customers, average household use was 105 l/p/d PCC, which included new builds and older properties with meters. They also noted the current Building Regulations (2010) [96] used by councils for planning applications, which states [97] that the estimated consumption must not be greater than the standard set by the Secretary of State of 125 litres/person/day of wholesome water or 110 litres/person/day where the optional requirement applies. It was noted that councils are applying the optional requirement where needed, which is more ambitious than the proposed target [98, 99]. The WEAG noted that the proposed Environment Act 2021 target is long term, and its ambition needs to be increased above current levels to protect the water environment.

The WEAG highlighted that the National Framework [100] report in 2020 had a PCC recommendation of 110 l/p/d needed by 2050, on which government policy and water company plans are currently based. This was recommended in the absence of additional government policies to drive greater water efficiency. With some of these policies now in train (notably the mandatory water efficiency label committed to in a written statement to Parliament), the WEAG suggested that as the Environment Act 2021 target will extend to 15 years and more and it should be more ambitious than following the trajectory to 110 l/p/d by 2050. This would require additional actions and policy, as noted by the National Framework Steering Group.

The WEAG also highlighted that current water company plans aim to achieve a national average PCC per day of about 118 l/p/d by 2050. A report on pathways to long term PCC reduction [101] was noted with some combined actions to improve water efficiency, notably a mandatory water labelling scheme, and increased smart metering could offer reductions in water use, resulting in forecast PCC of 101 l/p/d by 2035 and 82 l/p/d by 2065.

The WEAG noted that the target should drive policy and innovation, and suggested setting a higher level of ambition in the Environment Act 2021 for water demand, similar to policies within the Climate Change Act that aim to drive more ambitious policy and action. They suggested a higher level of ambition for water demand is feasible and necessary. Experts also pointed out that they believe Defra is not currently on track to achieve the reductions needed in the three sub-categories (PCC, NHH, leakage).

Mandatory water metering was noted by experts as an area which would improve water efficiency, and in particular smart metering (on which recent evidence was also clear on the positive cost benefit to already metered properties). Both Defra and the WEAG agreed that this could cause increased bills for currently unmetered properties, and that there would need to be safeguards for communities to support a high ambition target for metering.

Overall, the WEAG advised that the target ambition be increased but noted that the target currently recommended will meet the National Framework targets which will be reflected in government policy and water company water resource management plans.

Defra noted that in developing the target we took the above into account, however this policy is making a statutory commitment to reduce water demand, whereas previous initiatives and commitments were voluntary. We felt that this target was the right ambition level to require actions from Government, water companies, and businesses in a more holistic way than water efficiency has been targeted previously, and drive change, whilst balancing potential impacts on the public.

Achievability

The WEAG welcomed Defra's policy statement on reducing personal water use, made by the Defra Secretary of State to Parliament on 1st July 2021. This statement committed to a number of measures, including regulations to establish a mandatory water efficiency label for products, encouraging local authorities to adopt the currently optional minimum building standard for new homes of 110 litres per person per day, and in 2022 to develop a roadmap towards greater water efficiency in new developments and retrofits. The WEAG suggested that while welcome, these policy announcements would not be enough to meet the demand reduction required to improve the water environment as well as help ensure resilience of supply for homes, businesses and the public sector, and to underpin the economy even at current levels, as well as economic growth, and for public health goals. However, the policies already announced are spurring greater action and collaboration between Defra, BEIS, DLUHC and other Government departments to deliver water demand reduction. Going further would impact on bills, e.g., beyond existing commitments on leakage, and changes to metering policy are not included as this protects unmetered family homes from unexpected large increases in bills.

The WEAG noted that other necessary measures including centring water efficiency in policymaking and legislation on economic growth, net zero carbon, housing policy, energy efficiency, and policy and regulatory changes would be required to increase delivery on water efficiency across the household and non-household sectors. An increase in smart meters for homes and businesses would also be required, to facilitate the necessary behaviour change in water efficiency, as well as underpin water sector resource planning [102].

The WEAG noted that one leakage reduction target across all companies seems challenging as some areas have differing starting levels of leakage. Defra responded that the national proposed target is an overall percentage that takes account of variation present, and that targets will be agreed with water companies on outcome delivery.

The WEAG noted that achieving the target, by reducing water use and increasing efficiency, will need to work alongside current water management agreements with Wales and Scotland, and the devolved administrations where needed. Ofwat is the regulator for water companies in England and Wales, with separate environmental oversight, the EA in England and NRW in Wales. They suggested that this is considered during the public consultation phase, especially where assets are under a different administration and subject to previous legislation. They highlighted that there are currently no cross-boundary water resource transfers from Scotland to England.

The WEAG noted that messaging on targets and what people can do to deliver benefits to the environment should be clearer. This would be alongside joined up messaging about water efficiency to also support net zero objectives.

It was highlighted that Leeds City Council has adopted the 110 litres per person per day specification for new developments [103]. Experts noted that the proposed target level was very achievable, though also mentioned concerns about an appropriate level of ambition (see previous section).

Impact

The ability to reduce water demand without constraining economic activity was discussed. The reduced economic dependence on heavy industry and manufacturing means there is no longer a strong link between non-household water demand and economic activity. There is the potential for increased non-household water efficiency to enable more business to function on the same volume of water resources. We also see the benefits to people's lives with water efficiency delivering energy efficiency and bill savings. Defra will work with the water sector to ensure vulnerable households are protected in terms of affordability of water and access where they may need greater volumes (e.g., due to disability).

The WEAG raised concerns about the concentration of pollutants in waterbodies as overall water consumption is decreased. For example, washing detergents will still be flushed from households, however when these are discharged from treatment works or storm overflows, they will be less diluted if water consumption has decreased. The links between long term water demand and wastewater targets need to be considered holistically and it was noted that if more water is left in the environment (e.g., due to reduced abstraction), then there should be more water in the river channels to dilute discharges from point sources. Some investigation into how these would play out under a changing climate, in catchments with differing water resource resilience and vulnerability to low flow driven water stress would be beneficial in informing approaches going forward.

The WEAG noted the importance of ambitious demand management to the UK's climate change adaptation programme, as well as its key contribution to statutory carbon targets/net zero carbon from heating, pumping, and treating less water.

Scope

The WEAG highlighted that changes in abstraction, relating to agriculture and climate change, are not included in the target. They noted that the majority of water abstracted is non-consumptive, but is returned to the environment e.g., for cooling purposes in electricity generation. This is regarded as having low environmental impact, although there is a risk to the environment from; the time lag between water being abstracted from the environment and returned to it, the different points in the river or groundwater where this is taking place, and the changed physical (e.g., temperature) and chemical properties of the water once returned to water bodies. Organisms which suffer significant thermal stress (particularly in the juvenile stages of development) were discussed, as this can affect recruitment and replenishment of adult populations, and cause long-term declines in, for example, fish stocks at or around the point of discharge of abstracted water. Experts noted this merited further consideration in the setting of targets for such abstraction and recharge regimes.

The WEAG also highlighted that reporting of dilution is critical to maintain stream or river chemistry, water levels and physical properties such as temperature and turbidity. The physical impacts of changing water levels and amount of use will impact alongside chemical impacts to water environments.

The need for consistent terminology in this target was highlighted by the WEAG. This includes how the target relates to public water supply (including household, non-household and leakage), and that non-public water supply related to direct abstraction is not covered by this target.

Case studies

Experts mentioned a consultancy that has started a 2-year knowledge transfer project considering social and behavioural practices related to improving water use efficiency.

To underpin the WEAG's recommendation for more ambition, experts cited:

- Data from the Thames smart metering trial showing the significant reductions in household consumption which were possible under existing policies-their smart meter visit with installation of water-saving devices and fixing of leaks saved homes on average 10%, and identified that 8% of homes were leaking water constantly
- The existing water efficiency targets set for their non-household customers by water retailers (e.g.. 20% reduction aim by Business Stream [104], and a water retailer reducing water consumption by 9.4 million m^3 by 2026 [105]).

Additional points

The WEAG stated that most of the energy use in the anthropogenic water cycle is used for heating water in the home, a 2008 study estimated around 89% [106], which accounts for about 5% of total GHG emissions.

The WEAG stated that unconstrained and often stimulated economic growth and population growth will lead to negative environmental outcomes. It is not possible to sustain all of these things simultaneously. This affects any water quality targets, as it needs to balance environmental requirements with the push for increased economic growth that utilise water resources and environments. Experts also noted that economic growth itself relies on the resilience of the water supply, which is already at risk, according to many government and government-linked reports, without more ambitious demand management.

Water Expert Advisory Group advice on other potential target areas

A potential target area was considered for storm overflows, to reduce storm overflow spills into the water environment. This was discussed with the Water Expert Advisory group, alongside the wastewater P reduction target.

During the course of preparing targets for water under the Environment Act 2021, the issue of storm overflow discharges has received more public attention. A Storm Overflows Evidence Project was set up, which reported in more detail on the topic. Following the progress of the Environment Act 2021 through the Parliamentary process and Royal Assent, action on storm overflows was written into sections 80 to 84 of the Environment Act 2021 [107]. It was therefore decided that targets around storm overflows would be better established through those Environment Act 2021 duties, including for the government to produce a Storm Overflows plan, rather than as part of this suite of targets. Action on Storm Overflows continues to be informed by expert advice and an evidence-based approach.

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