Poole Harbour Consent Order Technical Investigation and Recommendations

Results and recommendations from the schedule of work under High Court of Justice Consent Order (CO/3029/2015)

FINAL

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Glossary of terms

AA – Affected Area AIH – Area of Intertidal Habitat AMP – Asset Management Plan CBA – Catchment Based Approach CLA – Country Land & Business Association CO – Consent Order COGAP – Code of Good Agricultural Practice CPM – Combined Phytoplankton and Macroalgae Model CS – Countryside Stewardship CSF – Catchment Sensitive Farming CSMG - Common Standards Monitoring Guidance DAIN – Dissolved Available Inorganic Nitrogen DS – Diffuse solution DWF – Dry Weather Flow EA – Environment Agency EC – European Commission EPR – Environmental Permitting Regulation EEOY- Environmental Economic Optimum Yield EQR – Environmental Quality Ratio (used in WFD assessment to determine class) ES – Environmental Stewardship G -- Gram HD – Habitats Directive (1992) HR – Habitats Regulations LTA – Long Term Average MA – Macroalgae N – taken to be inorganic nitrogen unless specified otherwise	N2K – Natura 2000 site (SACs and SPAs) NE – Natural England NFU – National Farmers Union NLT- Nitrate Leaching Tool NMP – Nutrient Management Plan NVZ – Nitrate Vulnerable Zone OP – Orthophosphate reactive as phosphorus PCC – Primary Catchment Contact PR19 – Periodic Review 2019 RBMP - River Basin Management Plans RoC - Review of Consents SAC – Special Area of Conservation SPA – Specials Protection Areas SSSI - Sites of Special Scientific Interest STW – Sewage Treatment Works TAL – Technically Achievable Limit TN – Total Nitrogen TP – Total Phosphorus UK TAG - UK-wide Technical Advisory Group for WFD standards UWWTD – Urban Wastewater Treatment Directive WBD – Wild Birds Directive (2009) WFD – Water Framework Directive WPZ – Water Protection Zone WWTW- Waste water treatment works

Executive Summary

Background and Habitats Directive Conservation Status

Poole Harbour is a designated 'transitional water body' and 'protected area' under the Water Framework Directive (WFD). The intertidal habitats and coastal waters of Poole Harbour are of international nature conservation importance with the site designated as a Special Protection Area (SPA) under the Conservation of Habitats and Species Regulations 2017 (Habitats Regulations 2017). As part of the Conservation of Habitats and Species Regulations 2017 and Article 6(3) of the Habitats Regulations (HR), Poole Harbour need to comply with specific Conservation Objectives for the SPA. Poole Harbour is also designated as a Ramsar site which are afforded the same provisions under the Habitats Regulations, the harbour is also nationally designated as a Site of Special Scientific Interests (SSSI).

The SPA is failing to achieve the conservation objectives for the site, in part due to the high nutrient load and enrichment of the water body. This has consequential effects on wetland birds and their supporting habitats through complex changes in the marine environment and ecology, including high levels of opportunistic green macroalgae growth (*Ulva* spp and *Cladophora* spp) on mudflats, an indicator of eutrophication. The Ramsar and SSSI are also correspondingly failing in condition.

In 2015 the World Wide Fund for Nature, the Angling Trust and Fish Legal undertook a Judicial Review (JR) against the Secretary of State for the Environment, Food and Rural Affairs and the Environment Agency (EA). It was based on the perceived non-consideration of Water Protection Zones (WPZs), to deliver measures to tackle diffuse water pollution impacting on water-dependent Natura 2000 (N2K) sites, in this case Poole Harbour SPA.

As a result of the JR, the EA, working with Natural England (NE), undertook to evaluate whether the existing measures and mechanisms to tackle pollution will lead to the improvements in water quality necessary to meet the conservation objectives for each N2K site. This document, represents this review for Poole Harbour and recommends the measures that should be put in place in the harbour and catchment to deliver these objectives.

It builds on the previously published Nutrient Management Plan (NMP) "Strategy for Managing Nitrogen across the Poole Harbour Catchment to 2035" and considers the most relevant up-to-date evidence and scientific understanding.

http://webarchive.nationalarchives.gov.uk/20140328091437/http://www.environment-agency.gov.uk/research/library/publications/148450.aspx

Current Water Framework Directive Conservation Status

The overall WFD status of the waterbody, classified in 2016 is "moderate" as a result of the dissolved inorganic nitrogen (DIN) concentrations and the macroalgae condition. It has however been identified as an area with a requirement to RESTORE water quality, including winter DIN and macroalgae condition (Appendix 10).

When applying UK TAG guidance (in 2017), six major areas of the harbour were identified as being in an unfavourable (declining) condition, [Holes Bay, Arne (including Wytch Channel and Wareham Channel), Ower Bay and Newton Bay (Figure 2.2.1)] . The assessment also shows there are no recovering areas, and that Salterns area and Green Island are showing as at risk.

The HR and WFD provide the main statutory drivers for protecting and improving the natural environment of Poole Harbour.

Actions undertaken to deliver Conservation Objectives

In 2013, the NMP produced by the Environment Agency and NE identified the “other actions” that are required to reduce nitrogen (N) loads within the harbour to a level to restore the condition of the harbour and achieve the conservation objectives of the SPA and Ramsar site. The NMP recommended reducing N loads to early 1980’s levels, 1730 tonnes N/yr and agricultural nitrogen loads down to c1194 tonnes N/yr (from high nutrient input land).

Despite efforts of the farming community, the agricultural sector are estimated to have reduced N losses by c120 tonnes N/yr to c1679 tonnes, some c485 tonnes N short of their target. These savings were very dependent on continuation of grants provided under Environment Stewardship scheme and international agricultural commodity market. The only long term improvements forecast to have been made are around 21 tonnes N/yr, resulting from the implementation of New Farming Rules for Water New Farming Rules for Water - GOV.UK. It is clear that the reductions achieved by the agricultural community under the voluntary approach is significantly below what was required by the NMP.

Updated Evidence and Future Targets

Recent evidence indicates that the long term nutrient loads forecast to enter the harbour are still in the order of 2300 tonnes/N/yr. Phosphorus loads are estimated to be around c51 tonnes of orthophosphate; reactive as P (OP)/yr and 71 tonnes of Total Phosphorus (TP)/yr.

As a result of further research, modelling and analysis, this document identifies that the NMP N target is tightened, establishing a pathway that goes further on the reduction of nutrients in order to achieve the conservation objectives of the site.

Updated modelling (based on macroalgae growth) suggests that phosphorus loads entering the harbour also need to be reduced, in conjunction with N, to bring the average macroalgae density to below 500g/m^2, the modelled target.

In order to move the harbour away from a green macroalgae-dominated state to towards a healthier functioning marine environment and thereby make progress toward achieving the conservation objectives of the SPA, an interim goal of nutrient load entering the harbour, has been identified:

- Reducing nitrogen to c1500 tonnes/N/yr in conjunction with
- Reducing OP inputs reduced to c22 Tonnes OP/yr.

Evidence outlined in this review suggests that achieving these targets will substantially reduce dense mats of green macroalgae, however Natural England’s current advice is that a further longer term reduction to c1000 tonnes/N/yr will be required to secure the full restoration of the harbour and conservation objectives of the SPA with regard to water quality. The necessity of this more stringent target will be subject to review, informed by evidence, monitoring and modelling while progress towards the interim goal is being made. This evidence shall be collected within the next River Basin Management Plan cycle 3, (RBMP3) from 2021-2027. The interim target will remain in force during this period.

Under the ‘polluter pays principle’, all sectors which release nitrogen and phosphorus to the surface and groundwater environment within the catchment, should reduce their nutrient loads to deliver their fair share of this interim target, as detailed in Table 7.1:1 and 7.1:2. This document identifies that the interim target can be achieved by reducing:

- Diffuse agriculture loads from all agricultural land, from c1679 tonnes N/yr (including Environmental Stewardship schemes reductions) to c1127 tonnes N/yr and c3 tonnes P/yr.
- Water company Waste Water Treatment Works (WWTW) discharge N and P loads, (including combined sewage overflows), from a target of 327 tonnes N/yr identified in the NMP, to 209 tonnes N/yr and reducing phosphorus to c16 tonnes OP/yr respectively.
- Other permitted discharges, including fish farms to c38 tonnes N/yr. Further monitoring and research is however needed to confirm the absolute loading from non WWTW permitted discharges, prior to these changes being made.
- urban losses below c78 tonnes/yr N,
- un-sewered loads to c10 tonnes/yr N,
- non-agricultural land loads to c39 tonnes/yr N (predominantly from atmospheric deposition)

Maintenance of load conditions should be applied to any applications to increase permitted flow in the future to maintain these objectives.

It may be appropriate for catchment nutrient offsetting to be used in part to deliver fair share targets. Where any land use change or agricultural measures are implemented to deliver these objectives, they must clearly go beyond what each sector needs to deliver to achieve their own limits.

A timetable for this delivery has been identified and can be found in Section 11.5.

While there will always remain some uncertainty surrounding the exact extent of the nutrient reduction required to restore the condition of the harbour, it is abundantly clear that significant reduction in both diffuse nitrate and point source phosphate is required.

Following an **adaptive management** approach will ensure the environmental objectives are delivered in a timely way, without risking excessive, unwarranted regulatory burden being applied to commerce across the catchment. Whilst providing sight that further reductions of nitrogen into the harbour maybe required in the longer term; this longer term reduction could significantly draw from opportunities that restore natural nutrient removal processes (e.g. wetlands) in the catchment and the harbour itself.

This “enhanced adaptive management approach” is in line with current internal Environment Agency and Natural England guidance[1], in taking forward actions on Natura 2000 and Ramsar sites affected by diffuse water pollution, where there remains some uncertainties regarding the target.

Options to deliver these targets

Diffuse options:

Farmscoper modelling indicates that it will be feasible for the agricultural community to achieve a target of 1127 tonnes N/yr and 22 tonnes OP/yr. This equates to reducing N and P losses from all agricultural land, reported in 2010 (62,178 ha) to an average of about 18.1 kg/ha/yr N and about

[1] Enhanced adaptive management approach and RBMP 3 implementation of Diffuse Water Pollution Plans (DWPP’s); Environment Agency and Natural England, May 2019.

0.05 kg/ha/yr P. It will however require farmers to fully implement Farming Rules for Water as well as a combination of other measures to maximise nutrient management efficiencies. The type of measures that could be put in place to deliver the target are outlined in Section 7 and are highlighted below. These measures should not be considered to be prescriptive, but are indicative of the level of nutrient reduction that could be achieved through different bundles of measure and the scale of change that are likely to be required. An element of each type of measure will need to be deployed:

- Reducing nutrient application rates to a point which maximises the yield achieved, but does not cause harm to the water environment (environmental economic optimum yield).
- Improving soil condition and water and nutrient holding capacity.
- Improving farm infrastructure to prevent the uncontrolled release of chemical and nutrients to surface and groundwater.
- Improving farm storage capacity so slurry, manures and other dirty water can be applied to land when there is crop need and when it would not damage soil structure and or present a risk to the environment (and would be Farming Rules for Water compliant).
- Reduced stocking densities (by c17%) and the area of land in high input agriculture (by c23%), (bundles 1-6).
- Implementing alternative measures, such as the installation of c380 ha of wetland systems, (Section 7).

Construction of on stream wetlands (were river flows with high nutrient content are directed through a wetland) may provide a way in which significant nutrient reductions can be delivered strategically across the catchment. It is estimated that a well located and managed wetland system could deliver a reduction of c750 kg/ha N and c20 kg/ha P of wetland.

The Government led Clean Air Strategy on air quality issues, will help to reduce the amount of ammonia, NOx released to the atmosphere and so reduce future nitrogen atmospheric deposition loads into Poole Harbour and other catchments. It will however increase total nitrogen concentrations in manures and slurry's which will need to be accounted for by farmer's in future nutrient management plans.

Point source options

Point source loads to the catchment from WWTW also need to be reduced substantially to 209 tonnes N/yr and c16 tonnes OP/yr. Modelling suggests that Poole WWTW has a significant influence on the macroalgae growth within Holes Bay and the Outer Harbour. A large proportion of this will therefore need to be delivered through reducing N and P loading to Holes Bay, by improving treatment at Poole WWTW.

It is therefore recommended that permit load from Poole WWTW is reduced to an equivalent maintenance of load target, using 2010-11 flows, discharging at 5mg/l N or less. A large proportion of the OP reduction required from WWTW across the catchment should also be achieved by installing P stripping at Poole WWTW (or alternative measures at this site) introducing a permit limit of c0.25mg/l TP.

A further fluvial OP reduction from WWTW of c30% (c3 tonnes) should also be delivered from within the Wessex Waters overall fair share target. In reality this may already have been achieved through c2.5 tonnes OP/yr under AMP 7 measures introduced by Wessex Water (Table 3.1) and further indirect OP reductions that are likely to result from Wessex Waters catchment N offsetting schemes.

The exact options introduces to deliver these reductions by Wessex Water and revised permit conditions to ensure “WWTW do not compromise the ability to achieve favourable condition”, should be investigated and determined as part of Wessex Waters AMP 7 investigations. They should be agreed under PR24.

Industrial Discharges (non WWTW)

There remain some uncertainty regarding overall nitrogen and phosphorus load derived from non WWTW, permitted discharges (particularly fish farms and water cress farms). It would be recommended that a further review is undertaken to calculate the average nutrient loading that comes from large non WWTW discharges to the catchment and if any further permit reduction is required to meet HR targets.

Much of nutrient loading derived from urban and non-agricultural land comes from atmospheric deposition. Government action on reducing agricultural and industrial aerial emissions in the future will start to reduce these loads and contribute to the solution.

Further urban reductions can be delivered through resolving mis-connections between foul and clean water soakaways. Implementation of Sustainable Urban Drainage systems in new developments, reduce run-off and nutrient input to the surface water system and harbour from existing urban infrastructure.

Local authorities may decide to reduce the use of fertilizers and chemicals across their land holdings.

Connection of rural systems to mains sewerage network, may deliver reductions in un-sewered loads. Where appropriate, these could be offset by catchment management schemes.

Mechanisms and timescales to deliver water quality objectives

Diffuse mechanisms

It is unlikely that diffuse pollution reductions will be delivered unless all farmers across the catchment follow some **minimum farming rules**. The primary purpose of these rules are to ensure each farmer across the catchments, understands the impact their farm practices are having on the environment and put in place measures to improve nutrient management efficiencies each year. This can be delivered individually by farmers across their farm holding, or collaboratively by farmers where they join an EA agreed scheme.

A summary of the **minimum farm rules** are detailed below.

- **Farm regulatory compliance**; Specific regulations have come into force over the last 20 years to ensure farm infrastructure and practices will not in themselves result in a point or diffuse pollution risk, (Section 3.3.1.1). To achieve the N target across Poole, it will be essential for **all farmers** to URGENTLY become fully compliant with these regulation. To achieve this, they should annually self-assess their current level of compliance and put in place a plan to resolve any areas of non-compliance within an agreed time period.
- **Target:** The average nutrient loss across each farm holding, should not exceed the maximum leaching target set out in this document. Where the farmer is part of an EA agreed scheme which follow the minimum farming rules and have demonstrated earned recognition, they may follow a **Glide Path** to deliver the water quality **targets** within an agreed **timescale.** The target is set out in this report and it is proposed that the glide path should achieve the target by 2030.

- **Nutrient planning to deliver environmental economic optimum yield;** Farmers need to start to calculate the nutrient losses that are likely to result from their proposed nutrient plan. In particular considering the yield they seek to achieve, soil and nutrient management measures they propose to implement and the impact this will have on nutrient losses from their farm holding. Having calculated the nutrient losses, they should then adjust their nutrient application rates, measures they propose to implement, to a point where they can maximise crop yield without causing harm to the environment, the **Environmental Economic Optimum yield.**
- **Whole Farm Nutrient Balance**: Farmers across the Poole harbour catchment should annually calculate[2] the average nitrogen losses that are modelled to have occurred from the previous year's nutrient plan and farm measures that <u>were implemented</u> the previous season. They should then calculate the nutrient losses that are forecast to occur from their <u>proposed nutrient plan</u> for the following season. They should then compare this figure with the catchment target and adjust their nutrient management plan until the target is met. Where the farm is part of an EA agreed scheme, they may buy or sell nutrient credit from fellow members so as to meet their glide path target, so long as their application rates do not exceed crop need.
- **Farm Annual Reporting**: Farmers should report the measures they have implemented to maximise their nutrient efficiency and deliver their EEOY. They should also report nutrient plan and whole farm nutrient balance annually to the Environment Agency. Where they are part of an EA agreed scheme, they may report this information to an agreed independent 3rd party, appointed to oversee the scheme and validate farm compliance with the membership rules of the scheme. This reporting is essential to track the progress in delivering the water quality objectives and providing confidence to partners that the target will be met in a timely way.
- **Catchment Reporting:** The Environment Agency or for an agreed nutrient trading scheme, an independent third party should annually **amalgamates this farm level data at the water body scale** so that the progress in delivering the catchment targets can be monitored and any issues that may be arising identified and resolved.
- The **tools and techniques** used to calculate farm nutrient losses, whole farm nutrient balance and nutrients trade, should be scientifically robust and agreed by the Environment Agency.

As indicated above, these recommendations could be implemented through a scheme, such as "nutrient trading" approach, currently being proposed by the NFU, to encourage and incentivise farmers to deliver their farm and catchment level water quality targets. This voluntary approach would help to maintain the current **good will** of many farmers. The above minimum farming rules would need to be integral to any scheme or farm level delivery. Additional rules and measures may also be required as part of any such scheme.

Farmers in any nutrient trading scheme, are likely to be deliver their target though increasing their nutrient management efficiencies. Some farmers may also voluntarily reduce their intensification, through reducing stocking numbers and converting some land from high nutrient input to low input. This would have clear benefits to the environment and to the farmer by reducing the amount of nutrient credit they need to purchase if above the glide path target, or increase the amount of credit they could sell if they were below the target. Farmers may also seek to implement alternative

[2] By agreed modelling technique, across all their agricultural land holding in the Poole Harbour Catchment, under typical (average) climatic conditions.

measures, such as the installation of farm wetlands or on stream wetlands to achieve the same objectives.

Modelling indicates that if farmers deliver their N target and are farming rules for water compliant, they are also likely to reduce P losses and achieve their OP target.

Delivery of the overall water quality target could be achieved by 2030, if farmers follow a glide path, reducing the nutrient losses by c6% a year (Section 7.7).

Farmers should commence following the minimum farming rules set out in this document within 6 months of the publication of this document. Any nutrient trading scheme could be trialled in April 2021-22 and fully implemented across the catchment in October 2022.

If the agricultural community do not agree to implement the minimum farming rules as part of a nutrient trading scheme, the EA should write to all farmers and formally request that they provide this relevant information detailed in this report, annually, under NVZ and pollution prevention regulations [EPR (2016) 61(1)]. Under these circumstances, farmers should also be asked to assess their current regulatory compliance and where appropriate, develop an individual plan to achieve their nutrient loss targets and achieve full regulatory compliance within a prescribed period of time. This is likely however to require much greater regulatory effort than an agreed nutrient trade scheme.

Progress in delivery of this target should be monitored and modelled annually. A formal review of progressing in delivering the target should be undertaken by December 2024 and December 2027 (Section 11.5).

Where confidence remains low that the targets will be fully delivered by 2030, the EA should seek new powers to deliver Habitat Regulation objectives and a Water Protection Zone may be the most efficient ways to achieve this (Section 8.1.5).

To deliver the recommendations of this report, further financial resource will be required to:

- Enforce existing and future regulations
- Set up, operate and audit the nutrient trading scheme.
- Develop, operate and maintain tools to calculate farm and catchment scale nutrient loss and to trade N.
- Set up and manage processes for receiving, compiling and analysing farm data sent to the EA.
- Manage the wider delivery of consent order recommendations and findings.

The aim would be that in the longer term, nutrient trading may become self-financing.

Point Source mechanisms

Point source improvements for the water sector should be delivered through the Asset Management Planning Process (AMP).

Schemes are in place under AMP7 to investigate the water quality impacts of WWTW on Poole Harbour. The EA and NE shall need to work with Wessex Water to identify the ecological impact of this. Any final permit and infrastructure changes that result from this assessment should be agreed within the PR24 planning timescales.

The EA should review other point source nutrient discharges to Poole Harbour catchment as part of any review of permits, to ensure industrial fair share reductions are also achieved (See Section 11.5). Any permit variation should be delivered before 2030.

If recommendations of this report are followed, no activity within the Poole Harbour catchment should compromise the ability to deliver the interim targets by 2030. It should however be recognised that the environmental improvements that result from the implementation of these measures are likely to take years/decades to be observed within the harbour. This is because of the delay in N reaching the harbour once it has been leached from the soil and due to the significant P store that is understood to be within the harbour sediment and delays in ecological response. As a result, ecological improvements within the harbour will be delayed as these nutrient stores are depleted. This is however not a reason to delay the implementation of measures set out in this document.

1 Introduction.

In 2013 EA and NE jointly produced a strategy for reducing the nitrogen input to Poole Harbour, a Natura 2000 site for wild birds (SPA) affected by excessive nutrient enrichment[3]. The strategy (Bryan et al, 2013) arose from investigation showing that nitrogen loads entering the harbour had increased greatly in recent decades and were continuing to increase and that this could be linked with nuisance growths of green macroalgae across the intertidal mudflats, a phenomenon that can detrimentally impact on estuarine ecology. The strategy has informed the delivery of measures to reduce nitrogen from wastewater, agricultural and other sources, and led to a nitrogen neutral approach being adopted by the planning authorities in decision making on development growth.

In 2015 the World Wide Fund for Nature, the Angling Trust and Fish Legal undertook a Judicial Review (JR) against the Secretary of State for the Environment, Food and Rural Affairs and the Environment Agency (EA). This was based on the perceived non-consideration of Water Protection Zones (WPZs) as a mechanism for meeting the site conservation objectives of water-dependent Natura 2000 (N2K) sites affected by diffuse water pollution.

As a result of this JR, a legally binding Consent Order (CO) was agreed between the parties. This requires the EA, working with Natural England (NE), to evaluate whether the existing measures and mechanisms to tackle pollution will lead to the improvements in water quality necessary to meet the conservation objectives for each N2K site and evaluate what further measures and mechanisms, including consideration of a WPZ, are needed to meet these objectives for each site.

This report, provides the review for Poole Harbour. The site Conservation Objectives, current status and requirements to deliver these objectives are outlined in Section 2.0. The actions put in place to meet these objectives and reduce water pollution are presented in Section 3. The way in which the Consent Order investigations have been undertaken and key principles around this are described in Section 4. An update on evidence and catchment objectives are highlighted in Section 5. A review of water quality targets is presented in Section 6.0, including modelling the primary biological effects of eutrophication (nutrient enrichment) on Poole Harbour (mainly opportunistic macroalgae abundance), reviewing the interaction of point and diffuse sources of pollution. Section 7.0 reviews the contribution each sector should make to future targets (fair share calculations) and considers the diffuse and point source options for delivering water quality targets. The cost and qualitative assessment of each option is also considered. The mechanisms to deliver these objectives are highlighted in Section 8, consultation process that has been undertaken, Section 9 and final conclusions and recommendations in Sections 10 and 11. Technical supporting information is provided in a series of Appendices.

Improvements recommended and implemented as a result of this review, are likely to take many years or decades to achieve the site conservation objectives for Poole Harbour in relation to nutrient status. This is because of natural delays in the response of nutrient status, nitrogen (N) and phosphorus (P) in particular to anthropogenic source reductions in the catchment and at the harbour itself.

These delays include decadal long travel times for N loads draining through the catchment geology and multi-year timescales for depletion of large P stores in the harbour sediment that have accumulated over many decades. N and P inputs to the harbour are also affected by complex

[3] Poole Harbour is also designated as a Ramsar site and as a Site of Special Scientific Interest (SSSI). The special interest includes all the wild bird features of the N2K site.

catchment nutrient storage, cycling and removal and release processes that are only partially understood, and exchanges via tidal flows with coastal waters.

These factors create a level of complexity that raises uncertainty in establishing the levels to which nutrient sources need to reduce so as to meet the site conservation objectives and the relative effectiveness of different reduction measures. Thus **an adaptive management approach** is taken in this report. The approach identifies ways forward on nutrient reduction on which there is evidence providing a high degree of certainty and which can be taken forward now, while pointing toward the potential for further needs on which there is currently less certainty, a situation which is likely to improve over time as understanding of ecological responses and modelling improve. The complexity of the nutrient situation is not therefore a reason to delay implementation of the adaptive approach recommended in this report.

An adaptive management approach is taken in this plan to reduce the nutrient and achieve the conservation objectives.

2 Background

2.1 Site conservation objectives

Poole Harbour is classified as Special Protection Area (SPA) under the Conservation of Habitats and Species Regulations (as amended) 2017[4] (referred to as the Habitats Regulations), it is also a Ramsar site. The UK Habitats regulations and duties with regard to European wildlife sites including SPAs are derived from the European Union Directives.

The first piece of legislation bringing the requirement for European wildlife sites to be classified within member state territories was the Council Directive on the conservation of wild birds (79/409/EEC), which was introduced in 1979 and is most commonly referred to as the 'Birds Directive.' This Directive serves to protect birds that are rare or vulnerable in a European context by directing Member States to classify Special Protection Areas (SPAs) for bird species listed within the Directive.

In 1992 the European Habitats Directive (92/43/EEC) came into force. The Habitats Directive seeks to protect flora and fauna other than birds, where species and habitats are rare or vulnerable in a European context, and to achieve their Favourable Conservation Status (FCS) across their naturally-occurring range. The Habitats Directive requires each Member State to designate Special Areas of Conservation (SACs) for those species and habitats listed within the Directive.

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The term 'European site' is formally defined in regulation 8 of the Habitats Regulations. It includes Special Protection Areas (SPA), which are classified under the Birds Directive, and Special Areas of Conservation (SAC), which are designated under the Habitats Directive. SACs and SPAs in marine or intertidal areas are also known as European Marine Sites, SAC and SPA are also sometimes referred to as Natura 2000 sites or N2K sites.

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[4]. At the point of UK's Exit from the European Union the UK Habitat Regulations remain, the 2017 Regulations were amended by Conservation of Habitats and Species (Amendment) (EU Exit) Regulations 2019.

It is important to note that the UK Government has signed the Ramsar Convention (1971, and subsequent amendments), which means parties have agreed to establish and protect wetlands of international importance.   The UK Government has stated that, as a matter of policy, listed Ramsar sites should be afforded the same level of protection as SPAs or SACs. There should not be any difference between the way that European and Ramsar sites are treated in project management and decision making.

Competent authorities are required under the Habitats Regulations to avoid the deterioration of Poole Harbour SPA for its qualifying bird features and take steps to secure the sites conservation objectives. Authorities should use the conservation objectives for Poole Harbour SPA summarised in Box 1 along with the more detailed Supplementary Advice on Conservation Objectives (SACOs) and any case-specific advice issued by Natural England when assessing how activities (including those that impact water quality) may affect Poole Harbour SPA.

Box 1: The Conservation Objectives for Poole Harbour SPA as published by NE are:

Ensure that the integrity of the site is maintained or restored as appropriate, and ensure that the site contributes to achieving the aims of the Wild Birds Directive, by maintaining or restoring;

- *The extent and distribution of the habitats of the qualifying features*
- *The structure and function of the habitats of the qualifying features*
- *The supporting processes on which the habitats of the qualifying features rely*
- *The population of each of the qualifying features, and,*
- *The distribution of the qualifying features within the site.*
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The qualifying features are:

- *non breeding populations of Little egret, Eurasian spoonbill, Common shelduck, Pied avocet, Black-tailed godwit and the overall waterbird assemblage;*
- *breeding populations of Mediterranean gull, Sandwich tern and Common tern*

Attributes listed in the Supplementary Advice on Conservation Objectives are considered to be those which best describe the site’s ecological integrity and which if safeguarded will enable achievement of the Conservation Objectives for the site.

There is a specific attribute for water quality – nutrients, however, sufficiently low nutrients must also be achieved to meet other attributes listed in the supplementary advice on conservation objectives. The attributes listed that are particularly important when considering whether sufficiently low nutrient levels have been reached to achieve the conservation objectives for the site, are listed in Box 2.

Box 2: Supplementary Advice on Conservation Objectives, as published by NE , relevant to supporting habitat for the qualifying bird features and on which nutrient status has a bearing include:

Water Quality - nutrients
Restore water quality to mean winter dissolved inorganic nitrogen levels at which biological indicators of eutrophication (opportunistic macroalgal and phytoplankton blooms) do not affect the integrity of the site and bird features.

Supporting Habitat (saltmarsh, littoral sediment (includes seagrass))
Restore the extent, distribution and availability of suitable habitat (either within or outside the site boundary) which supports the feature for all necessary stages of the breeding cycle (Mediterranean gull, Sandwich tern and common tern) and non-breeding/wintering period (all other bird features)

Food Availability
Restore the structure, function and availability of the following habitats which support the assemblage feature for all stages of the non-breeding period: intertidal sediments (includes seagrass)

Restore (shelduck) and maintain (all other features) the availability of key food and prey items at preferred sizes.

Poole Harbour is also designated as a 'transitional water body' under the Water Framework Directive (WFD) and, being an SPA is also a 'Protected Area' under this Directive. As a WFD Protected Area there are also requirements to avoid the deterioration of the site for its qualifying bird features and take actions that will achieve the SPA's Conservation Objectives.

2.2 Conservation Condition of Poole Harbour

Current Condition of Poole Harbour Special Protection Area

A highly elevated nutrient status is a major cause of unfavourable condition in Poole Harbour. Nitrogen loadings forecast from current land use and discharges are about 2300 tonnes/yr, which is greatly elevated above natural conditions (Appendix 3 & 13). This has led to a reduction in the biomass of the preferred prey items available of some bird species, while opportunistic green macroalgae has grown into thick mats which have prevented some birds from accessing the mud (Axelsson et al., 2012; Pinn and Jones, 2005; Thornton, 2016). WeBs (Wetland Bird Surveys)[5]alert analysis highlight a number of bird species to have declined in recent years in Poole Harbour – shelduck, curlew, redshank, dunlin, red-breasted merganser, goldeneye, pochard and lapwing comparisons with regional trends indicate, apart from dunlin and red-breasted merganser, these declines are due to site specific pressures. Although this is likely to be due to a number of pressures, the very large decline in the winter population of shelduck has been attributed to the thick algal mats, with their feeding activity (scything action) likely to be physically inhibited by the algal mats

[5] [5] Wetland Bird Survey monitors internationally important non-breeding waterbirds in the UK - https://www.bto.org/our-science/projects/wetland-bird-survey

(Soulsby et al, 1982), while redshank are known to favour certain invertebrate food sources in littoral sediment impacted by opportunistic macroalgae (Thornton et al, 2020)

A recent harbour-wide assessment of saltmarsh extent indicated a 28 ha loss in the 6 years from 2008 to 2014, the area reducing to 562.1 ha (Green et al, 2020). This has led to the loss and deterioration of a number of bird roost sites around the Harbour (Morrison, 2019). This recent saltmarsh loss is well illustrated in Holes Bay with its fragmentation into small 'islands' divided by bare mud and developing creeks (Figure 1). In this bay, retreat of marsh at the seaward face and within creeks has also occurred. The pioneer (colonising) zone was also reduced while there was an expansion of reed beds into saltmarsh and mudflat. Similar changes have been found in other parts of the Harbour. Further more recent aerial photos in 2017 and 2020 are also presented in Figure 1.

2002	16/05/2002
	
2013	18/06/2017
	
2020 (Google image)	
	

Figure 1. Aerial photography showing loss of saltmarsh in part of Holes Bay between 2002, 2013, 2017, 2020 (google maps)

The extent of the main seagrass beds at the entrance of the Harbour has remained relatively stable in recent decades, although historically at the beginning of the 20th century, seagrass was much more widespread across the Harbour. A recent condition assessment, however, found the leaves of the plants in the remaining seagrass beds had moderate epiphyte loads and wasting disease infection - a sign that the plants are maybe weakened and of poorer health. Moreover dense algal mats were recorded within and alongside one of the beds (Natural England, 2018).

Current condition of Poole Harbour WFD waterbody

The overall status of Poole Harbour as a WFD waterbody, [classified in 2016 by EA,]() is “moderate” as a result of excessive winter dissolved inorganic nitrogen (DIN) concentrations and excessive abundance of opportunistic macroalgae. The assessment of phytoplankton met Good status.

The macroalgae WFD assessment, was carried out using an “[opportunistic macroalgae blooming tool]()” which considers composition, macroalgae cover, abundance and disturbance-sensitive taxa. The tool provides a classification at a waterbody scale and is composed of five metrics. For Poole Harbour to pass, the macroalgae occurrence should:

a. That the available intertidal habitat (AIH) is <15% cover
b. The affected area is < 50ha coverage
c. <5% entrainment
d. Phytoplankton restored above a target 0.6 (moderate / good boundary).
e. When little or no cover >1kg/m^2

Failure to achieve one of these criteria will not result is HR failure, but should be considered in combination as part of the overall WFD test and at a N2k site scale in line with established guidance (Annex 11).

Common Standards Monitoring Guidance (CSMG) published by the Joint Nature Conservation Committee (JNCC) for N2K sites and SSSIs, further informed by relevant attributes in the Supplementary Advice, is used by NE to assess the condition of the N2K and Ramsar site, and the underlying SSSI for their designated features. The CSMG for estuaries is particularly relevant to Poole Harbour (JNCC, 2004). The guidance states that ‘water quality is an essential functional component of estuaries and **must be assessed for all sites’.** Several attributes are identified for consideration in assessing water quality, including on nutrient status: nitrogen, mats of algae, phytoplankton and chlorophyll-a.

The guidance was produced at a time when standards and assessment of the water environment were evolving under statutory programmes such as the WFD. It suggests that target values should default to appropriate national or international standards under these programmes. These should be used to inform individual feature assessments.

The CSMG guidance on setting appropriate site targets refers to EA guidance for the Review of Consents (RoC) which, for example, on opportunistic macroalgae indicates what amount of algal mats would be problematic:

- Reference level for mass of weed = 100g/m^2 wet wt.
- Up to 500 g/m^2 wet wt. is not a problem.
- 1 000 g/m^2 wet wt. is a problem.

Further guidance has been provided by UK Technical Advisory Group (UK TAG) on methodology to determine WFD status on a waterbody scale. It was developed to provide coordinated advice on the science and technical aspects of the European Union's WFD (2000/60/EC). It was designed to address concerns about some of the existing standards, gaps in our understanding of the relationships between pressures and ecological impact where we may be subject to challenge, and interlinkages between Natura protected areas and WFD.

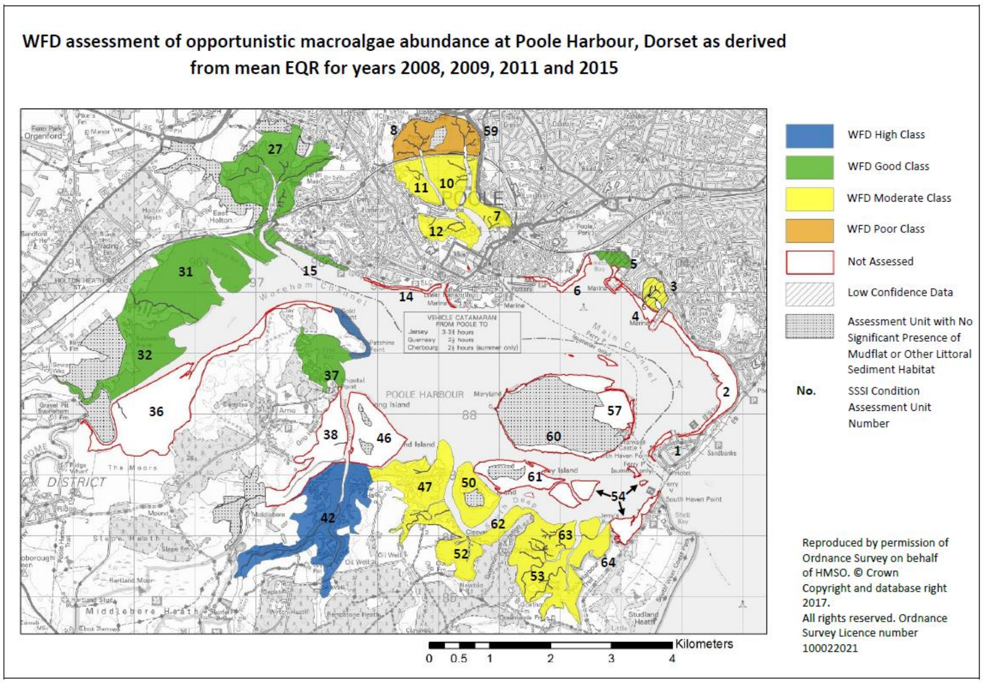
An assessment (2017) for opportunistic macroalgae in different parts of the harbour at sub harbour scale (so not representative for WFD final assessment) using the similar analytical method and class values used for WFD assessment, is shown in Figure 2.2.1a, alongside the condition assessment for the SPA/Ramsar and SSSI in figure 2.2.1b . This reveals considerable differences in condition on macroalgae abundance in different parts of the harbour with intertidal mudflat habitat. Some parts, particularly mudflats in sub-estuaries and embayment's below the inflow of rivers to the harbour, achieved values equivalent to WFD Good class or High class. Other embayment's on the north side of the outer harbour (Holes Bay at units 10 and Blue Lagoon at unit 3) and nearly all the bays along the south shore of the outer harbour achieved values at WFD Moderate class. The northern part of Holes Bay (at units 8 and 59) achieved the lowest value at WFD Poor class.

The assessment found no clear trend in the WFD values in different parts of Poole Harbour over the survey years but revealed considerable year to year differences. This reflects observed variations in the abundance of macroalgae from year to year and within individual years that is probably due to variation in environmental factors influencing macroalgae growth. This analysis, despite being sub WFD scale is useful in enabling us to identify where within the water body ecological issues and stresses are occurring which may assist in identifying solutions to these issues.

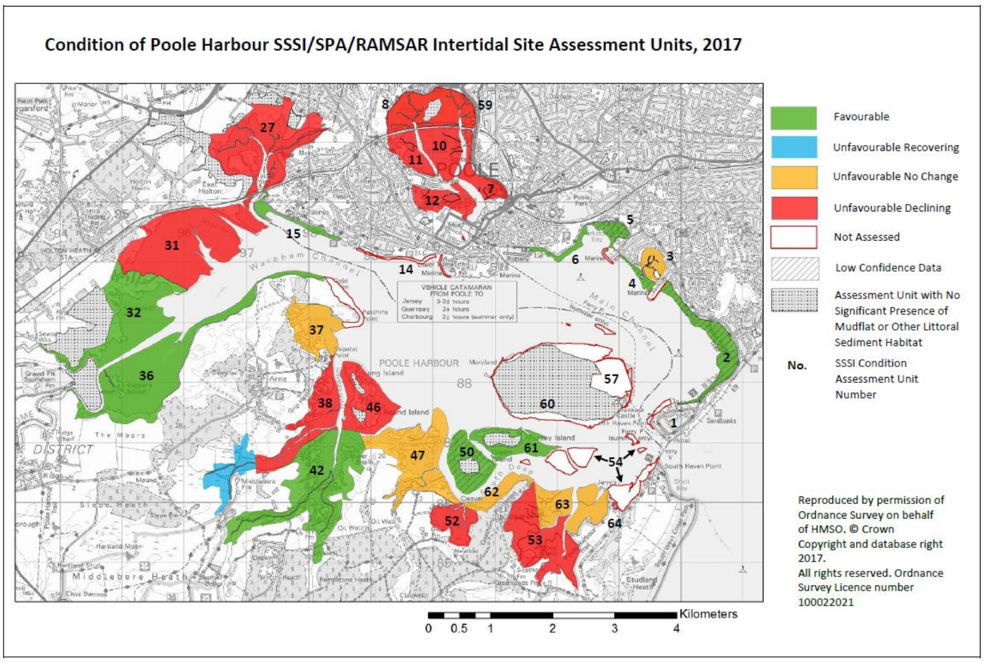
Poole Harbour has been identified as an area with a requirement to RESTORE water quality, including winter DIN and macroalgae condition.

Figure 2.2.1a and b Condition of Poole Harbour SSSI, SPA and Ramsar site intertidal assessment units, 2017 (Source NE)

a) Assessed using the UKTAG Opportunistic Macroalgae assessment tool CAPTAIN v12.8.



b) UKTAG (2017)



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Whist the updated UK TAG methodology provides further refinement to WFD assessment, identifying where across the water body, macroalgae issues are being observed, overall assessment of compliance modelled in Section 6 of the report will be compared with model findings for the whole of the water body. When interpreting data at a finer resolution, care must be taken to ensure the sampling approach was design for this scale of assessment.

2.3 Requirement to Deliver the Conservation Objectives of Poole Harbour SPA

'Favourable Conservation Status' (FCS) is a concept defined in Article 1 of the Habitats Directive and is referred to in Regulation 3 of the Habitats Regulations. In this sense it is applicable to those habitats and species listed in Annex I and II of the Habitats Directive. Note that this concept does not apply to wild birds and those species listed in Annex I of the Wild Birds Directive. This requirement is expressed in Article 2(2) as follows:

"*Measures taken ... shall be designed to maintain or to restore, at a favourable conservation status, natural habitats and species of wild fauna and flora of Community interest*"

The Favourable Conservation Status of a natural habitat or species has to be considered across its natural range according to the Habitats Directive. Range will include the distribution of habitats and species both within and outside the protected sites network. Each Natura 2000 site contributes to the ecological coherence of the network and so any assessment of FCS would need to include contributions at the site level.

Favourable Conservation Status should <u>not</u> be confused with the term 'Favourable Condition'. The latter does not appear in the Directives or the Regulations. In the UK favourable condition is defined by the monitoring targets and attributes for habitats and species that were and are used to measure progress towards the UK Government's SSSI objectives according to UK agreed monitoring standards. As the majority of European sites in England are composed of one or more SSSIs, the monitoring of feature condition for SSSIs has to date been interpreted to apply to the measurement of favourable condition for habitats and species that form interest features at both the European and national site level.

Site-level Conservation Objectives are required to ensure that each part of the site makes a full contribution to the Directive's overall aim of achieving a Favourable Conservation Status (FCS) for the site's qualifying habitats and species across their natural range in the UK.

Article 6 of the Habitats Directive makes it clear that in order for individual SACs to contribute to the achievement of FCS, a dual approach at a site-level is to be applied;

- *proactive* conservation measures are to be established which maintain or where necessary restore the conservation status of each qualifying feature on each site, based on their ecological needs (required by article 6(1)),

  and;

- *preventative* steps are to be taken to generally avoid the deterioration of qualifying habitat features and the significant disturbance of qualifying species (under Article 6(2)), and, more specifically, to ensure an assessment is made of those new plans and projects likely to have a significant effect on SACs before they are allowed to proceed (under Articles 6(3) and 6(4)).

It is worth noting that Article 6 of the Habitats Directive should be construed as a coherent whole, and that the provisions of Articles 6(2) and 6(3) are designed to ensure the same and equivalent level of protection is applied to all European Sites (SAC, SPA & Ramsar).

There is also a need to consider the supporting habitat alongside the bird features of the SPA to ensure the conversation objectives of the SPA are met, as set out in the Supplementary Advice on Conservation Objectives (SACO).

The Habitats Regulations have no timetable for the appropriate steps, however, timetables are set in place by WFD. This requires the objectives of Protected Areas such as Poole Harbour to be met at the latest by 2015. Extended deadlines to this timescale, on a 6 year cycle to 2027, are allowed for specified reasons: that completing the improvements within the timescale would not be technical feasibility or would involve disproportionate cost, or the required improvements to the environment are delayed by natural conditions. Compliance with the objectives for Poole Harbour as a Protected Area has been extended to 2027 under the WFD Regulations 2017.

The Habitats Regulations, in relation to marine N2K sites such as Poole Harbour SPA, require all authorities to exercise their functions which are relevant to nature conservation, including marine conservation, so as to secure compliance with the requirements of the HR and WBD. In the case of marine sites, any relevant authority may go further and establish a management scheme under which their functions (including any power to make byelaws) must be exercised so as to secure compliance of the marine site with the requirements of these Directives.

Similarly, the WFD Regulations 2017 include requirements to secure compliance with the requirements of the WFD, specifically in relation to the Secretary of State and EA. A programme of measures must be prepared by the EA to secure the environmental objectives for each river basin district, including water bodies that are Protected Areas, and from 2009 the programme must be updated on a 6 year cycle. **The Secretary of State, EA and all public bodies** must, in exercising their functions, have regard to the river basin management plan.

3 Actions undertaken to deliver Conservation Objectives Prior to Judicial Review.

3.1 Implementation of the Urban Waste Water Treatment and Nitrates Directives under their domestic Regulations

Poole Harbour was designated as both a Sensitive Area [Eutrophic] under the Urban Waste Water Treatment Directive (UWWTD) and a Polluted Water [Eutrophic] under the Nitrates Directive in 2001.

The UWWTD requires further reduction of nutrients from wastewater discharges into marine Sensitive Areas and their catchment areas unless it can be demonstrated that the removal will have no effect on the level of eutrophication. Poole sewage treatment works (STW; now referred to a Waste Water Treatment Works, WWTW) was identified as requiring nitrogen reduction by 2008. This scheme became operational in December 2008 with a discharge consent limit of 10 mg/l Total Nitrogen mean annual concentration. After an initial experimental period, in 2010 the scheme was calculated to be removing around 240 tonnes N from its discharge into the harbour, a reduction of nearly 40% from the total N load of WWTWs discharging into the harbour and its landward catchment (Figure 3.2.1). Under Stage 4 of the RoC, the modelled reduction in nitrogen load achieved by Poole Harbour N removal for 2004 was 304 tonnes (Leegwater & Jonas 2010).

Subsequently EA has identified a requirement under the UWWTD for N removal at Wareham WWTW by 2021, setting a permit limit of 15mg/l. This for 2010 discharge volume would reduce the discharge load from around 29 tonnes to 17 tonnes N, a 12 tonne N yr reduction. EA has identified no further requirements under the UWWTD for N reduction from other WWTWs that discharge directly into Poole Harbour or into its landward catchment area.

Poole Harbour Sensitive Area was identified in a context of nitrogen enrichment and to date no requirements have been identified for P removal at WWTWs under the UWWTD. Some WWTWs in the landward catchment area have or will have P removal under (periodic review) other programmes not connected with Poole Harbour (3.4).

With designation of Poole Harbour as a Polluted Water [Eutrophic] under the Nitrates Directive nearly all the catchment area has been defined as Nitrate Vulnerable Zones (NVZs). The Nitrate Regulations set limitations in NVZs on the application periods and amount of nitrogen fertiliser and organic manures that can be applied through the year. Using the Farmscoper model, the NVZ rules and background changes in farming are calculated to reduce nitrate-nitrogen loss from agricultural holdings in the Poole Harbour catchment by about 170 tonnes based on 2010 land use, a reduction of 8% (Table 3.5.1.1) (Gooday et al, 2017).

3.2 Review of Consents

The EA reviewed the impact of permitted discharges into the Poole Harbour catchment, under Regulation 63 of the Conservation of Habitats and Species Regulations 2010, the Review of Consents (RoC).

Following the polluter pay principles, the RoC identified the proportionate nutrient load that entered the Poole Harbour catchment and identified the reduction that would be required from permitted discharges to achieve their “Fair Share” reductions (Section 4.4). The largest discharges were from Wessex Water and a number of their permits were varied to deliver these objectives. The primary way this was achieved was by setting a 10 mg/l total N (annual average) permit condition for final effluent from Poole WWTW and a standstill provision on five other discharges, Dorchester, Wareham, Lytchett Minster, Blackheath, and Wool WWTW. Nitrogen removal at Poole, resulted in a c240 tonne N/yr reduction in N being discharged to the harbour or c980 tonnes N/yr when comparing influent flows to the WWTW and the load discharged from the WWTW.

The approach used in the RoC established that the major part of the N load carried by the rivers came from diffuse sources. This diffuse load, largely attributed to the agricultural sector, would also need to be substantially reduced. Under the Habitats Regulations, in situations where the permissions being reviewed are a contributor but not the sole cause of an impact, the authority undertaking the review may affirm the permissions where it appears to them that other action to be taken by them, or by another authority, will mean or ensure the permissions do not adversely affect the integrity of the N2K site.

The RoC concluded (EA, 2010) by:

- affirming, without change, all discharge consents into Poole Harbour and its catchment;

- recommending a standstill provision on N at Dorchester, Wareham, Wool, Lytchett Minster and Blackheath WWTWs to avoid deterioration from increase in the discharged N load considered in the HR appropriate assessment;
- recommending development of a Nitrogen Management Plan incorporating, as an initial starting point, actions on expanding the NVZ, delivery of Catchment Sensitive Farming and Higher Level Stewardship schemes, water company Asset Management Plans (AMP) and WFD requirements to enable a conclusion of no adverse effect on integrity.

3.2.1 Implementation of actions from Review of Consents on permitted discharges

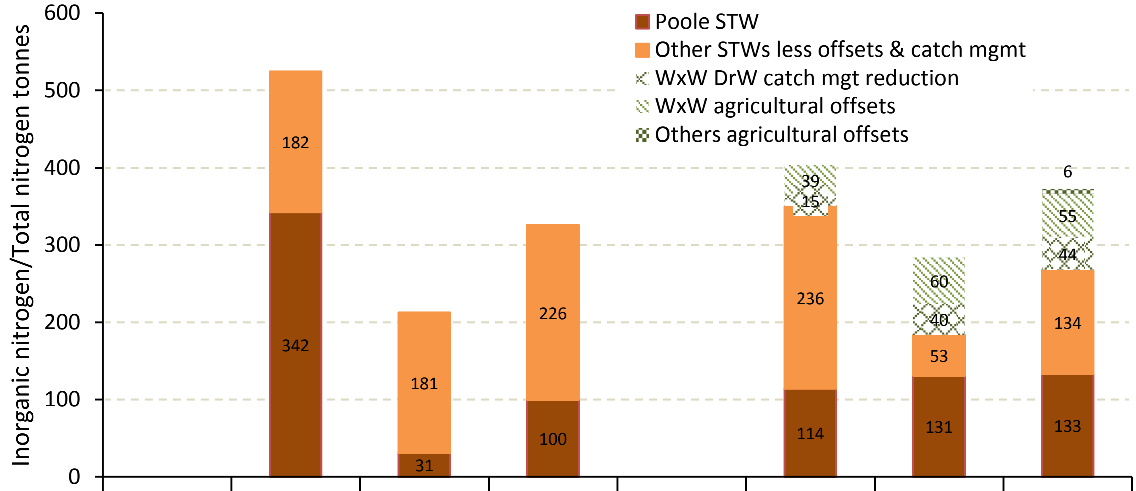
The outcome of the RoC on permitted discharges informed statutory requirements in subsequent AMP periods for Wessex Water as follows:

- AMP5 (2010-2015) Investigation to understand the contribution of Wessex Water WWTW assets to nutrient enrichment (primarily nitrogen) within Poole Harbour relative to other sources and to consider the impacts of future development (reported in Wessex Water, 2012).
- AMP6 (2015-2020) Catchment management to deliver nitrogen reductions of 40 tonnes/year by 2020 to offset the existing load from Dorchester WWTW. This equates to the RoC standstill provision on N load at the 5 WWTWs, as calculated in Wessex Water (2012) from predicted WWTW load increases to 2035 with development growth.

The effect of the UWWTD and HR RoC on wastewater discharges by Wessex Water WWTWs, and reductions by the company from agricultural diffuse sources through catchment management, are shown in Figure 3.2.1. Variability in some year to year data reflect incomplete monitoring and assumptions made by the company to fill the gaps. WWTW loading reduced from around 680 tonnes in 2004 to around 326 tonnes in 2010/11 to meet UWWTD and Wessex Waters Fair Share. As Wessex Water trialled the new treatment plant, WWTW loads were lowered further than this.

Since variation of Wessex Waters permit at Poole WWTW, in January 2009, the annual N load discharged by these WWTWs has increased by over 100 tonnes, particularly at Poole where the discharge in more recent years has been managed much closer to the consent limit. Much of this increase has been ‘offset’ by reductions in N losses from agricultural land through a combination of the AMP6 catchment management scheme and other catchment management by Wessex Water to reduce nitrate concentrations in groundwater drinking water sources in the catchment. However, the reduction in N losses calculated from agricultural land is likely to be less than the equivalent increase in N emissions by WWTWs, particularly those discharging direct into Poole Harbour, due to catchment groundwater delays and natural process that remove N from drainage water moving through catchment soils and wet environments. All such changes have been within permit headroom and fair share reduction requirement at the time.

Figure 3.2.1 Annual wastewater nitrogen loads emitted into the Poole Harbour catchment by Wessex Water Waste Water Treatment Works (WWTW) before and after the implementation of regulatory control at Poole WWTW in 2008, and the scale of offsetting from agricultural diffuse sources relative to these loads (source: Natural England from Wessex Water unpublished data)



Year	pre 2009 / RoC	2009	2010/11	-	2015	2016	2017
STW total t/N/yr	524	212	326	-	403.5	284	372
less offsets	524	212	326	-	365	224	311

3.3 Nutrient Management Plan and Target Setting

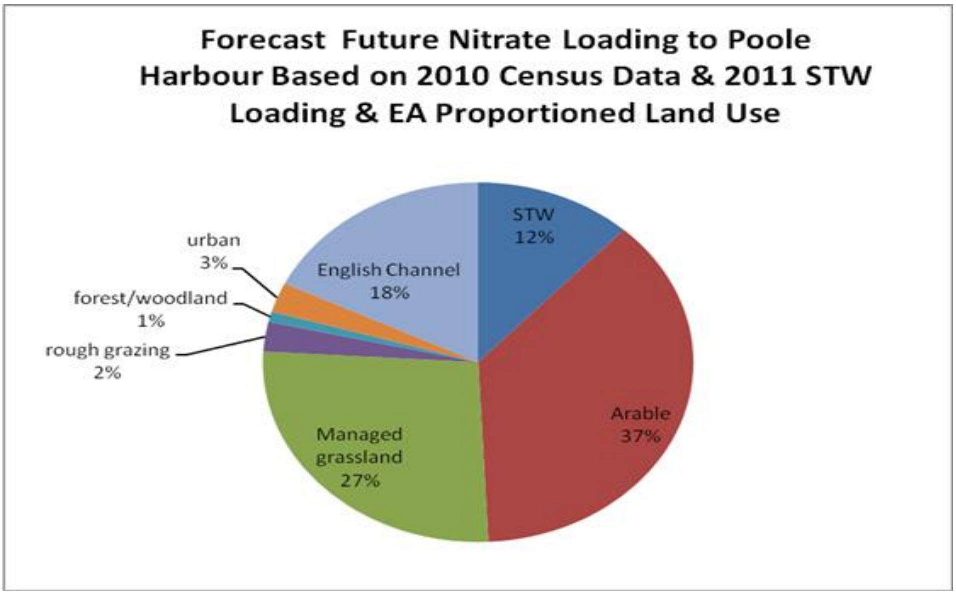
The requirement identified by the RoC for a Nitrogen Management Plan was taken forward jointly by EA and NE as a Nutrient Management Plan (NMP): "Strategy for managing Nitrogen in the Poole Harbour Catchment to 2035" (Bryan et al, 2013). This sets out a strategy, supported by an accompanying technical report (Kite et al, 2012), to reduce the nitrogen load from point and diffuse sources to meet favourable condition of Poole Harbour and, where technically feasible, WFD Good status for the waterbody by 2027.

http://webarchive.nationalarchives.gov.uk/20140328091437/http://www.environment-agency.gov.uk/research/library/publications/148450.aspx

These documents reviewed information on the N load entering the harbour from its catchment, the biological effects and the sources of N, and modelled strategic catchment scale scenarios for reducing the N load and the effect on macroalgae biomass. Technically feasible options and possible delivery mechanisms are identified to meet a target nitrogen load in the harbour.

Updated source apportionment from the work, concluded that of the total nutrient load entering the harbour, c64% was estimated to come from Arable and Managed Grassland, 18% English Channel, 12% WWTW and the remainder from urban, rough grazing and forested areas Figure 3.2:1.

Figure 3.2:1 Forecast Future N Loading to Poole Harbour Based on 2010 Census Data & 2011 WWTW (from NMP 2013)



The technical report also identified phosphorus as being important in controlling macroalgae growth. This was not taken forward in the strategy, as there was uncertainty on P loadings to the harbour and its role in the harbour in limiting algal growth. This evidence has now been reviewed and different conclusions have been reached (Section 5).

The NMP confirmed earlier work showing very considerable inputs of inorganic nitrogen into Poole Harbour from its catchment. N loads (excluding the marine sources) were calculated to have risen from around 1730 tonnes N/yr in the early 1980's to around 2100 in 2010-11 and had approximately doubled in the last 50 years. Nitrogen loads were forecast to rise and stabilise at around 2300 tonnes/ N/yr based on 2010 land use, 2010-11 waste water discharge quality, and predicted growth to 2035.

The NMP recommended a limit for inorganic nitrogen based on documented historical evidence on the abundance of macroalgae mats in the harbour, evidence on the rise in nitrate concentrations carried by the inflowing rivers and emerging water quality standards from UK TAG and others. An interim approach was identified, recommending nutrient levels were reduced to early 1980s levels, 1730 tonnes N/yr, when macroalgae mats had developed to a scale warranting scientific attention as a basis for the delivery of measures to limit the nitrogen load. Modelling using the CPM model suggested limiting the N load to this level would reduce the macroalgae standing stock by about 33% compared with a do nothing approach. This was in a context with recent survey showing dense macroalgae mats (≥75% cover) occurring on 25-30% of the harbour's mudflat area.

Because of the offsetting already delivered by the water company at Poole WWTW under RoC, UWWTD within AMP4, the NMP recommended the majority of the nitrogen reductions bringing loads from c2300 tonnes to 1730 tonnes, should be achieved by diffuse nitrogen load reductions. The report therefore recommended:

- N loads to the harbour should be reduced to 1730 tonnes N/yr (the calculated mean annual load in 1980-84).

- Diffuse loads from **agriculture** (arable and pasture) should be reduced to around 1194 tonnes N/yr (c1200 tonnes N/yr) or c24kg/ha for high nutrient input land (based on 2010 land use).

- Diffuse loads from **all rural land uses** (including agriculture, woodland etc.) should be reduced to c1280 tonnes N/yr or c18 kg/ha (based on 2010 land use).

The NMP also recommended that new development should not result in a net increase in N loads to the harbour. It proposed that this would be achieved by:

- Further nutrient offsetting by water companies (c75% of future loads; to continue to deliver UWWTD and NMP objectives)

- Local Authority offsetting of c 25% of future growth, as detailed in "Supplementary Planning Document".

https://www.poole.gov.uk/planning-and-building-control/planning-policy-and-guidance/supplementary-planning-documents/

Since the publication of the NMP in June 2013 the EA and its partners, have continued to implement the recommendations of the plan. The EA have also continued to monitor water quality in the rivers and estuary and macroalgae densities across the harbour. Wessex Water have monitored water quality discharged from WWTW.

Wessex Water have also been delivering the requirements of AMP 6 program (2015 -2020) to reduce the environmental impact of their permits. Under periodic review (PR19) Wessex Water worked with the EA and NE to agree the further measures and investigations that would and have been implemented under AMP7 to continue to achieve these objectives (section 3.2.2).

3.3.1 Diffuse Pollution Reduction

To reduce diffuse agricultural pollution, it was agreed that the EA and NE would initially work with farmers to try and achieve the reduction on a **voluntary basis** and would review the NMP in 2019-20 (NMP Section 5.5).

A plan was agreed to deliver these objectives "Diffuse Pollution Plan for Agriculture" and the EA and NE agreed a position statement with the National Farmers Union (NFU) and Country Landowners Association (CLA) outlining that farmers should implement "all reasonable measure" to maximise soil and nutrient management efficiencies to achieve these objectives. Details relating to this can be found in:

This diffuse pollution plan outlined how partner organisations would work to help inform and assist farmers, signposting Catchment Sensitive Farming, voluntary agri-environment schemes and Wessex Water's Catchment Management schemes and support as appropriate. It focused on:

- Farmers maximising soil and nutrient management efficiencies to achieve catchment targets, improve farm practices and the environment.

- Partners provide prioritised agricultural advice through single point of contact (primary catchment contact), focusing advice in land areas and activities that present the highest potential risk and greatest environmental gain.

- Advisers help farmers to understand how soil and nutrient management efficiencies can be improved and the environmental risk of not doing so.
- Advisers agree with farmer's further measures that should be put in place to ensure current and future practices do not cause pollution.
- Partner seek farmers to implement measures voluntarily, signposting funding opportunities.
- Where farmers will not engage or implement required measures, EA will undertake compliance visit to assess farm risk. Continued non engagement may result in EA using regulatory tools/powers to ensure farmers do not cause pollution.

The primary means of advice came through **Government assisted support:**

- Catchment Sensitive Farming (CSF).
- Environmental Stewardship [ES - replaced by Countryside Stewardship (CS) from 2015]

Currently about 75% of the agricultural area is covered by ES agreements. This area is expected to decline as agreements expire and fewer holdings enter CS agreements. CSF has engaged holdings covering about 60% of the agricultural area, advising them on suitable measures and helped address many issues through uptake of agri-environment options. This has substantially increased the uptake rates of mitigation measures from the background situation with regulatory requirements, but implementation is estimated to remain below 50% for nearly all measures (ADAS REPORT- APPENDIX 6).

The EA, also commissioned additional advisory visits across the Poole Harbour Catchment by FWAG in 2014-15 to help to deliver the NMP objectives.

This involved:

- On farm trials and events
- Bespoke visits to demonstrate and promote the benefits of efficient N use in the Frome and Piddle catchments
- Piloting the use of a Nitrate Leaching Tool (NLT) to assist in identifying farm nutrient losses and measures that could be put in place to maximise soil and nutrient management efficiencies.
- Preparation of literature

The effectiveness of this approach in reducing diffuse nitrogen loss from agriculture is difficult to distinguish from that which would have been achieved by delivery schemes without the approach and from background changes in agriculture in the catchment (Table 3.5.1.1). But the approach is anticipated to provide an uplift in the effectiveness of these schemes.

Over this time the EA have used available resource to continue to enforce existing laws and regulations, following the principles outlined in Wessex Diffuse Pollution Plan (Annex 7).

The approach has been very useful in getting agreement on roles and responsibilities and improving the efficiency of working relationships. Partners have however, advised that in some instances, this may have made it harder to influence some farms into delivering their legal obligations. This is because in following the principles in the position statement the EA would not typically visit a farm unless a problem had been reported or the EA had looked at data, such as for Safeguard Zones.

Despite all this support to farmers, agriculture have only achieved a very small proportion of the overall nitrogen reduction that is required (See Section 5.2).

3.3.1.1 Current legal powers to prevent diffuse pollution

Nitrate (N) and phosphorus (P) are non-hazardous pollutants and farmers (and other land holders, owners) must not cause or knowingly permit the entry of polluting matter to inland freshwaters or coastal waters otherwise they commit an offence [Environmental Permitting Regulations 2016 Regulations 38(1) (a) and 12(1) (b)][6].

Farmers should ensure they are compliant with other regulations such as Nitrates Pollution Prevention Regulations 2015 (NVZ Regulations), Reduction and Prevention of Agricultural diffuse Pollution Regulations 2018 known as New Farming Rules for Water - GOV.UK (April 2018), Water Resources (Control of Pollution) (Silage Slurry and Agricultural Fuel Oil) Regulations 2010 (SSAFO) and other relevant regulations and Directives. Farmers should implement the measures appropriate to ensure they are compliant with the most stringent regulations and Directives relating to their activities. Compliance with Nitrates Directive (and NVZ Regulations) is not therefore a defence to breaches of other Directive requirements.

The environment Agency shall enforce laws that protect the environment, in line with the Environment Agency enforcement and sanctions policy.

Recommendations on the level of nutrients applied to land to achieve the best financial return for a farm business are produced by the AHDB, a statutory levy board funded by the farming industry. The Codes of Good Agricultural Practice (COGAPs) produced by Defra in collaboration with the farming industry bring together much of the legislative context as Statutory Management Requirements (SMRs) for those claiming farm payments and as guidance on Good Agricultural and Environmental Conditions (GAECs) to protect the quality of water, air and soil. The Nitrate Regulations set limitations on the amount of organic manures that can be spread through the year and timing of its application. High levels rules for this are as follow:

Within NVZ

- Farm limit of 170kg N/ha/year from livestock manures averaged over the total area of the farm.
- Field limit of 250kg N/ha/year from livestock manures. These figures exclude the load deposited by animals whilst grazing.
- Additional inorganic N can be applied in accordance to crop requirements outlined in RB209[4]

Outside NVZ

- Field limit of 250kg N/ha/year from livestock manures. These figures exclude the load deposited by animals whilst grazing.
- Additional inorganic N can be applied in accordance to crop requirements outlined in RB209[4]

Modelling work and field observations across the country and within Poole Harbour have shown that this alone is not sufficient to prevent pollution. N applications at the maximum rates allowed under the Nitrate Regulations and recommended by RB209 may still result in pollution and as a result Poole Harbour farmers may need to go further.

Where a farms use of N and P or farming practices result in pollution, some of the measures available to the EA beyond Nitrate Vulnerable Zones for controlling N inputs to groundwater are:

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[6] In 2012, the Environment Agency Diffuse Pollution Project Board, agreed that where farmers fail to take all reasonable measures to reduce nutrient losses to an acceptable level, the Environment Agency should use the Environmental Permitting Regulations 2010 and or other powers to control their use of nitrogen

- works notices under section 161A WRA 1991
- Environmental Permitting Regulations (EPR) 2016 Schedule 22 (9)(2) issue a prohibition notice or under EPR (2016) Schedule 22 (10)(2) require farmers to apply for a permit to use these chemical.
- Application for Water Protection Zone

New Farming Rules for Water (April 2018) [New Farming Rules for Water - GOV.UK] bring additional requirements that will further improve the control of nutrients, these are summarised below.

1. Planning use of manures and fertilisers

- Plan in advance each application or organic manures and manufactured fertilisers to meet but not exceed soil and crop nutrient needs
- Your planning must take into account soil testing for pH, N, P, potassium (K), and magnesium (Mg). N levels can be determined by assessing soil N supply instead of soil testing.

2. Organic manures must not be stored on land

- Within 10 metres of inland freshwaters or coastal waters
- Where there is significant risk of pollution entering inland freshwaters or coastal waters
- Within 50 metres of a spring, well or borehole

3. Organic manures or manufactured fertilisers must not be applied

- If the soil is waterlogged, flooded or snow-covered
- If the soil has been frozen
- If there is significant risk of causing pollution

4. Organic manures must not be applied

- Within 10 metres of and inland freshwaters or coastal waters
- Within 50 metres of a spring, well or borehole

5. Manufactured fertiliser must not be applied

- Within 2 metres of inland freshwaters or coastal waters

6. You must take all reasonable precautions to prevent significant soil erosion and runoff from

- The application of organic manure and manufactured fertiliser
- Cultivation practices and harvesting
- Poaching by livestock

7. Protecting against soil erosion by livestock

- Any land within 5 metres of inland freshwaters and coastal waters must be protected from significant soil erosion by preventing poaching by livestock

8. Livestock feeders must not be positioned

- Within 10 metres of any inland freshwaters or coastal waters
- Within 50 metres of a spring, well or borehole
- Where there is significant risk of pollution

The full implementation of these rules will significantly improve the control of nutrients across the Poole Harbour catchment as it makes clear that organic and inorganic fertilizers should not be applied in excess of the crop need and any application needs to be justified/supported by soil testing. Like other legislation it also confirms that agricultural activities should not result in pollution.

If fully enforced the implications of these rules will help to significantly reduce soil nutrient leaching. For example manure should not be applied where the soil has a high "P" index. This means farmers may need to transport their manure further from their farm to meet this condition. No activities should take place that result in excess nutrient loss that would result in pollution.

Other legislation driving pollution reduction include, inter alia: Silage, Slurry and Agricultural Fuels Order 1991 (SSAFO); Habitats and Birds Directive; Nitrates Directive 1991; Environmental Permitting Regulations 2010; Water Resources Act 1991 and the Reduction and Prevention of Agricultural Diffuse Pollution (England) Regulations 2018. It is essential that before any new regulatory tools are used that the existing tools are enforced and effectively targeted and implemented.

3.3.2 Current point source reductions and offsetting: Achieving Nitrate Neutrality

3.3.2.1 Water Company improvements

Having delivered the majority of point source fair share nutrient loading reductions under water company Asset Management Planning Cycles 4 (2005-2010), further measures were delivered during AMP5 (2010-15) and AMP6 (2015-2020).

AMP 6 measures include catchment management schemes offsetting for WWTW growth at Dorchester (c40 tonnes N/yr) and in Safeguard Zones to prevent the need for further treatment. Further benefits are delivered by these initiatives in offsetting P and wider biodiversity improvements.

Further measures are being implemented under AMP7. AMP6 and proposed AMP7 schemes are outlined in Table 3.1 below.

Table 3.1 Summary of the water company catchment schemes in the Poole Harbour catchment under AMP6 and AMP7

	Current Total permit mg/L	Proposed P limit (WINEP3) mg/L	Permit dry weather flow M^3/day	Estimated Nutrient Reduction in discharge[*1] (tonnes/yr)	Completion date
Maiden Newton WWTW	P:None	1	318	0.46	April 2020
Corfe Castle WWTW	P: None	1.3	370	0.50	December 2021
Piddle Hinton WWTW	P: None	4	295	0.11	April 2025
Dorchester WWTW	P: 1mg/l	0.7	9450	1.04	April 2025
Cerne Abbas WWTW	P: None	0.8	159	0.24	December 2021
Wareham WWTW	N: None[*2]	15 mg/l N	2502	10.35	December 2021
AMP 7 Investigations					
Title			**Objective**		

Poole Harbour Catchment WWTW N and P Data Collation	Collate water quality data for all WWTW assets within the catchment to understand source loading
Holes Bay N and P Investigation	To identify the water quality impact of Poole WWTW on N and P concentrations within Holes Bay
Poole Harbour NSW Shellfish Investigations	Investigate the impact of WWTW assets on Shellfish
Dorchester Seasonal Permitting Investigation	To identify the feasibility and benefit of seasonal permitting at Dorchester WWTW
Dorchester Frome Compliance Investigations	To identify the impact of WWTW and water company assets on the River Frome between Dorchester and Wareham and identify measures that can be put in place to achieve CSMG targets

*1 assuming an existing TP discharge of 5mg/l where no current treatment is in place. *2 existing discharge quality of 26.33 mg/l N.

3.3.2.2 Local Authority Improvements

The NMP outlined that Local Authorities should offset c25% of N load from forecast future growth. The EA and NE identified how this might be achieved in their "principles paper"; http://webarchive.nationalarchives.gov.uk/20140328091437/http://www.environment-agency.gov.uk/research/library/publications/148450.aspx

Poole Borough Council produced and adopted a "Supplementary Planning Document" outlining their nutrient offsetting approach in the following document:

> https://www.poole.gov.uk/planning-and-building-control/planning-policy-and-guidance/supplementary-planning-documents/

The ways in which nutrient offsetting is being achieved is outlined in this document. Initial reductions have been achieved through:

- Reverting a local authority owned farm from high input nutrient activities to low input.
- Purchasing land to install a wetland to provide future offsetting opportunities.

3.4 Other Initiatives, deliver pollution reduction

River restoration schemes, enhancing river and riparian habitat to more natural structural diversity can increase de-nitrification in surface water drainage and river flow. There are two schemes that operate in parts of the catchment:

- River Frome SSSI rehabilitation plan. A long-term initiative, led and funded by EA, to restore the morphology of the River Frome SSSI to favourable condition.
- Dorset Wild Rivers. A long-term initiative by the Dorset Wildlife Trust, funded by the Water Company and EA, centred on enhancement works along mostly smaller watercourses.

Poole Harbour **Catchment Initiative** (Catchment Based Approach) hosted by Wessex Water also brought together catchment stakeholders in a Delivery Group and farming interests in a Farmers

Group. Through this initiative EA, NE, CSF and the water company work in synergy in providing advice to farmers, focussing on the farms that present the highest potential diffuse pollution risks and working with them to identify how they can reduce these risks and meet the catchment targets. Where appropriate, modelling tools are used to assist farmers in understanding the impact their land use practices are having, and identify through modelling the most efficient measures to implement to reduce diffuse pollution.

4 Judicial Review Consent Order process and key principles

The Consent Order requires the EA, working with NE, to identify if current measures/interventions will achieve protected area objectives for each N2K site (if the site is at unfavourable condition due to diffuse water pollution). If they do not, this work should evaluate how far the existing interventions (measures and mechanisms) will take us and identify if additional or alternative measures are needed. This could include the need for a WPZ.

The details below provide some clarity around key principles for the Diffuse Water Pollution JR Consent Order work which are applicable to Poole Harbour, qualitative targets, feasibility, fair share, and baseline assumptions. This has been taken from EA guidance agreed with NE.

This report is further informed by environmental principles listed in the EU (Withdrawal) Act 2018 and which the government has committed to incorporate in legislation with an accompanying statutory policy statement. The environmental principles relevant to the Consent Order process, as defined in the government information paper on the matter[7], are taken to be:

(a) The precautionary principle so far as relating to the environment:
'…the principle that, where there are threats of serious or irreversible damage, lack of scientific certainty shall not be used as a reason for postponing coast-effective measures to prevent environmental degradation.'

(b) The principle of preventative action to avert environmental damage:
'The principle states that action should be taken to avert environmental damage, rather than simply tolerate or rectify it after it occurs. This means that measures should be taken to avoid harm, such as pollution.'

(c) The principle that environmental damage should as a priority be rectified at source:
'The principle means that environmental damage should, as a priority, be addressed by targeting its original cause and taking preventative action at the origin of the problem.'

(d) The polluter pays principle:
'The principle provides an overarching convention of environmental responsibility and cost allocation. (It) helps to manage the costs of damage to the environment by setting out an approach that, where possible, the costs should be borne by those causing the damage.'

4.1 Application of water quality targets

The relevant habitat CSMG sets out the water quality targets for achieving favourable condition, including P, N and sediment. Although the CSMG targets are advisory, for the preparation of the 2015 River Basin Management Plans (RBMP) local NE and EA teams agreed P targets for some rivers,

[7]https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/766299/env-bill-information-paper.pdf

with an interim (for 2021) and long term (for 2027 and beyond) objectives. The 2021 targets were based on what is achievable with current measures and planning assumptions. These agreements were based on CSMG and local evidence and knowledge available at the time. The NE CSMG long term targets (for 2027 or beyond) are the best guide to what is required to meet protected area objectives.

For rivers feeding into the harbour, the CSMG provides a choice for setting the P targets for favourable condition, between:

a. 'Maximum concentrations for achieving favourable condition' for sites which have significant anthropogenic impacts and therefore it is not feasible to restore the site to near natural levels; and

b. 'Near natural concentrations' for sites which have little or no anthropogenic impact and therefore are already achieving this target or where it is feasible to restore the site to these levels.

For a river reach which is not compliant with scenario "a", the target should be adopted to achieve conservation objectives.

CSMG guidance for rivers suggests that targets for total inorganic N can be set if there is site-specific evidence for this. Any proposals for river N targets would require review by NE and EA nationally. The EA believes that further technical and policy review is required prior to adoption of river N targets. N targets are however set for estuarine environments.

4.2 How to deal with qualitative targets

There are some sites (e.g. terrestrial wetlands, estuaries and coastal sites) or water quality attributes (e.g. sediment), with qualitative or ecological based targets (as opposed to quantitative water quality targets). This, as is the case with Poole Harbour, can make it difficult to assess whether measures and mechanisms needed to achieve the objectives are sufficient. In these cases there are two potential approaches:

a. In the majority of cases, a reduction target which is expected to achieve favourable condition should be agreed locally between NE and EA in consultation with stakeholders, with an agreed escalation route if needed. The reduction target should be based on the best available evidence. There are several approaches that could be used to develop a reduction target as suggested below. These should be prioritised using data where possible, modelling and expert opinion in that order.

    - modelling to determine the water quality that will achieve the desired ecological outcome (macroalgae modelling),
    - water quality (including loading) information from a comparable favourable site,
    - water quality (including loading) information from a historical time when the site was favourable,
    - standards or thresholds from other relevant directives or assessments,
    - expert opinion based on the known requirements/sensitivity of the interest feature(s) in question.

b. In a few cases where the habitat would under natural conditions have very little nutrient input e.g. raised bog, it may be appropriate to look to remove any anthropogenic sources within the constraints of feasibility set out in the water quality targets section above.

It is acknowledged that for attributes where a reduction target has been agreed, there will be greater uncertainty over whether this will actually achieve favourable condition and therefore it is likely that an adaptive management approach will be needed.

In Poole Harbour, modelling tools have been used to set water quality targets and these will need to be updated and reviewed through time to ensure they are sufficient to deliver the required outcome.

4.3 Consideration of feasibility

Technical feasibility will limit the measures and mechanisms identified and considered within the options appraisal. A technically feasible solution, is one that can be implemented through reasonable use of the tools available. What is technically feasible will vary between sites depending on the local conditions in the catchment, but might include:

- use of advice and incentives (e.g. CSF/CS) based on a realistic assumption as to the likely uptake of measures,
- a WPZ to address agricultural pollution in a catchment,
- technically achievable limit (TAL) at a sewage works which will be the limit of treatment available at that site,
- moving a point source discharge point to a suitable location agreed with water companies.

The scope of the options appraised, should be as wide as necessary, while being constrained by their technical feasibility, but not by socio-economic factors at this stage. The evidence around the socio-economic impacts as well as the effectiveness, cost and benefits of the different options should be gathered as part of the options appraisal and used at the decision making stage to identify the most appropriate measures and mechanisms that could achieve favourable condition.

4.4 Fair Share

The requirement of the Consent Order is to identify the most effective measures and most appropriate mechanisms to achieve the objectives for the site. In the options appraisal, all technically feasible options should be identified and considered, this can include options that go beyond fair share. However, the fair share principle will be applicable to the implementation of the measures and mechanisms identified as a result of the options appraisal at least until the end of PR19 timescales. The Consent Order work should explore what might be necessary beyond current planning assumptions, to determine if policy changes are required. Outcomes from the Consent Order work would inform the review of fair share and the approach used in PR24 and river basin management planning

When looking at an option based on fair share, the baseline should be set to 2009 to account for actions that have already been undertaken by a sector. The use of a 2009 baseline should be applied to the consideration of agricultural measures as well as WWTW measures; this ensures a consistent and workable approach. Within PR19 timescales, the water industry will adhere to its fair share contribution if there is growth at WWTWs.

Water companies may choose to do more than their fair share where this is supported by their customers (i.e. those who ultimately pay for the measures).

Where it is not technically feasible for a sector to achieve its fair share reduction, we shall identify alternative technically feasible and cost-effective measures to deal with the problem.

4.5 Options Appraisal

4.5.1 Identifying Options

The purpose of this report is to identify if current interventions or measures will deliver favourable condition across Poole Harbour. Where it is not likely to, the report reviews any additional interventions which will achieve compliance with the above targets.

The interventions, or options, will identify various levels of reduction in sector inputs (WWTW, industry, agriculture etc.). Some options could have reductions all in one sector, others over multiple sectors. The fair share option is the one where all sectors make reductions in their contribution based on the proportion they contribute. When determining whether options will meet the long term rCSMG targets, the starting point should include existing WWTW permit conditions and take into account potential developments/changes within catchment.

Recommendations put forward as part of the report are summarised in Section 11, but highlighted through the report by use of boxes and use of "®".

4.5.2 Appraising Options

The options identified should be appraised for their:

- Technical feasibility
- Practical Feasibility
- Socio-economic impacts
- Proportionality (fair/share)
- Cost/benefit
- Regulatory instrument (e.g. WPZ)
- Delivery timescale

These factors will be used at the decision making stage. A description of each definition is detailed in Table 4.5:1 below.

Table 4.5:1 Definition of Option Appraisal Definitions

Option appraisal	Definitions	Description
Technical feasible	Yes/No	Is the solution technically feasible to deliver?
Practical feasibility	High/Medium/Low	Is the option highly practical to implement or of medium to low practicality?
Socio-economic impact	High/Medium/Low	What are the socio-economic impact of the measure
Cost Beneficial	Yes/No	Is the option cost-beneficial compared to other options?
Proportionality (fair Share)	Yes/No	Is it proportional within fair share?
Regulatory Instrument	Yes - No (WPZ) Policy	Is a regulatory instrument in place to deliver this and is it within existing guidance? Yes or No Policy= if policy change is required such as to go beyond fair share.

Delivery timescales	2018-20 (AMP6) 2020-25 (AMP7) 2025-30 (AMP8)	Years, aligning to water company Asset Management Planning (AMP)

5 Consent Order Review: Updated Evidence and Catchment Objectives

5.1 Conservation Status of Poole Harbour Catchment

As outlined in Section 2.2, WFD assessment (2016) highlight that the harbour is at “Moderate” status as a result of dissolved inorganic N and macroalgae conditions. But with a requirement to “Restore” water quality and macroalgae condition. Using the updated UK TAG guidance (in 2017) classification approach, the harbour is failing its conservation objectives (Figure 2.2.1).

Changes have been made to the targets since publishing the NMP. The reduction advised in the NMP (Section 1.2) state that:

- the extent of thick algal mats (> 2kg/m) is limited to <5% across Poole Harbour as a whole, and < 10% cover of any individual mudflat.

A revision to these targets is proposed by UKTAG (2017), using a wider base of monitoring information and state that:

- Average modelled biomass of <c500g/m2 is required across the available intertidal habitat, to ensure there are no adverse effect from opportunistic macroalgae.
- A wet weight macroalgae biomass of 1.0 kg/m^2 on suitable intertidal habitat should be used as a threshold value in, for example, assessing field data, as the point at or above which significant harmful effects on habitat biota are likely to occur.

The tightening of the UKTAG targets from 2014-17, have resulted in a shift from predominantly favourable and recovering condition to predominantly unfavourable, no change or declining condition.

5.2 Source Apportionment and Nutrient reduction from the current strategy

5.2.1 Nitrogen

N loads entering the harbour have increased greatly through time as a result of increased intensification of agriculture and population growth (Figure 5.2:1, Table 2.5:1 and Appendix 3 & 13).

A reduction in discharge load to the harbour of around 240 tonnes N yr was observed after the introduction of N removal at Poole WWTW in 2009, and from a total harbour N loading of 2450-2550 tonnes in 2004 (RoC). This offsetting is forecast to be diminished by continued rise in river concentrations, from around 2050-2100 in 2010/11 to c2200 in 2013-17 (and calculated from observed flow and river concentration; Appendix 12) to around 2300-2400 tonnes N/yr, assuming land use were to remain the same as reported in 2010 agricultural census (Table 5.2:1 & Appendix 12). If Poole WWTW treatment had not been in place, the loading to Poole Harbour in 2010/11 would have been around 2525 tonnes N/yr.

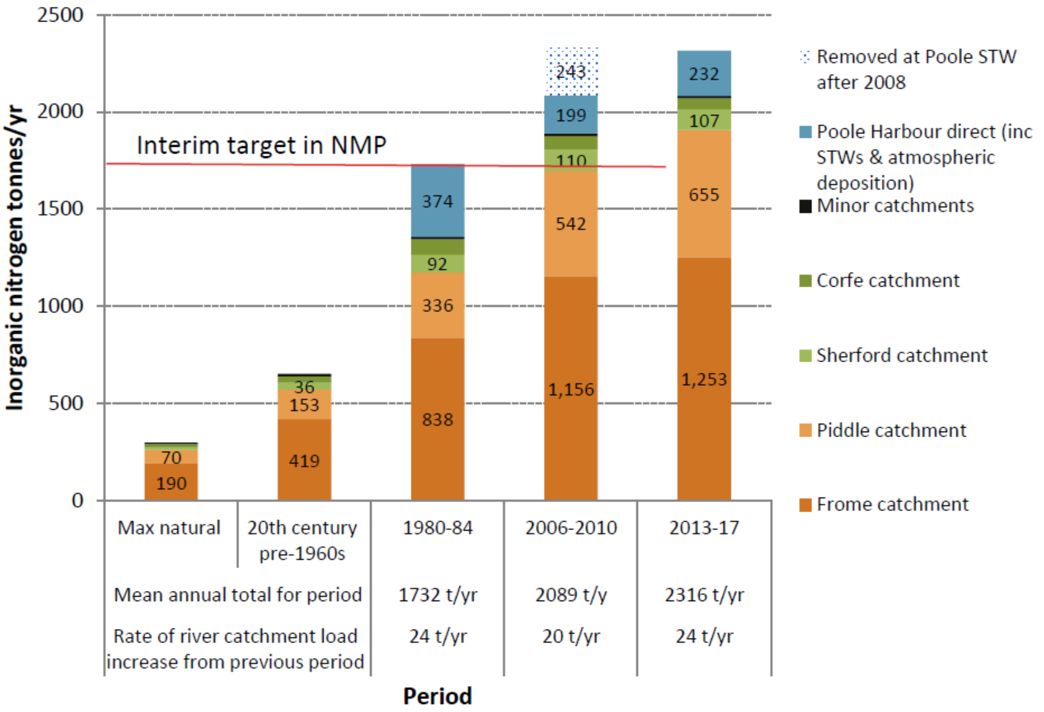
Table 5.2:1 Nitrogen Source Apportionment for 2010/11 based on direct discharge and ADAS modelled agricultural losses in 2010

			Estimated de-nitrification *8	Harbour loading (inc de-nitrification)	
Source Emmissions	(a) Source emmissions 2010 (or later) baseline t N/yr *9	(b) %age of total	®	(d) Loading to harbour	(e) %age of total load
1. STW including Poole STW operating 2010 flows and quality + combined sewer overflow (3.4 tonnes N) *1	331.13	14%	1%	327.16	14%
2. Industrial (Fish farms & cress farms) SAGIS SIMCAT *11	59.93	2%	0%	59.93	3%
3 Agriculture nitrogen emmissions (ADAS Nov 2017) *2	1784.00	73%	2%	1748.32	74%
4. Urban loading *7	123.39	5%	2%	120.93	5%
5. Atmospheric deposition direct to the harbour *3	43.33	2%	0%	43.33	2%
6. Boats and other harbour sources*4	uncertain				
7. Unsewered (including coldharbour) *5	15.77	1%	2%	15.45	1%
8. Non agricultural land [military land, forestry plantations, heathland not in rough grazing; mainly atmospheric deposition))] *6	60.97	2%	2%	59.75	3%
sub total	2418.52			2374.86	

**1 WWTW load (predominantly water company) = estimated 2010/11 WWTW load taken from NMP with Poole WWTW operating at 7.15mg/l discharge quality + estimated combined sewer overflows estimated for Wessex Water in 2017 (3.4 tonnes), WWTW load excludes Godmanston and Stinsford WWTW *2Farmscoper modelling+B97, *3 Atmospheric deposition direct to Poole Harbour from APIS modelling (2014-16 data), p14 in James et al, 2018, *4 No accurate data exists for this source but recognised as potential source that needs to be reviewed and controlled to reduce nutrient input and bacterial input to the harbour from boats and related sources, *5; estimated un-sewered loads from Nutrient Management Plan Technical Annex Table 4b in Kite etal 2012 ,*6 N source emission estimated at 5kg/ha/yr based on source reviewed in Natural England 2000; applied to non-agricultural holdings areas of 12193 ha. *7 estimated as 14.3 kg N/ha/yr based on 8629 ha urban area in 2010 (see Nutrient Management Plan); including small streams entering holes bay, primarily sources from urban catchment. *8 estimated de-nitrification from inland waters Saunders & Kalf 2001. SAGIS-SIMCAT data already includes decay factor so it not duplicated. No de-nitrification is assumed to occur from any direct discharge to the harbour, de-nitrification from WWTW discharges are apportioned between inland rivers (2%) and direct discharges (0%) to give 1.2% assumed. *9 Data closest to 2010, or after, where 2010 data not available. Land area loads based on landward catchment area of 83,000 ha and Poole Harbour area of 3800 ha.*10: this is the emission limit for the sector which following de-nitrification is estimated to result in the given harbour nitrogen loading *11: SAGIS SIMCAT includes a decay function of 0.1 to account for de-nitrification and other processes reducing nitrogen concentrations, so no additional de-nitrification has been included.*

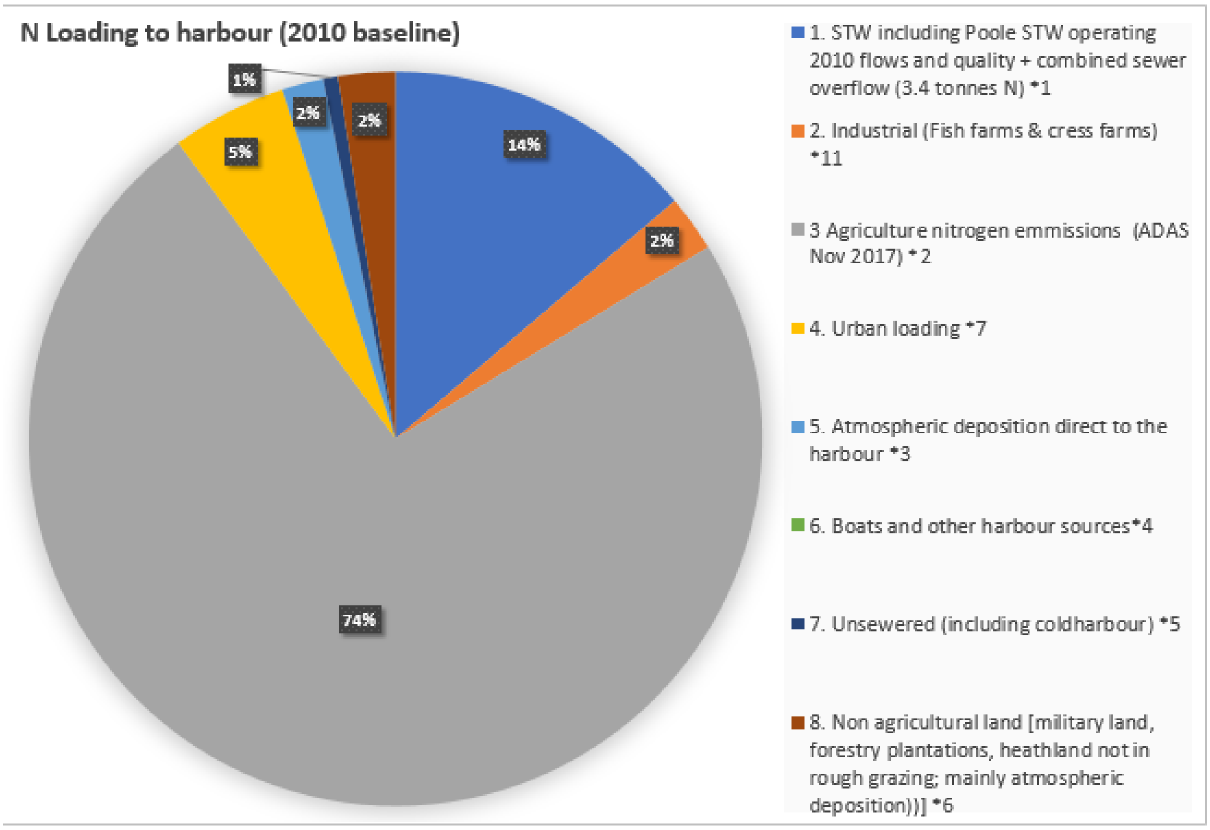
The sector apportionment of loads for the baseline year, remain very similar to those estimated in the NMP in 2013. c14% loading coming from WWTW, 74-79% agriculture (when Poole WWTW treatment is included in the baseline). If Poole treatment had not been in place, the loading would have been c22% loading from WWTW & 72% from agriculture (Appendix 12). A larger proportion of the agricultural loading forecast by Farmscoper, is however now coming from livestock, rather than arable.

Figure 5.2:1 Nitrogen Source Apportionment for Poole Harbour Catchment (from Kite & Nicholson 2018; Appendix 3).



** The average annual load removed by the nitrogen removal plant is 980 tonnes N/yr, taken from the difference between the incoming load in the raw influent and that discharged to the Harbour as final effluent. The calculated 243 tonnes/year quoted is the difference between the final effluent load prior to 2008 and the load following the construction of the N removal plant.*

Figure 5.2:2 Updated Source Apportionment; Assuming Land Use Remains at 2010 Census levels and assuming Poole WWTW treatment is included in baseline year (total loading of c2300 tonnes N/yr Total Load entering harbour 2375 tonnes N/yr



5.2.2 Phosphorus

TP and OP loads estimated to enter the harbour for a number of different years between 2004 and 2017 are detailed in Table 5.2.2 and in Appendix 11. These results show that TP and OP loads entering the harbour in 2013-17 were approximately 71 & 51 tonnes/yr respectively (Table 5.2:2 and Appendix 4). In 2010-12 OP loads were estimated to be c50 tonnes OP/yr. If the WWTW full permit conditions were taken up (based on 2009 permit conditions), OP discharge loads would have increased to c68 tonnes OP/yr (Table 5.2.2 & Appendix 4).

Unlike Nitrate, phosphorus transport pathways to rivers and the harbour are all considered to be relatively rapid (through shallow surface routes). SAGIS SIMCAT modelled phosphorus loading, calibrated against observed water quality for any given years are therefore considered representative of fluvial inputs over this time. No time lag adjustment to the source apportionment was therefore required for fair share calculations (Section 7.1). Total loads were estimated by adding fluvial inputs to direct harbour inputs.

Table 5.2:2 TP and OP Source Apportionment for Poole Harbour Catchment using LTA River Flows, 2015-17 WWTW flow and concentration data

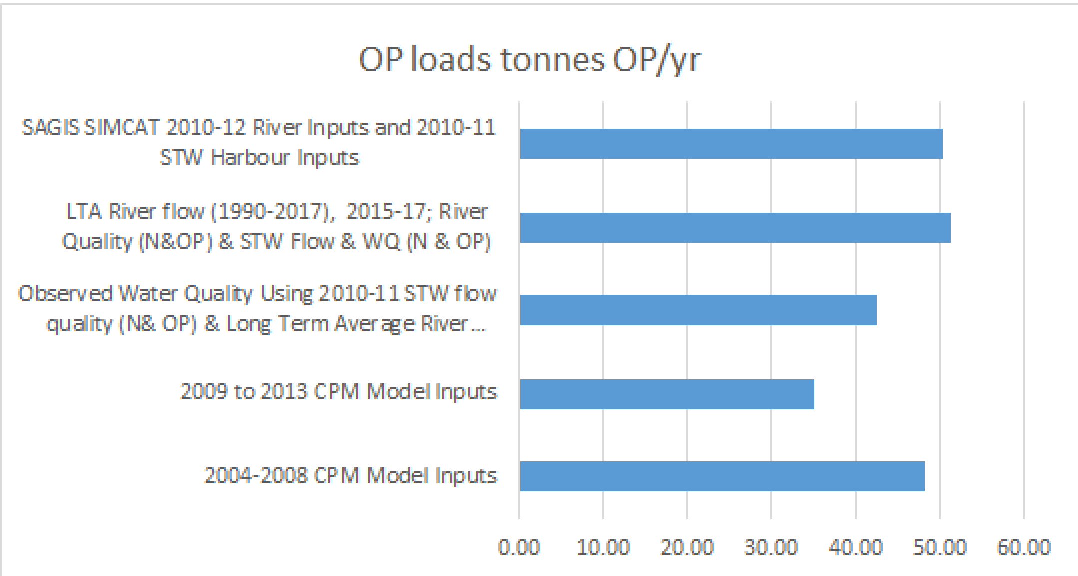
	Mean Flow 10-12	Mean Flow 1990-17 (m3/s)	Mean DAIN 2013-2017vmg/l	Mean TP (2013-17) mg/l	Mean OP (2013-17) mg/l	TP loads 2013-17 using mean river flow kg/y	OP loads 2013-17 using mean river flow kg/y	Full Permit OP Loads from SIMCAT (2010-12) kg/yr	Fluvial OP loads 2010-12 from SIMCAT kg/yr	Fluvial OP loads 2008-11 from SIMCAT kg/yr
River Frome		6.657	5.634	0.093	0.049	19419	10297	15021	11764	11027
River Piddle		2.581	7.057	0.062	0.038	5070	3057	3611	2703	2476
Sherford		0.479	5.958	0.260	0.169	3920	2548	2574	2891	2292
Corfe		0.451	3.450	0.207	0.134	2940	1911	1964	1795	2292
Creekmoor		0.041	2.037	0.047	0.031	61	40			
Upton		0.028	1.505	0.084	0.054	74	48			
Wareham Forest Stream								40	26	20.81
Sub-total (kg)						31484	17901	23210	19179	18108
Op:TP ratio				0.650						

Note: Sherford, Corfe, Upton and Creekmore TP calculated by applying 0.65 factor to OP (average op:tp ratio 2013-17)

Point source inputs

	Direct discharge volume 2010/11 M3/d	STW direct discharge volume 2015-17 m3/d	Mean DAIN 2015-17 Conc	Mean total phosporus discharge qaulity 2015-17 mg/l	Mean Orthophosphorus dicharge quality (OP) 2015-17 mg/l	Direct harbour TP loads 2015-17 kg/y	Direct harbour OP Load 2015-17 kg/y	Estimated direct harbour Inputs @ Full Permit flow OP 2010-12 kg/y	Direct harbour inputs OP Load 2010-11 kg/y
Poole STW	38139	42336	8.675	2.054	1.68	31735	25968	36573	23394
Wareham STW	3095	2926	26.291	5.515	4.97	5890	5304	5669	5610
Lytchett Minster STW	1909	1934	14.010	2.993	2.57	2113	1815	1877	1792
Holton Heath STW	192		19.122	1.043	0.835	0	0	0	58
Studland STW	136	184	21.699	2.000	1.600	134	107	164	79
Brownsea Island	192	190.00	22.539	2.000	1.600	139	111	140	112
sub total (kg/y)						40011	33306	44424	31046
						TP load (kg	OP Load (kg/	OP Full Permit Load (kg/yr)	
Grand Total input (Kg)						**71495**	**51207**	**67633**	**50226**

Figure 5.2:3: Total River OP loads to Poole Harbour for different Model Scenarios.



Apportionment of OP loads entering the harbour in 2010-12, indicate that c76% of these loads come from WWTW Figure 5.2:4 & Appendix 4. Poole WWTW contributes around 50% of the total OP load (Table 5.2:2).

Figure 5.2:4 Poole Harbour Source Apportionment 2010-12

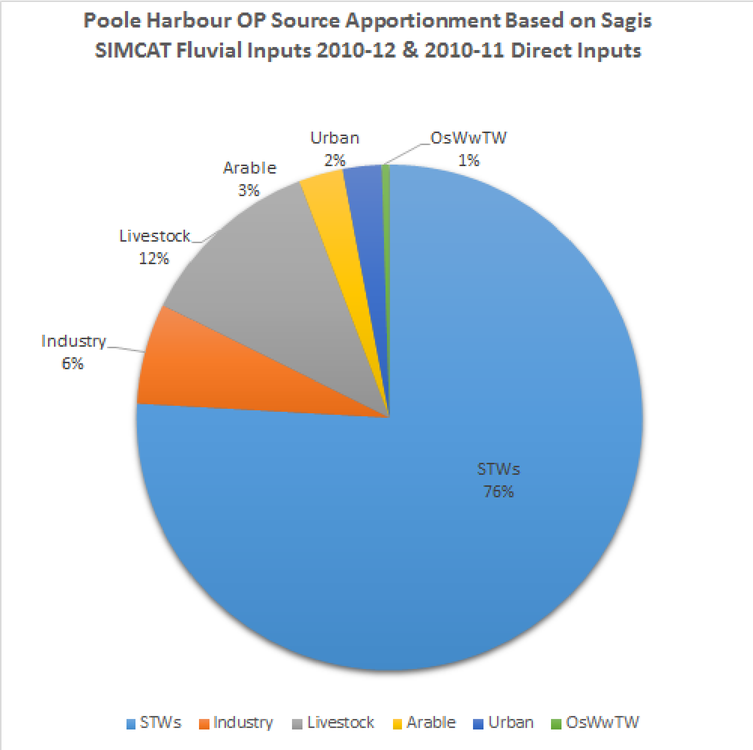
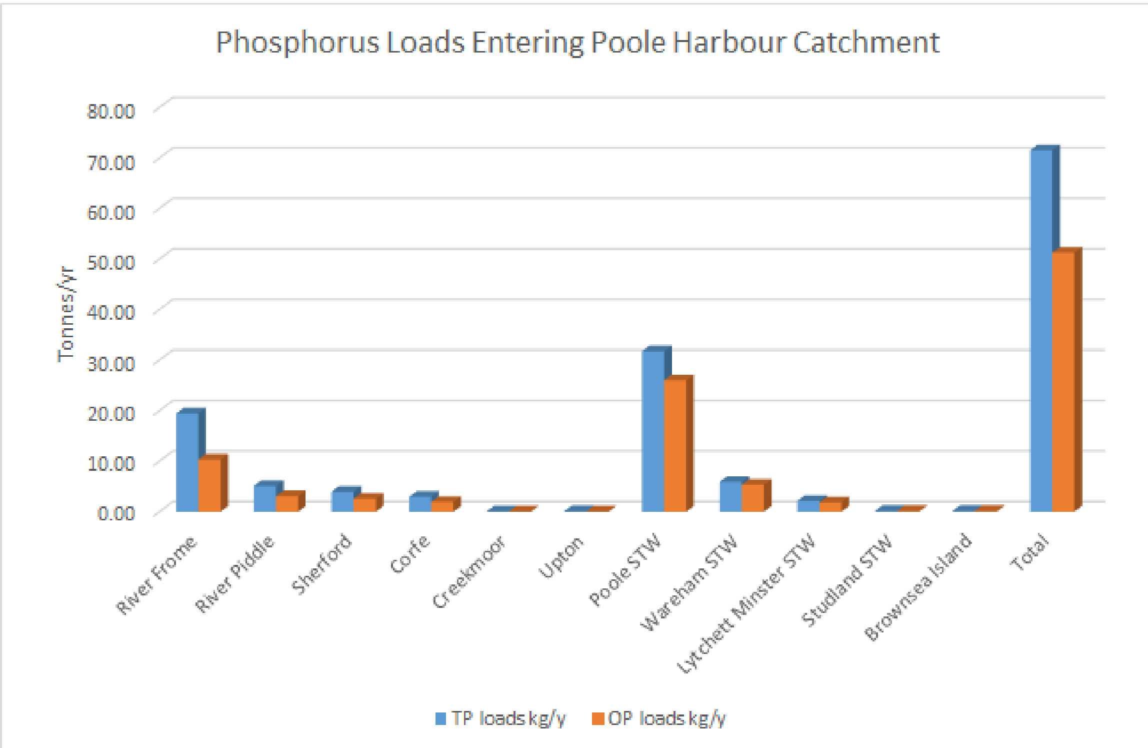


Figure 5.2:5 Estimated direct and indirect input of TP and OP entering the Poole Harbour catchment based on 2013-17 river water quality, long term average flows (1990-2017) and WWTW loads and concentrations 205-2017). Note river inputs include P from natural, diffuse and point source P inputs (from Bryan 2018 Appendix 4).



5.2.3 Diffuse Apportionment

In 2015 an updated partial agricultural census was undertaken and data from this has been used to assess the changes in agricultural practices from 2010-2015.

ADAS Ltd were commissioned in 2017 to update the understanding of diffuse agricultural N and P inputs to the catchment, using the Farmscoper (v4) modelling tool (Appendix 6). To do this they reviewed 2010 and 2015 agricultural census data and modelled the change in nutrient loading and loss that were likely to have occurred where Environmental Stewardship (ES) agreements were in place and the loads that would result if they were not.

Some of the key land use change that are recorded to have occurred from 2010 to 2015 appears to be:

- Increase in woodland
- Decrease in arable- other (non-cereals)
- Increase in grassland (and dairy cattle)
- Increase in sheep
- Increase in Poultry

From this, ADAS estimated that the diffuse agricultural N and TP losses from farms are c1797 tonnes N and c28 tonnes TP with only a Nitrate Vulnerable Zone regulated background. The implementation of the New Farming Rules for Water, together with agricultural environmental schemes [CSF, Water company catchment management schemes, Environmental Stewardship (Countryside Stewardship from 2015)] were predicted to reduce N losses to around 1679 tonnes and TP to 22.8. This is a 120 tonne/yr N & 5.5 tonnes/yr TP reduction respectively (Annex 6; Table 12).

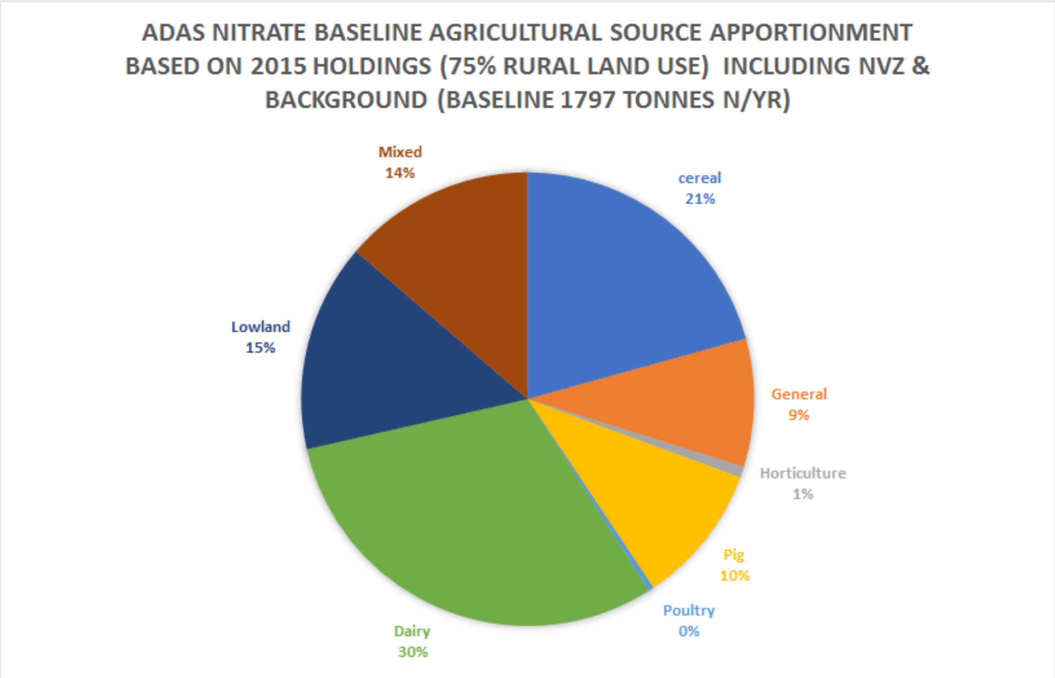
If Environmental stewardship Schemes were no longer in place, the reduction in N & TP predicted to have occurred are estimated to be 21 tonnes N and c1 tonne TP. This is primarily delivered by the new farming rules (Scenario 1; Table 5.1:1 and Appendix 6).

The impact of river restoration schemes on N reduction is not known but at a catchment scale is likely to be small.

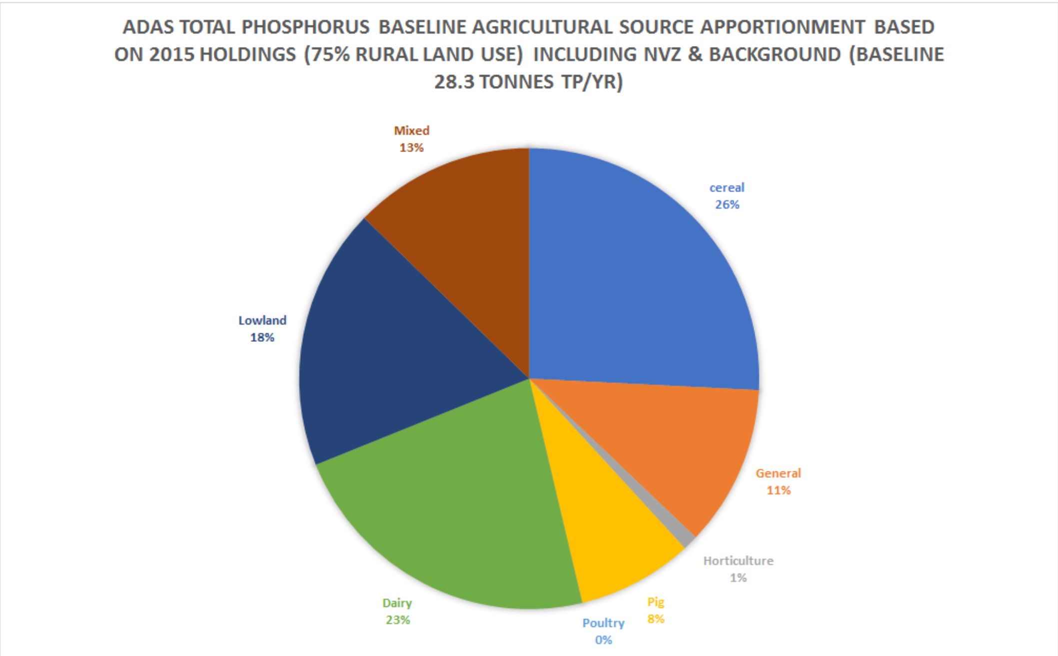
The proportion of diffuse N and TP coming from each agricultural land use are detailed in Figures 5.2.6a and b.

Figure 5.2.6a & b Agricultural N and TP Sources Apportionment of Agricultural Land inputs (tonnes/yr) based on 2015 Census data and c75% rural land use

a)



b)



Assuming a TP:OP ratio of 0.65 (Appendix 4), diffuse agricultural losses are forecast to be:

- c27 tonnes TP or 17.5 tonnes OP assuming only NVZ rules are in place.
- c22 tonnes TP, equivalent to around 14 tonnes OP/yr assuming Environmental Stewardship schemes are in place.

Diffuse loads entering rivers and Poole Harbour, using an annual average approach, have also been calculated using SAGIS SIMCAT (Appendix 4). This tool, estimates the average annual loss from arable, livestock and urban to be around 9 tonnes (OP) in 2010-12 with 7.7 tonnes OP estimated to come from Livestock and Arable. This is likely to be under- estimated because a large proportion of diffuse losses will occur during high intensity rainfall events and at periods of high river flows. An annual average approach may not capture these losses.

Further losses will come from other rural land uses and point sources.

There is a discrepancy between the diffuse TP/OP loads estimated to be lost from agriculture using Farmscoper and SAGIS SIMCAT models. The actual P load that enters rivers will be lower than forecast by FARMSCOPER as some attenuated will occur between the edge of field and river corridor. This is not included in the Farmscoper tool. SAGIS SIMCAT is thought to under estimate the load, due to the use of annual average water quality and flow data and the export co-efficient approach. The likely losses are likely to be somewhere between the two.

We have greater confidence in the point source TP/OP loads forecast for 2015-17, because WWTW flows and discharge quality were monitored directly and our estimates use this data. It is likely that diffuse agricultural TP/OP loads which are lost at times of high flow are either discharged to sea or may settle out into sediment and remain in store and will gradual leach out in future years.

5.2.4 Nutrient Loading Summary

Nutrient loads entering Poole Harbour catchment, based on 2010 land use and discharges in 2013-17 are forecast to remain around:

- c2300 tonnes N/yr (NMP 2013 and Annex 3)
- c51 tonnes OP (Appendix 4)
- c71 tonnes TP (Appendix 3 and 4)

Despite a reduction in nutrient load predicted from agriculture, overall loads that are forecast to enter Poole Harbour from current land use and point sources, remain significant short of achieving 1730 tonnes N/yr NMP targets. Diffuse agricultural loads remain well above their NMP target of c1200 tonnes N/yr (NMP Section 3.1 Table .1:1). No target in the NMP was set for P entering the harbour but both diffuse and point source TP/OP loads remain high.

Based on new evidence, the NMP strategy is set to fail in meeting the conservation objective as:

- The modelled macroalgae target has become more stringent (UK Tag 2017).

- Diffuse agricultural N reductions are <u>unlikely</u> to be delivered in the near future, based on the current direction of travel.

- Poole WWTW is thought to have a more significant impact on the water environment than predicted in 2013.

Any future offsetting will need to be calculated from a baseline of N loads of c2300 tonnes N/yr; and c51 tonnes OP/yr or 71 tonnes P/yr (Appendix 4). Actual N and phosphate loads are however likely to be higher if a flow apportioned approach were taken accounting for nutrient losses at high flows (Bower 2009).

Any future offsetting will need to be calculated from a baseline of N loads of c2300 tonnes N/yr; and c51 tonnes OP/yr or 71 tonnes TP/yr ®

6 Review of the water quality targets using a macroalgae modelling approach.

Both the 2013 NMP and prior to this, the RoC contain uncertainties when putting forward water quality requirements for meeting the ecological based targets of the Poole Harbour N2K site. Furthermore, as outlined in section 3, the ecological targets and their scope have evolved over recent years as scientific evidence on nutrient enrichment at Poole Harbour and in other estuarine environments has improved.

Since publishing the NMP, the combined phytoplankton and macroalgae (CPM) model used to estimate macroalgae biomass and density (g/m^2) has been updated and improved. As part of the Consent Order work this model has been used to identify whether nitrogen reductions alone (as put forward in the RoC and NMP) are likely to deliver the macroalgae based ecological target and what further nutrient reductions may be required. The findings of this work are outlined below and covered in more detail in Appendices 1 and 2.

6.1 Macro-algae densities modelled from 2010-11, 2013-17 and NMP Scenarios.

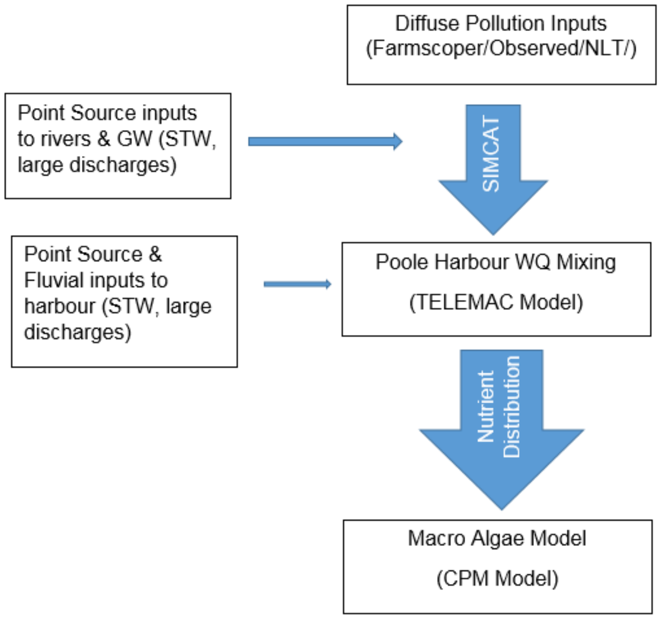
Varying models were used to calculate the likely change in water quality and macroalgae biomass across the harbour from current and potential management scenarios. An outline of the approach is illustrated in

Figure ***6.1.1***.

The CPM model is a state of the art, linked box model that can be used to model the biomass of phytoplankton and macroalgae communities. Both the phytoplankton and macroalgae formulations within the CPM are very complex and based on a large body of research into primary producers. The model comes out of work by the UK CSTT (Comprehensive Studies Task Team). The Poole Harbour model build, is designed to simulate the balance between the growth of phytoplankton and macroalgae based on a range of environmental parameters. The model has been widely used across England and Ireland. At the time of writing, the model is the best scientific tool available for predicting eutrophication in our estuarine waterbodies.

The main model inputs include nutrient loadings from freshwater and other direct sources, offshore nutrient and chlorophyll exchanges, submarine optics (light attenuation), and the extent of the available intertidal area suitable for macro-algal growth. The dynamic version of the model simulates a complete annual cycle at daily timescales and accounts for seasonal variability in forcing factors, and is described more fully in Appendix 2.

Figure 6.1.1 Approach taken for modelling the macroalgae growth in the harbour.



The first part of the modelling approach is to calculate the N and OP loads entering the harbour from riverine sources, primarily the rivers Frome, Piddle, Sherford, Corfe and other minor streams (Appendix 1). An additional loads from point sources, discharging directly to the harbour have then been calculated. These loads were assigned according to their discharge point to either Wareham Channel, Holes Bay, or direct discharges to the Outer Harbour (Table 6.1:1 and Figure 6.1.2). This enabled mean macroalgae biomass to be modelled in each of the three Poole Harbour 'boxes' or combinations of these boxes or across the harbour as a whole, as required for WFD.

Table 6.1:1 Input Data Sources for CPM Model (shaded cells highlighted the nutrient source included in each modelling "box")

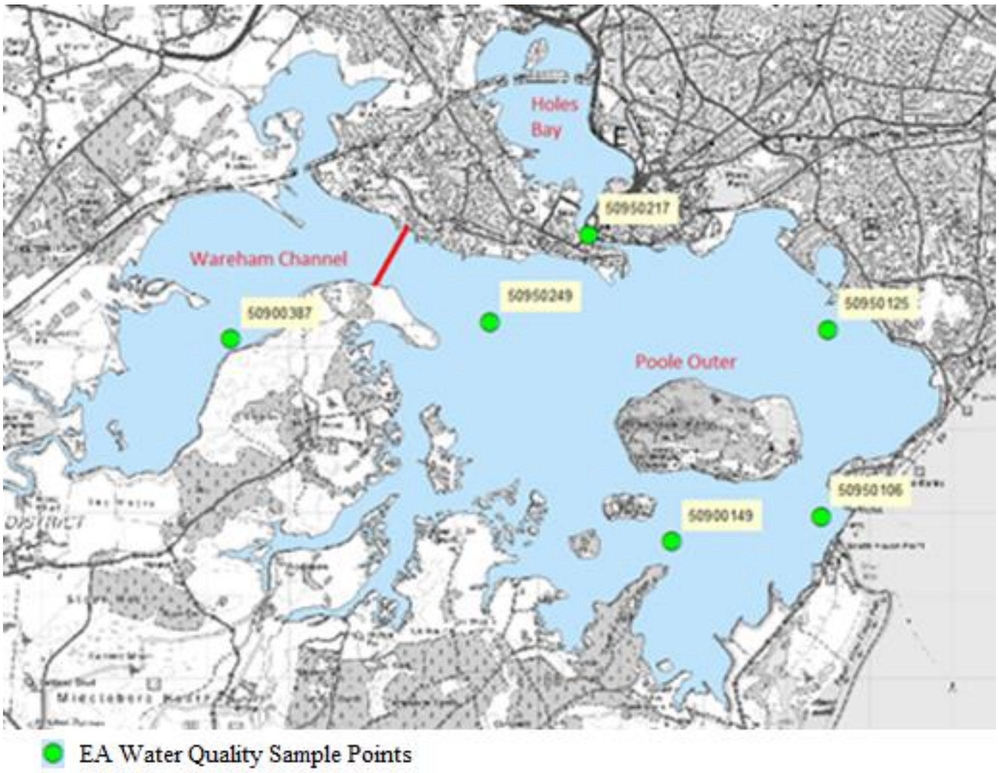
	Wareham Channel	Holes Bay	Outer Harbour
Lytchett WWTW			
Wareham WWTW			
Poole Harbour Direct Inputs			
Sherford River			
River Piddle			
River Frome			
Coldharbour un-sewered			
Aerial Deposition			
Poole WWTW			
Small Streams Holes Bay			
Small Streams Outer Harbour			
Corfe River			

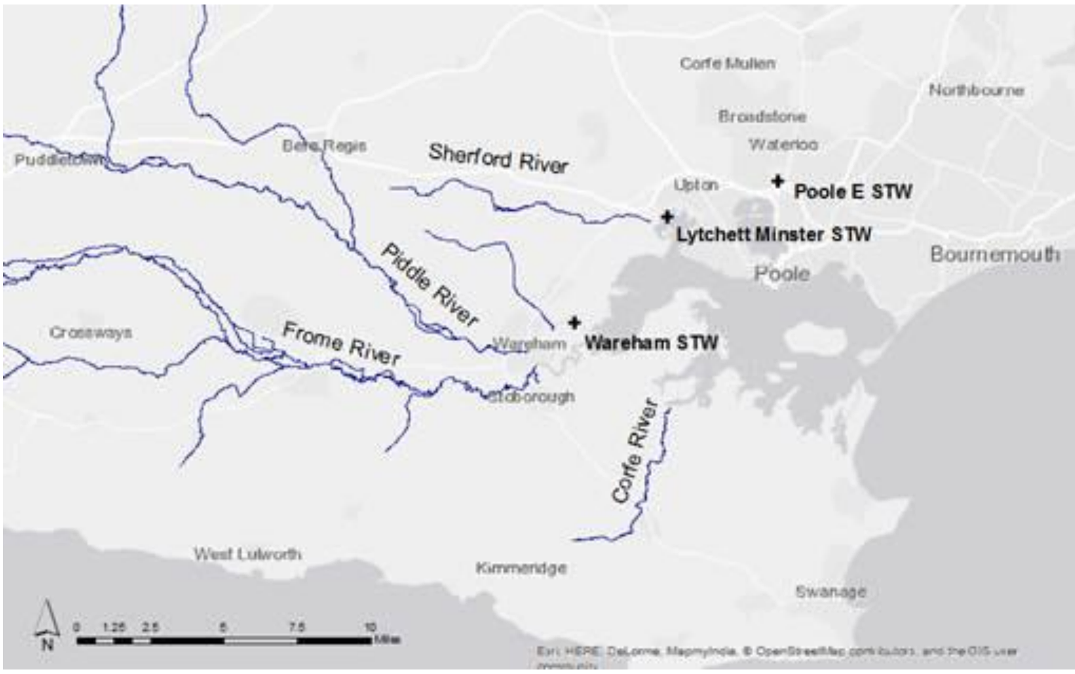
The three 'box' approach allows for some spatial differences in the structure and functioning of the HR site, however this can only partially reflects spatial differences. Details within each model box, such as the difference between the exposed north shore of the outer harbour and the sheltered bays along the south shore cannot be represented. These local influences have a direct impact on the macroalgae density. The data that would be required for modelling at a finer scale are not available and not currently required for WFD assessment.

The CPM model can only calculates mean macroalgae biomass over the defined habitat area, not the full scope of biomass, extent and entrainment values used as ecological targets for the N2K site and in WFD class assessment. It is however conservative in the sense that it assumes optimum conditions for growth, given the various input parameters. The model has been calibrated to +/-30% of observed data (Appendix 1) and when considering the variables which influence biological growth this accuracy is very good and is the most suitable scientific tool available. Future developments would try to incorporate more detailed special data if sufficient information and resources are available.

For the purpose of modelling achievement of the ecological macroalgae target, the modelling used a target of 500g/m^2 mean biomass, equivalent to one criteria for the lower value for WFD Good class on biomass (Section 5.1).

Figure 6.1.2 Location of Differing "Boxes" modelled in CPM model and contributing catchments





Following a national steer the modelling approach taken was precautionary, where like the EA SAGIS-SIMCAT water quality models, WWTW inputs for TP were used as opposed to OP. This potential over estimate P entered into the CPM model from WWTW by c19%, based on the OP: TP ratio for Poole, Wareham and Lytchett WWTW - Appendix 4. As a result the model output **are thought to be conservative** and therefore the macroalgae densities that results from each scenario may be slightly lower than forecast.

Other nutrient inputs included in the model are dissolved available inorganic nitrogen (DAIN) and fluvial OP (Appendix 11).

A precautionary approach has been adopted in forecasting macroalgae density that will result from water quality and management scenarios as a result of using WWTW TP concentrations rather than OP.

Calibration and sensitivity analysis of the CPM model, showed that it does not give a good representation of macroalgae densities within the Wareham Channel 'box', where monitored levels of macroalgae are significantly lower than the model predictions (observed data suggests MA growth here is not an ecological concern). It is uncertain why exactly this is occurring, but it is thought to result from factors limiting growth, other than nutrients, such as water depth, salinity, available intertidal area, bed shear stress, sediment moisture content, sedimentation and light penetration. For this reason, targets at the Wareham Channel modelled 'box' were not included in model interpretation.

The calibrated model was then used to run three baseline models. The purpose of these were to identify if current and proposed interventions under AMP 6 and 7, would deliver the macroalgae targets required:

- Case ID 1a: Nutrient loading entering Poole Harbour in 2010-11 period
- Case ID 1b: Nutrient loading entering Poole Harbour in 2013-17 period
- Case ID 1c: Nutrient loading that would enter the harbour with N meeting the targets in the 2013 NMP (1730 tonnes N/yr) (based on 2010-11 scenario).

The assumptions included in each model run are outlined in Table 6.1.2, with results detailed in Table 6.2.1 and plotted for each model box in Figure 6.2.1. Further details and included in Appendix 2.

Table 6.1.2. Matrix of the nature of N and P reductions included in each model case using the Combined Phytoplankton and Macroalgae Model.

		1a	1b	1c	5A	5B	5C	5D	5E	5F	5G	5H	5I
	1500 tones												
Catchment	NMP Target of 1730 tonnes of N	Yes	Yes	Yes									
Catchment	Reduce all STW in the catchment to 10mg/L			Yes									
Poole STW	STW maintained at 7.15 mg/L			Yes									
Poole STW	N and P loads removed		Yes		Yes			Yes	Yes				
Poole STW	N at 25% BAT					Yes							
Poole STW	N at 50% BAT						Yes			Yes	Yes	Yes	Yes
Poole STW	P at 70% BAT									Yes			
Poole STW	P at 10% BAT										Yes	Yes	Yes
Poole STW	iterate Holes Bay P												
Poole STW	Full Permit												
Large STW	Poole, Wareham, Dorchester and Lytchett, Blackheath and Wool STW at 50% BAT												
STW	AM6 Planned measures												
Corfe	30% OP reduction and 20% N reduction												
Catchment	OP decreased in Wareham by 20%							Yes			Yes	Yes	
Catchment	OP decreased in Wareham by 30%								Outer Harbour only	Outer Harbour only			Yes
Catchment	Predicted growth included	Yes	Yes	Yes									
Model	Iterate Wareham N to achieve 500g				Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Model	Iterate Wareham P to achieve 500g								Yes				
Model	Iterate Holes Bay P												
River Flow	LTA				Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
STW	Remaining STW at 2013-2017 loads				Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
STW	Remaining STW at 2010-2011 loads	Yes	Yes	Yes									
	Iterate Holes P to achieve 500g MA												

TAL is 10 mg/L for N and 0.25 mg/L for TP; Case 5 variations are where the model has been used to iterate the nutrients required to meet the 500g/m^2 target. Iterate – this is where the model is used to reduce the nutrient input until the macroalgae target is met; detailed information on the N and P inputs is given in appendices 4, 5and 13.

In line with national guidance the assessment of the water body compliance is carried out by combining the macroalgae results for Holes Bay and the Outer Harbour, (Table 6.3, column 12) and comparing these with the modelled targets. Results for Wareham channel have not been included in this analysis for the reasons outlined above and in Appendix 1 and 2. Results for each modelling box have been presented, to provide a conceptual understanding of the areas in the harbour that are modelled to exceed or meet the target.

Further refinement of the CPM model may ultimately be required to ensure any measures put in place to deliver favourable condition across Holes Bay and the Outer Harbour, will also deliver this status across the Wareham Channel (including Lytchett Bay) and in important feeding areas of the harbour (Section 6.4). This will require further funding, time and an improved conceptual understanding and numeric representation of the processes occurring in Wareham Channel.

Further water quality cases were prepared to model the maximum N and OP loads that would be required to deliver the macroalgae biomass target across the harbour through reductions on diffuse and point sources (Table 6.1.2 and Appendix 2).

Table 6.1.3 Outline of the most relevant cases modelled using CPM.

Case ID	Description
1a	**2010-11 Loading**, Note: Poole operating at 7.15mg/l. P Baseline set as 2013-17 using LTA flow- no measures + Holton Heath (now redundant)
1b	**2013-17 loading**: 2013-2017 flow and WQ; All WWTW direct discharges at 2015-17 flow and load: Note: 2013-17 was wetter than average and so river flows are higher
1c	**NMP Objectives Deliver**: Macroalgae density when achieving NMP target of 1730 tonnes of N per annum: Note point source loading 328 tonnes, including c32 tonnes for growth (added to Poole WWTW; baseline) The figure of 1730 tonnes was taken from the NMP and1.34 tonnes P from growth of 20430 people discharging 1mg/l at Poole WWTW
2	**NMP + Poole WWTW removed**: As case 1 + Removing N and P loading from the Poole East WWTW from Holes Bay (assuming Poole WWTW discharge is piped out to sea or to different catchment).
3	**NMP+ all WWTW @ TAL for N:** As case 1 + Model based on reducing all WWTW discharges to 10mg/L (TAL) of N with exception of Poole which is maintained at 7.15 mg/l N. including growth
5a	**Wareham Channel N load required to deliver targets based on scenario 2**: Poole: Poole WWTW discharges out of catchment- N Iterate at Wareham to achieve 500g in Poole Outer (All main rivers N inflow assumed to enter Wareham channel) updated LTA Flow[*1],
5b	**Wareham Channel N load following improved treatment at Poole WWTW:** Poole WWTW at baseline flow, 25% TAL- N only – N Iterate at Wareham to achieve 500g in Poole Outer (WWTW as 2013-17). Corfe P entering outer channel , Corfe N assumed to enter Wareham Channel (so total N iterated[*2]) no other measures; updated LTA river Flow;
5c	Wareham Channel N load following **Improved treatment at Poole WWTW**: Poole WWTW at baseline flows and 50% TAL – N only– N Iterate at Wareham to achieve 500g in Poole Outer (WWTW as 2013-17). Corfe P entering outer channel , Corfe N assumed to enter Wareham Channel no other measures; updated LTA Flow *1
5d	**Wareham Channel N load required to deliver targets: Poole WWTW discharged out of catchment and 20% P reduction: As 5a Poole WWTW discharges out of catchment P decrease by 20%**: Wareham Chanel Iterate for N to achieve 500g in Poole Outer (WWTW as 2013-17). Corfe P entering outer channel , Corfe N assumed to enter Wareham Channel no other measures; updated LTA Flow *1
5e	**N and P loads required to meet target when Poole WWTW discharge removed from harbour.** As 5a Poole WWTW discharges out of catchment. If P is still limiting No Poole P decrease outer harbour P by 30% and iterate for P in Wareham Channel: Wareham Chanel also Iterated *2 for N to updated LTA Flow *1 achieve 500g in Poole Outer (WWTW as 2013-17). Corfe P entering outer channel , N assumed Wareham Channel no other measures; updated LTA Flow *1
5f	**N loads required in Wareham Channel when P reduced by 30% and Poole WWTW treatment improved**: As 5c Poole WWTW at baseline flows, N at 50% TAL, Poole WWTW P reduced by 30% (P @ 0.7 mg/l TP), P reduction of 30% across the catchment Iterate to achieve 500g in Poole Outer (WWTW as 2013-17). Corfe P entering outer channel , Corfe N assumed entering Wareham Channel no other measures; updated LTA Flow *1
5g	**N loads required in Wareham Channel when P reduced by 20% and Poole WWTW treatment improved**: As 5f Poole WWTW at baseline flows, N at 50% TAL, But Poole WWTW P reduced to 0.1 mg/l OP) discharging in holes bay, P reduction of 20% across the catchment Iterate to achieve 500g in Poole Outer ((WWTW as

	2013-17). Corfe P entering outer channel , N assumed Wareham Channel no other measures; updated LTA Flow *1
5h	**N loads required in Wareham Channel when P reduced by 20% and Poole WWTW treatment improved Based on 2013-17**: Updated river and WWTW flows 2013-17 + Corfe P entering outer box As 5f Poole N at 50% TAL, But Poole WWTW P reduced to 0.1 mg/l OP) discharging in holes bay, P reduction of 20% across the catchment Iterate to achieve 500g in Poole Outer (All main rivers N inflow assumed to enter Wareham channel)
5i	**N loads required in Wareham Channel when P reduced by 30% and Poole WWTW treatment improved Based on 2013-17**: Updated river and WWTW flows 2013-17 + Corfe P entering outer box As 5f Poole N at 50% TAL, But Poole WWTW P reduced to 0.1 mg/l OP) discharging in holes bay, P reduction of 30% across the catchment Iterate to achieve 500g in Poole Outer (All main rivers N inflow assumed to enter Wareham channel)
5j	**N loads required in Wareham Channel when P reduced by 20% and Poole WWTW treatment improved but full permit uptake: Based on 2013-17:**As 5h but Poole WWTW @ full permit uptake
5k	**Phosphate loads required in Wareham Channel when N at NMP target and Poole WWTW treatment in place**: N @NMP, ALL WWTW @ 2010/11 loads N (except Poole @ 50% TAL for N (total WWTW load catchment load of 296 tonnes N/yr) and 0.1 mg/l OP for P and Studland and Brownsea Island WWTW operating at 2mg/l P*2) , River flows at Long Term Average + , Corfe river P reduced by 30% and N reduced in Corfe by 20%; iterate for P
5l	**Phosphate loads required in Wareham Channel when N at NMP target and Poole WWTW discharged out of catchment.** N @NMP minus Poole WWTW (c100 tonnes), Studland and Brownsea Island WWTW operating at 2mg/l P*2, River flows at Long Term Average flow, WWTW @2015-17, Corfe river P reduced by 30% and Corfe N reduced by 20%) ; iterate for P
5m	Phosphate loads required in Wareham Channel when N at NMP target and Poole WWTW treatment in place: N @NMP, ALL WWTW @ 2013/17 loads N (except Poole @ 50% TAL for N (5mg/l) and TAL for P (0.25mg/l) and Studland and Brownsea Island WWTW operating at 2mg/l P*2) , River flows at Long Term Average + , Corfe river P reduced by 30%and N reduced in Corfe by 20%; iterate for P
5n	As 5m but iterate for Pin Holes Bay. Note it was only possible to achieve Holes Bay compliance by reducing N/P input into Holes Bay and not by reducing N and P in Wareham Channel (given other fixed inputs)
5o	As case 5k but with N reduced by 230 tonnes from Wareham channel to test 1500 target. P as scenario 5k
5p	As case 5k but with N reduced by 230 tonnes from Wareham channel to test 1500 target. P iterated in Holes Bay to get close to maximum acceptable macroalgae density
5q	As case 5k but with N reduced by 230 tonnes from Wareham channel to test 1500 target. P iterated in Holes Bay and then Wareham Channel to get close to maximum acceptable macroalgae density

*1 LTA flow has been used to provide the best estimate of "typical" future flows we may expect to observe rather than short term variations which occurred in 2010-12 or 2013-17. *2 the models Nitrogen or OP input load was gradually changed until the macroalgae target was met. *2 Brownsea island discharge is thought to enter a reed bed system, which may take up this nutrient and reduce the final emissions to the harbour.

6.2 Model results - Water Quality Targets required to meet model macroalgae density and threshold density targets.

The results from the initial baseline model runs are presented in None of the four cases are predicted to achieve the macroalgae biomass target in any of the boxes or an average over the harbour as a whole. Some of the case outputs predict a macroalgae biomass of >1000g/m2, which is typically higher than the observed densities in recent years (see Figure 3.2.1). This is a result of the precautionary approach taken and that the model assumes optimum growing conditions as opposed to replication specific years. The output for the NMP case strongly indicates that the current NMP targets alone, will not be sufficient to deliver the biomass targets.

CPM modelling suggest the 2013 NMP N target alone of 1730 tonnes/yr (through reductions from agricultural diffuse sources) is not likely to achieve a reduction in macroalgae to the values of WFD Good class across the harbour.

Table 6. and have been colour coded so where each model box meets the macroalgae <u>modelling target</u> of <500g/m^2 the cell is highlighted in green and where it exceeds them but are below the threshold value of 1kg/ m^2 they are amber and red where they exceed these targets/thresholds.

These results show that the calculated nutrient inputs for 2010-11, 2013-17 and delivery of the NMP objectives (scenarios 1a-c respectively), fail to achieve the modelling target (Table 6.2.1).

None of the four cases are predicted to achieve the macroalgae biomass target in any of the boxes or an average over the harbour as a whole. Some of the case outputs predict a macroalgae biomass of >1000g/m^2, which is typically higher than the observed densities in recent years (see Figure 3.2.1). This is a result of the precautionary approach taken and that the model assumes optimum growing conditions as opposed to replication specific years. The output for the NMP case strongly indicates that the current NMP targets alone, will not be sufficient to deliver the biomass targets.

CPM modelling suggest the 2013 NMP N target <u>alone</u> of 1730 tonnes/yr (through reductions from agricultural diffuse sources) is not likely to achieve a reduction in macroalgae to the values of WFD Good class across the harbour.

Table 6.2.1 Option Appraisal to determine the impact of varying nutrient loading to the CPM modelling boxes on macroalgae density. GREEN box indicate the target is met (density <500g/m2) AMBER that it exceeds the target but is below threshold and RED, the density exceeds the threshold value of 1kg/m2.

		Phosphate Loading (kg/yr) (from CPM model spreadsheet)			DIN Loading kg N/yr[*1] (from v20 spreadsheet)			Macroalgae Density (g/m^2) - target in Outer only			Poole Outer and Holes Bay: Weighted Average Macroalgae Density (g/m2); using a Poole Outer to Holes Bay weighting ratio of 80:20 based on intertidal area of each box		-
Case	Details	Outer Harbour	Holes Bay	Wareham	Outer Harbour [*1]	Holes Bay [*2]	Wareham [*3]	Outer Harbour	Holes Bay	Wareham	Poole Outer and Holes Bay Combined	Total P (kg/yr)	Total DIN (kg/N/
	Aerial Deposition for box included in figures (kg/yr)	0	0	0	29800	2900	10600					0	43,300
1a	**2010-11 Baseline**, Note: Poole operating at 7.15mg/l. P Baseline set as 2013-17 using LTA flow- no measures + holton Heath (now redundant)	2593	14478	23943	99730	108753	2033472	812	2523	1397	1154	41014	2,241,955
1b	**2013-17 loading:** 2013-2017 flow and WQ; All STW direct discharges at 2015-17 flow and load: Note: 2013-17 was wetter than average and so river flows are higher	3183	31823	24347	81243	142116	2028405	1776	2447	1399	1910	59353	2,251,764
1c	**NMP Objectives Delived:** Macroalgal density when achieving NMP target of 1730 tonnes of N per annum: Note point source loading 328 tonnes, including c32 tonnes for growth (added to Poole STW; baseline) The figure of 1730 tonnes was taken from the NMP &1.34 tonnes P from growth of 20430 people discharging 1mg/l at Poole STW	2593	15820	23943	81943	108753	1539405	1098	1888	1396	1256	42356	1,730,101
2	**NMP + Poole STW removed:** As case 1 + Removing N and P loading from the Poole East STW from Holes Bay (assuming Poole STW discharge is piped out to sea or to different catchment).	2593	87	23943	81943	9220	1539405	735	55	1392	599	26623	1,630,568
3	NMP+ all STW @ TAL for N: As case 1 + Model based on reducing all STW discharges to 10mg/L (TAL) of N with exception of Poole which is maintained at 7.15 mg/l N. including growth	2593	15820	23943	80018	108753	1389482	1112	1717	1396	1233	42356	1,578,253
5a	**Wareham Channel N load required to deliver targets based on scenario 2:** Poole: Poole STW discharges out of catchment- N Iterate at wareham to achieve 500g in Poole Outer (All main rivers N inflow assumed to enter wareham channel) updated LTA Flow,	2593	87	23,635	32,180	9,220	779,996	493	47	1388	404	26315	821,396
5b	Wareham Channel N load following improved treatment at Poole STW : Poole STW at baseline flow, 25% TAL- N only – N Iterate at wareham to achieve 500g in Poole Outer (STW as 2013-17). Corfe P entering outer channel , corfe N assumed to enter Wareham Channel (so total N iterated) no other measures; updated LTA river Flow	2593	31,823	23,635	32,180	44,022	882,627	465	107	1392	393	58051	958,829
5c	Wareham Channel N load following Improved treatment at Poole STW: Poole STW at baseline flows and 50% TAL - N only– N Iterate at wareham to achieve 500g in Poole Outer (STW as 2013-17). Corfe P entering outer channel , corfe N assumed to enter Wareham Channel no other measures; updated LTA Flow	2593	31,823	23,635	32,180	78,824	862,101	473	448	1392	468	58051	973,105
5d	**Wareham Channel N load required to deliver targets: Poole STW discharged out of catchment & 20% P reduction: As 5a Poole STW discharges out of catchment P decrease by 20%:** Wareham Chanel Iterate for N to achieve 500g in Poole Outer (STW as 2013-17). Corfe P entering outer channel , corfe N assumed to enter Wareham Channel no other measures; updated LTA Flow	2,211	70	20,508	32,180	9,220	872,364	487	46	1389	399	22789	913,764
5e	**N & P loads required to meet target when Poole STW discharge removed from harbour.** As 5a Poole STW discharges out of catchment. If P is still limiting No Poole P decrease outern harbour P by 30% and iterate for P in Wareham Channel: Wareham Chanel also Iterated for N to updated LTA Flowachieve 500g in Poole Outer (STW as 2013-17). Corfe P entering outer channel , N assumed Wareham Channel no other measures; updated LTA Flow	2,020	61	**18,000**	32,180	9,220	2,052,622	481	47	1382	394	20081	2,094,022

		Phosphate Loading (kg/yr) (from CPM model spreadsheet)			DIN Loading kg N/yr*1 (from v20 spreadsheet)			Macroalgae Density (g/m^2) - target in Outer only			Poole Outer and Holes Bay: Weighted Average Macroalgae Density (g/m2); using a Poole Outer to Holes Bay weighting ratio of 80:20 based on intertidal area of each box		-
Case	Details	Outer Harbour	Holes Bay	Wareham	Outer Harbour *1	Holes Bay*2	Wareham*3	Outer Harbour	Holes Bay	Wareham	Poole Outer and Holes Bay Combined	Total P (kg/yr)	Total DIN (kg/N/
5f	N loads required in Wareham Channle when P reduced by 30% & Poole STW treatment improved: As 5c Poole STW at baseline flows, N at 50% TAL, Poole STW P reduced by 30% (P @ 70% TAL), P reduction of 30% across the catchment Iterate to achieve 500g in Poole Outer (STW as 2013-17). Corfe P entering outer channel , corfe N assumed entering Wareham Channel no other measures; updated LTA Flow	2,020	9,805	18,945	32,180	78,824	769,733	493	862	1388	567	30770	880,737
5g	N loads required in Wareham Channel when P reduced by 20% & Poole STW treatment improved: As 5f Poole STW at baseline flows, N at 50% TAL, But Poole STW P reduced to 10% TAL) discharging in holes bay, P reduction of 20% across the catchment Iterate to achieve 500g in Poole Outer ((STW as 2013-17). Corfe P entering outer channel , N assumed Wareham Channel no other measures; updated LTA Flow	2,211	1,462	20,508	32,180	78,824	821,049	490	177	1389	427	24181	932,053
5h	N loads required in Wareham Channel when P reduced by 20% & Poole STW treatment improved Based on 2013-17: Updated river and STW flows 2013-17 + Corfe P entering outter box As 5f Poole N at 50% TAL, But Poole STW P reduced to 10% TAL) discharging in holes bay, P reduction of 20% across the catchment Iterate to achieve 500g in Poole Outer (All main rivers N inflow assumed to enter wareham channel)	2,801	1,632	21,078	32,180	86,485	790,259	499	386	1389	476	25511	908,924
5 i	N loads required in Wareham Channel when P reduced by 30% & Poole STW treatment improved Based on 2013-17: Updated river and STW flows 2013-17 + Corfe P entering outter box As 5f Poole N at 50% TAL, But Poole STW P reduced to 10% TAL) discharging in holes bay, P reduction of 30% across the catchment Iterate to achieve 500g in Poole Outer (All main rivers N inflow assumed to enter wareham channel)	2,609	1,632	19,443	32,180	86,485	872,364	498	164	1388	431	23684	991,029
5j	**N loads required in Wareham Channel when P reduced by 20% & Poole STW treatment improved but full permit uptake: Based on 2013-17:**As 5h but Poole STW @ full permit uptake	2,609	1,828	19,443	32,180	96,273	872,364	496	249	1388	447	23880	1,000,817
5k	Phosphate loads required in Wareham Channel when N at NMP target & Poole STW treatment in place: N @NMP, ALL STW @ 2010/11 loads N (except Poole @ 50% TAL for N (5mg/l) and 10% TAL for P (0.1mg/l) & Studland and Brownsea Island STW operating at 2mg/l P) , River flows at Long Term Average + , Corfe river P reduced by 30%& N reduced in corfe by 20%; iterate for P	1,575	1,461	18,500	72,051	78,824	1,574,000	492	319	1384	457	21536	1,724,875
5l	**Phosphate loads required in Wareham Channel when N at NMP target & Poole STW discharged out of catchment.** N @NMP minus Poole STW (c100 tonnes), Studland and Brownsea Island STW operating at 2mg/l P, River flows at Long Term Average flow, STW @2015-17, Corfe river P reduced by 30% & Corfe N reduced by 20%) ; iterate for P	1,610	61	18,750	72,051	9,220	1,551,000	498	44	1384	407	20421	1,632,271
5m	Phosphate loads required in Wareham Channel when N at NMP target & Poole STW treatment in place: N @NMP, ALL STW @ 2013/17 loads N (except Poole @ 50% TAL for N (5mg/l) and TAL for TP (0.25mg/l) & Studland and Brownsea Island STW operating at 2mg/l P) , River flows at Long Term Average + , Corfe river P reduced by 30%& N reduced in corfe by 20%; iterate for P	1,611	3,933	6,750	72,051	78,824	1,574,000	318	1176	484	490	12294	1,724,875
5n	As 5M but iterate for P in Holes Bay. Note it was only possible to achieve Holes Bay compliance by reducing N/P input into Holes Bay and not by reducing N&P in Warham channel (given other fixed inputs)	1,611	1,900	6,750	72,051	78,824	1,574,000	318	485	484	351	10261	1,724,875

	Key
	Macroalgae meets target (0-499g)
	Macroalgae exceeds target but below threshold value (500-999g)
	Macroalgae exceed threshold>1000g

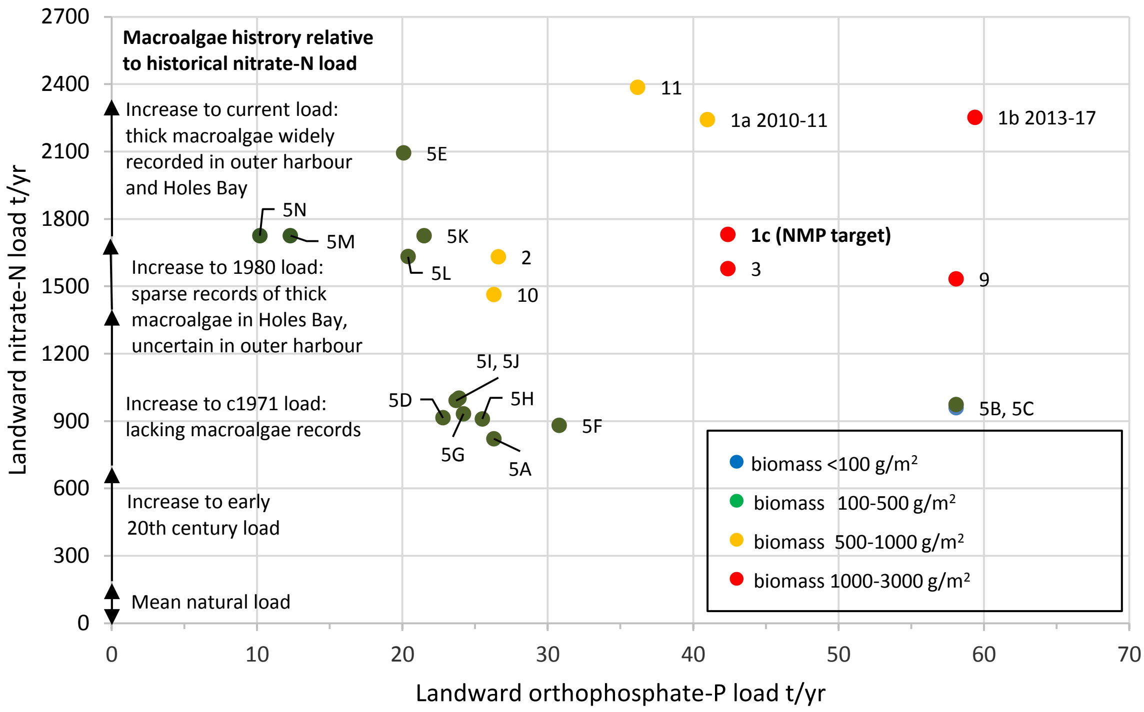
		Phosphate Loading (kg/yr) (from CPM model spreadsheet)			DIN Loading kg N/yr *1 (from v20 spreadsheet)			Macroalgae Density (g/m^2) - target in Outer only			Poole Outer and Holes Bay: Weighted Average Macroalgae Density (g/m2); using a Poole Outer to Holes Bay weighting ratio of 80:20 based on intertidal area of each box		-
Case	Details	Outer Harbour	Holes Bay	Wareham	Outer Harbour *1	Holes Bay *2	Wareham *3	Outer Harbour	Holes Bay	Wareham	Poole Outer and Holes Bay Combined	Total P (kg/yr)	Total DIN (kg/
5o	As case 5K but with N reduced by 230 tonnes frome Wareham channel to test 1500 target, P as scenario 5K	1,575	1,461	18,500	72,051	78,824	1,350,000	434	319	1384	459	21536	1,500,875
5p	As case 5K but with N reduced by 230 tonnes frome Wareham channel to test 1500 target, P iterated in Holes Bay to get close to maximum density	1,575	1,975	18,500	72,051	78,824	1,350,000	434	497	1384	495	22050	1,500,875
5q	As case 5K but with N reduced by 230 tonnes frome Wareham channel to test 1500 target, P iterated in Holes Bay and then Wareham Channel to get close to maximum density in the outter harbour.	1,575	1,800	18,650	72,051	78,824	1,350,000	438	435	1384	485	22025	1,500,875

Key

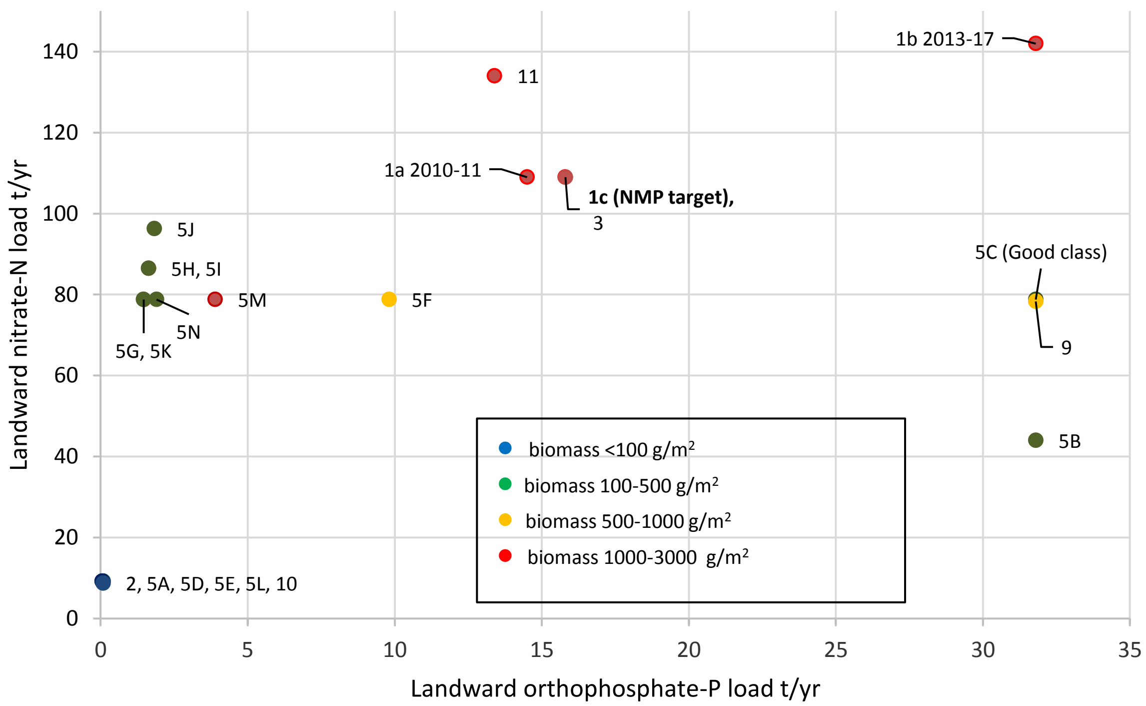
- Macroalgae meets target (0-499g)
- Macroalgae exceeds target but below threshold value (500-999g)
- Macroalgae exceed threshold> 1000g

Figure 6.2.1 CPM modelled mean macroalgae biomass for different N and OP load cases:
A: Outer Harbour modelled box plotted against N and OP input into whole harbour, and in the context of recorded macroalgae abundance over time plotted against past calculated landward N load entering Poole Harbour; B: Holes Bay modelled box plotted against N and OP landward input into Holes Bay. Note: these results are indicative and do not reflect WFD assessment as they are at sub water body scale and only included one element of the classification system.

A. Outer Harbour



B. Holes Bay



When we add to the measures included in the delivering the NMP target (case 1c) and model the impact of discharging Poole WWTW effluent out of catchment (case 2), we see a very large reduction in N and OP discharge loading to Holes Bay and modelled macroalgae biomass to Holes Bay box (<100g/m2). The biomass in the outer harbour is modelled to reduce to < 1kg/m2, but only results in a small biomass reduction compared to the 2010-11 baseline scenario 1a.

If the NMP scenario (1c) were further refined and all WWTWs discharges were improved to the Technically Achievable Limit (TAL) for N – (Case 3), but Poole WWTW still discharges to Holes Bay, the macroalgae biomass is forecast to remain >1000g/m^2 in both the Holes Bay and Outer Harbour model boxes.

This suggests major reduction of OP into Holes Bay is required to achieve the targets in this part of the harbour and further reductions in OP entering the Wareham Channel is also required to achieve the target in the outer harbour.

Further modelling cases were then run to identify how future compliance with the macroalgae biomass targets might be achieved.

- Cases 5a-5q primarily focus on adjusting N or OP loading down below the NMP target, until the macroalgae biomass is achieved in the outer harbour and Holes Bay.
- Cases 5a-e and 5g-5j focusing on reducing N, but with some reduction in OP where for example the scenario models discharge of Poole WWTW effluent out of the catchment.
- Cases 5e, 5K&5l focus on adjusting OP downwards from the NMP baseline.
- Cased 5m & 5n maintain NMP N, adjusting Poole WWTW to 50% TAL for N, but then adjusting input OP to the Wareham Channel.
- Cases 5o-q reduce the N loads into the Wareham channel by 230 tonnes, so the total nitrogen loading is reduce to 1500 tonnes.
- 5p and 5q, then further iterates the OP loading in Holes Bay and Wareham Channel to bring the macroalgae density as close to the maximum acceptable target density as possible to identify the minimum OP loading that would be required, with this combined nitrogen loading to achieve target objectives.

Each of the cases have varying assumptions about reductions in river loading (from diffuse and point source inputs). Scenarios of 20-30% N and P reduction from inflowing rivers have been assumed, typical of the upper level of agricultural diffuse pollution reduction that might be achieved through mitigation and modelled by Farmscoper.

The resulting N and/or OP loading modelled to deliver the macroalgae biomass target of < 500g/m^2 vary greatly but formed similar patterns of nitrogen and phosphorus limitation in both the Outer Harbour and Holes Bay boxes as shown in Figure 6.2.1.

For the Outer Harbour - When considering N inputs alone then the model predicts that a <1000 tonnes N/yr is required to achieve the macroalgae biomass target.

When considering OP reductions beyond NMP, a large reduction in OP to c21.5 tonnes OP/yr and N of 1730 tonne N/yr will achieve the target (5k).

Conversely when considering reducing both N and P together 1500 tonnes N/yr the target could be achieved by bringing OP loads to 22 tonnes/yr (5o-p).

In the Holes Bay box the modelled cases suggest that reducing the landward N load received by the bay to about 40-80 tonnes/yr may achieve the macroalgae biomass target irrespective of the OP loading. Conversely, with the OP loading reduced to below ~5-10 tonnes/yr the modelled macroalgae biomass was met in almost all cases irrespective of the N loading. The reasons for the exceptions (cases 5F and 5M) are due to the complex nature of the harbour, nutrient inputs and the primary production within it.

Further analysis of the results (in Appendix 2) indicates that the **modelled macroalgae biomass is sensitive to both N and OP loads and to the source of these nutrients**. WWTW inputs remain relatively consistent through the winter and summer compared with nutrient loads in river flows which are weighted towards winter when macroalgae growth is limited by other environmental factors. The result is that a like for like reduction in diffuse and point sources **at their source** will not result in the same reduction in modelled biomass. This is particularly important when comparing nutrient N and P reduction from diffuse sources and reductions from sources that directly or almost directly enter the harbour. The former are subject to varying degrees of catchment delay, storage and loss processes, the latter are not subject to these processes.

There is also competition for nutrient resources between phytoplankton and macroalgae and in cases where this is modelled and favours an increase in phytoplankton chlorophyll there is a related limitation on macroalgae biomass. None of the cases that were modelled to achieve <500g/m^2 on macroalgae biomass increased phytoplankton mean summer chlorophyll to above the chlorophyll thresholds included in the WFD tool for good status. Thus the N2K site ecological based target on phytoplankton (section 3) continued to be met.

The CPM model predicts that macroalgae biomass across Poole Harbour is sensitive to both N and OP loads.

Using different N and OP loading cases for the harbour as a whole, the model predicts that a macroalgae mean biomass target ≤ 500 g m^2 across the Outer Harbour and Holes Bay model 'boxes' would be achieved by:

1. reducing N to NMP target of c1730 tonnes N/yr and reducing OP to 20-21.5 tonnes OP/yr (cases 5k and 5l) ®

or

2. Reducing the landward nitrogen load to c 1500 tonnes (through Wareham channel) and OP loads to 22 (case 5p)

or

3. Reducing the landward N loading to about 1000 tonnes/yr or less (cases 5g to 5j

Further treatment at Poole WWTW is likely to be required to deliver this target c0.25 mg/l/TP & 5mg/l/N.

Macroalgae modelling also indicated that the outer harbour and Holes Bay were P limited and a reductions in P is calculated to result in a significant reduction in macroalgae density (Appendix 1 and 2).

6.3 A balanced approach to nitrogen and phosphorus reduction in controlling the effects of nutrient enrichment

The CPM modelling and knowledge on the nutrient environment and macroalgae abundance in Poole Harbour raises fundamental considerations on what option of N and/or P reduction would be most appropriate for controlling the effects of eutrophication. To assist decision making for this revised NMP, key scientific work on nitrogen and phosphorus limitation in the marine environment and studies on controlling the effects of eutrophication through nutrient reduction have been reviewed (Appendix 13). Some of the main points from this research are outlined below and in Section 6.4.

In recent decades a strong consensus has emerged that nitrogen is the major cause of algae blooms and other eutrophication effects in most coastal systems in temperate climates. However, the factors driving coastal eutrophication are far from straightforward as there is evidence across many studies that P also plays a role and some studies reveal an involvement by organic carbon and silicon. Long-term monitoring studies and modelling of nutrients and algal blooms on individual estuaries suggest P limitation can be a more dominant limiting factor in certain situations: toward the freshwater end of estuaries where there has been a strong reduction in P sources from the landward catchment and in enclosed estuaries that have limited tidal exchange with the sea creating a hydrological regime where there is long residence time. Poole Harbour appears to fit this situation in that there has been a strong decline in P from the landward catchment[8] and there is a low, double high tide regime that creates semi-lagoon characteristics. Phosphate limitation can become more dominant than N limitation because primary production mainly by algae, depresses P availability faster than its replenishment from river inflow or tidal inflow from coastal water.

The relative balance of N and P limitation is likely to drive ecological shifts in the marine environment. Where there has been an imbalance in the reduction of N and P, complex changes in marine ecology have been observed with consequential adverse effects on eutrophication control, but causality of nutrients and food web relationships is very difficult to establish. Thus various studies identify a need for dual N and P reduction strategies in estuaries and coastal waters, for optimal reduction of eutrophic effects.

In oceanic situations the ratio of N to P has been found to be relatively consistent in both the water and marine phytoplankton at 16:1 (the Redfield ratio). Historically, this ratio has been widely used as a reference to understand which nutrient is limiting in the marine environment and the formation of algae blooms. In coastal waters of Europe and North America the N:P ratio is generally much higher due to more elevated nitrogen loads compared with phosphorus draining from near-by land masses. Evaluation of various studies suggest that in these waters a seagrass-dominant state is associated with N:P ratios in the region of 20-30:1, but considerable variation from this is recorded (Appendix 13 Row 5b).

Pristine nutrient conditions within temperate drainage networks discharging to the North East Atlantic from continental Europe and Britain have been calculated from a broad range of studies (Desmit et al., 2018). The calculated mean values everywhere were below 0.45 mg/l nitrate-

[8] Poole Harbour Catchment Initiative Catchment Plan 2014. https://www.wessexwater.co.uk/environment/catchment-partnerships/poole-harbour-catchment-partnership

nitrogen and 0.03 mg/l orthophosphate-phosphorus. These values give an inorganic N:P ratio of 15:1 which is remarkably close to the Redfield ratio.

Marine near-shore waters off continental Europe and Britain show a tendency to have become P limited due to EU wide controls on P in wastewater, generally the major source of P in freshwater catchments. At further distances where there is exchange with the Atlantic Ocean there is a gradient to N limitation (Burson et al., 2016). This fits the situation at Poole Harbour with the background near-shore water (off The Needles near the boundary of Poole Bay with the English Channel) showing P limitation (inorganic N:P ratio of about 30:1). The N:P ratio increases greatly moving up through the harbour and shows very large seasonal cycles: high in winter and falling close to the near-shore ratio in summer (Appendix 5). This suggests a balanced N and P reduction strategy for Poole Harbour might need to focus in particular on N reduction.

The existing NMP strategy involves only N reduction and in terms of landward nutrient loading if P inputs remain constant (case 1c) would give an inorganic N:P input ratio of about 40:1. Pursuing options of P limitation alongside the NMP N target would increase the degree of N:P in-balance, for example case 5K: inorganic N:P input ratio of about 84:1. Conversely cases reducing the N input to about 1000 tonnes/yr **and** P input to about 25 tonnes year give an inorganic N:P input ratio of about 40:1. This is much closer to potential ratio in the near-shore environment, but still somewhat adrift from the Redfield ratio found in ocean systems, although as an input load ratio it does not include the effect of nutrient processes within the harbour and exchanges with the sea.

In Holes Bay the input N:P ratio is very different, being about 7:1 for the NMP modelled case 1c which suggests a likelihood of N limitation (nutrient input to the Holes Bay is however largely controlled by WWTW loading). This changes to a likelihood of P limitation in case 5K (54:1) and an even stronger ratio imbalance on P limitation in cases involving the removal of Poole WWTW N and P loads (>100:1). This extreme ratio may be a consequence of inadequate data on nutrient inputs from the landward stream catchments or because this simple assessment does not take account of nutrient loading from tidal exchange with the Outer Harbour, included in the CPM model. This matter is to be informed through AMP 7 investigations by 2022 (Table 4.4.1).

Care should be taken in relying too much on these ratios as freshwater seston [minute material moving in water and including living organisms (such as plankton and nekton) and non living] tends to have higher C:P:N ratio (Elser etal 2000). The variance in ratio between freshwater and marine seston were also statistically significant (Sterner etal 2008). Sterne etal (2008) also identified that the size and scale of the water body being considered had the greatest impact on ratios, with the constant ratio model often failing in small scale systems.

So in Poole harbour, due to the complexity of the system with freshwater and marine inputs, variable residence time, and the small scale of the system, use of the constant ratio model developed for oceanic systems, may be more limited. Any such use should take place with some caution. Further research is clearly required here.

6.4 Deriving the appropriate nutrient target to achieve the conservation objectives for Poole Harbour SPA (Natural England's advice)

To be able to define the most appropriate water quality targets, the macroalgae modelling scenarios need to be considered in the context of what this means with respect to achieving the relevant conservation objective targets for the SPA.

The supplementary advice, to achieve the Conservation Objectives for Poole Harbour Special Protection Area are summarised in Section 2.1, Box 2 and Box 1 respectively. Authorities should use this advice to assess how activities may affect Poole Harbour SPA. This same advice can help to identify the measures required to restore the SPA and the targets that should be set.

As described in section 2.2 large parts of the harbour (particularly within the bays) are in unfavourable condition. Saltmarsh and mudflat habitats have degraded and this has led to reduced food and suitable habitat availability for wildfowl and wading bird features. There have been declines in a number of species of birds that form the bird assemblage, in addition there has been a large decline in the population of the shelduck. There have also been indications that the health of the remaining seagrass beds that historically extended more widely across the harbour have been compromised. As described in section 2.2 and below an elevated nutrient status has been identified as a key contributor of the unfavourable condition of the site (Appendix 13).

Further details and references are provided in Appendix 13.

6.4.1 Water quality - nutrients

The modelling scenarios should be considered in the context of the wider scientific literature and historical evidence when determining the most appropriate nutrient target scenario to achieve the conservation objective water quality nutrients attribute target.

Nitrogen entering the harbour from rivers has more than doubled, estimated at about 650 tonnes/yr pre 1960 to over 2,000 tonnes/yr in 2013-17. With direct inputs from harbour, the catchment load received by the harbour is now about 2,300 tonnes/yr. (Kite and Nicholson in prep).

In addition, evidence indicates that a decline in water quality occurred from the 1960s to early 1970s that had a strong relationship with nitrate inputs (Crossley, 2019, Poole Harbour Catchment Initiative, 2019), with a tipping point at that time when the ecological system was no longer able to stabilise itself through natural feedback loops from cumulative pressures on the water environment. Returning nutrient inputs to the levels found before this tipping point (i.e. nitrogen harbour input load c1000 tonnes/yr) could return the Poole Harbour to its previous long-term steady state.

While early records are poorly available, records indicate macroalgae expansion in the harbour by 1980, showing a macroalgae expansion over mudflats that followed declines in the water quality of the previous decades.

The spatial scale of assessments within the outer harbour also needs to consider that there is significant variability in algal presence and density. As much of the saltmarsh and mudflat habitat impacted by dense macroalgae is within the bays of Poole Harbour there is a concern that there could be an underestimate as to the reduction of nutrients predicted by the outer harbour model required to reach favourable macroalgae densities within these bays.

As stated in 6.3 there is also a concern that a reliance on P reduction to avoid bringing N down by greater levels risks a high N:P ratio (Redfield ratio) which can have wider consequences on estuarine ecology. The modelling scenarios for the outer harbour consistently predict achievement of the macroalgae and phytoplankton biomass targets with a nitrogen loading limit of around 900-1,000 t N/yr into the harbour as a whole (including a limit of 80-100 t N/yr into Holes Bay). The modelling also predicts that these biomass targets might be achieved with much higher N loadings - from 1,500 t to about 2,100 t N/yr - but only when combined with larger reductions in the phosphorus load.

From this wider evidence, therefore Natural England considers that a lower target than the initial 1730 tonne N/yr and 21.5 tonne OP/yr, and 1500 tonne N and 22 tonnes OP/yr modelled in subsequent work to meet the macroalgae density target will be more in the region of 1000TN/yr in order to achieve the water quality-nutrient targets.

6.4.2 Food Availability

The site's ability to support and sustain an assemblage comprising a very large number of birds (in excess of 20,000) made up of a diverse mix of species will be reliant on the overall quality and diversity of the habitats that support them. Research has highlighted the importance of considering not just the community changes in benthic invertebrates, but also the size of bird species preferred prey items. For example, in Poole Harbour at macroalgae densities above 800 g/m2 there is evidence for increases in the relative abundance of smaller sized invertebrates and that this has the effect of reducing the amount of energy available to feeding birds (Thornton, 2016).

In Poole Harbour there have been declines in a number of species which are components of the water bird assemblage and there is a particular concern around the sharp decline in shelduck (a feature of Poole Harbour SPA). As well as a reduction in prey items, algal mats can put a physical barrier between birds and their prey with the sharp decline in shelduck in the Harbour is considered to be attributable at least in part due to the presence of algal mats (Soulsby et al., 1982). A large proportion of these bird species, including shelduck have favoured the embayment's of the harbour as feeding areas (Figure 6.4.2:1), with a comparison between two time periods showing a consistent distribution (Pickess, 2008).

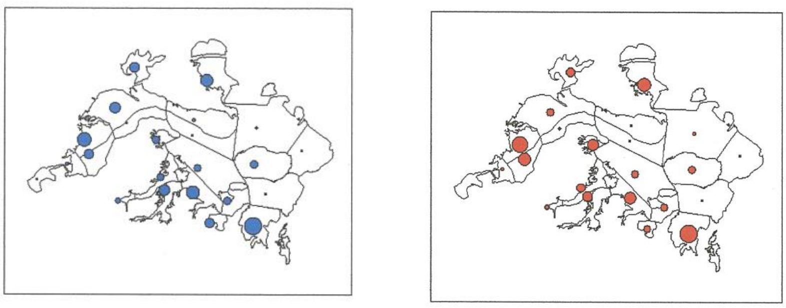


Figure 6.4.2:1 Shelduck favoured feeding sites: shelduck distribution (7 year monthly mean) between 1991/2-1997/8 (blue) compared to 1998/99 – 2004/5 (red)

The objective should therefore be to deliver a reduction in macroalgae density to <500g/, but also try to ensure this is achieved in key feeding areas as detailed in Appendix 13

6.4.3 Extent and distribution of supporting habitat

Evidence indicates that eutrophication, especially from nitrogen, is at least in part responsible for the loss and quality of saltmarsh and seagrass habitat. There is evidence that the smothering of macroalgae is leading to the loss of saltmarsh habitats. There is also a strengthening body of research demonstrating that nutrient enrichment of tidal water flooding over estuarine saltmarsh generates saltmarsh retreat through an impact on plant roots and sediment stability. This weakening of the stability of saltmarsh habitat can lead to it being more susceptible to erosional forces such as sea level rise leading o more rapid loss of the habitat. Nitrogen, rather than phosphorus, is identified as the driver of this process. Historical wider spread of seagrass and the literature also point to a requirement for N to be much lower than 1500TN loading to restore seagrass extent and health more widely across the Harbour (Appendix 13).

There are other factors that affect the condition of habitats in the harbour such as coastal squeeze. Physical and other chemical factors in the harbour may also be important in controlling the extent and health of seagrass and saltmarsh. The relative importance of these, in comparison with nutrient levels are not currently clear.

Poole Harbour appears to have undergone a shift in its ecological state from an eelgrass/saltmarsh-dominant habitat to a green macroalgae-dominant habitat (Figure 6.5:1). Published research indicate in other parts of the world, a similar ecological change has been concurrent with increased nutrient levels (Lyons et al., 1995; Burkholder et al, 2007; Shaw et al., 2018).

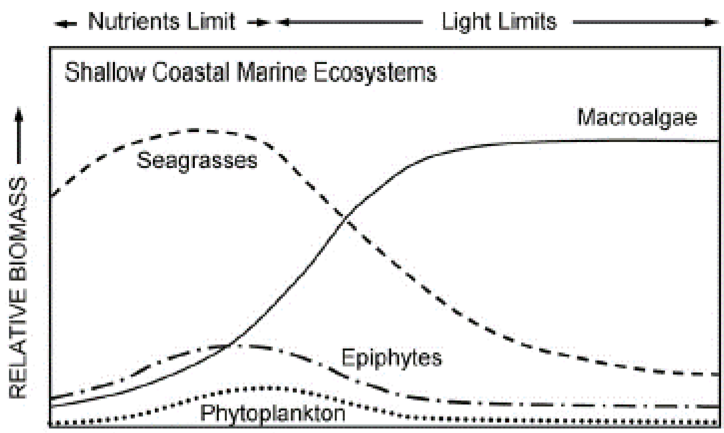


Figure 6.4:1. Conceptualised shift in plant dominance of shallow coastal marine waters from a seagrass-dominant state to a macroalgae dominant state with increasing nutrient enrichment (Burkholder et al., 2007)

Returning Poole Harbour to a stable eelgrass/saltmarsh dominant system would deliver targets across all the requirements in the Supplementary Advice for Conservation Objectives relevant to nutrient status (see Box 1 Section 2.1) and provide confidence in securing favourable condition for the supporting habitat features of the designated site and their ability to support the widest range of wildfowl and wading bird features in favourable condition.

It is difficult to determine the exact N level required to restore seagrass beds and saltmarsh in the Harbour when using literature sources that may not be comparable, e.g. different in nature, to Poole Harbour's receiving water. However the historical wider spread of seagrass and the literature point to a requirement for N to be lower than 1500tN loading to restore seagrass extent and health more widely across the Harbour. Evidence from various research suggests nitrogen concentrations across much of the outer harbour need to be reduced by more than 50% to provide a water environment more suitable for both seagrass and saltmarsh restoration. With the current inorganic nitrogen input load from the landward catchment amounting to about 2300 tonnes/yr, this again suggests that the load may in the future need to be reduced to a level in the order of 1000 tonnes/yr

The evidence (the scientific literature and modelling) is that a goal N limit of 1,500 t N/yr going into the harbour could make meaningful improvements toward the conservation objective requirements for the SPA. If adopted as an interim target, further evidence, monitoring and modelling could be undertaken whilst delivering this target, to resolve any areas of uncertainty regarding influence of nutrient level compared to other physical and hydromorphic influences on the loss and quality of saltmarsh and seagrass habitat. The overall water quality target can then be reviewed in light of this evidence and tightened if required.

In addition the direction being taken will lead to increasing removal of nitrogen by restoring catchment ecosystem processes and the services they provide to society. However Natural England consider further nitrogen reductions are still likely to be required to ascertain that nitrogen concentrations do not impede the protection and restoration estuarine features of Poole Harbour Special Protection Area.

Following an **adaptive management** approach will ensure the environmental objectives are delivered in a timely way, without risking excessive, unwarranted regulatory burden being applied to commerce across the catchment. They are in line with current internal Environment Agency and Natural England guidance[9], in taking forward actions on Natura 2000 and Ramsar sites affected by diffuse water pollution, where there remains some uncertainties regarding the target.

6.5 Recommended water quality targets to take forward to option appraisal

Modelling undertaken as part of the Consent Order investigations, identifies that changes in nutrient level are important in driving increased macroalgae growth. The nutrient target chosen will need to be sufficient to deliver the reduction in macroalgae to achieve UKTAG guidance levels.

Achieving this target will help to maintain natural invertebrate populations and species within the mudflats as well as reducing the physical (smothering) impact macroalgae may have on other species when growing in high densities. Lowering nutrient levels will also help to reduce the potential for faster growing reed species, to out compete smaller saltmarsh species in the pioneer zone, (Rodwell, 1995, Hill etal., 1999; Appendix 13).

Reducing nutrient levels is also likely to have a beneficial impact on other protected species, but the extent of this improvement is currently unclear, due to the complex interaction between nutrient level and other factors in their growth Section 6.3.

The main scenarios that were modelled to achieve macroalgae density targets, including:

- the reduction of total N loads to the harbour below <c1730 tonnes N/yr reducing total OP loads to <c21.5 tonne OP/yr (Case 5k) in combination with installing further treatment at Poole WWTW, reducing N discharges to 50% of TAL (5mg/l) and OP discharges to c0.1mg/l

[9] Enhanced adaptive management approach and RBMP 3 implementation of Diffuse Water Pollution Plans (DWPP's); Environment Agency and Natural England, May 2019.

OP, would achieve the macroalgae density target in Holes Bay and the Outer Harbour (Table 6.2.1).

- Reducing total N to 1500 tonnes N/yr, OP to 22 tonnes OP/yr in combination with installing further treatment at Poole WWTW, reducing N discharges to 50% of TAL (5mg/l) and OP discharges to c≤ TAL 0.25mg/l TP
- Reducing nitrogen loads to the harbour to c1000 tonnes N/yr to move more closely to Redfield Ratio principles and give greater confidence that wider conservation objectives relating to mudflat, seagrass and saltmarsh will be delivered. Further treatment of Poole WWTW N to 50% TAL is also likely to be required.

Whilst CPM modelling indicates a nitrogen target of 1730 tonnes and P target of c21.5 tonnes could achieve the macroalgae density target (scenario 5k), there is lower confidence that this nutrient loading would deliver wider conservation objectives for the harbour.

Reducing nitrogen levels to 1000 tonnes, may increase the confidence in delivering wider conservation targets, but from a high level review of Farmscoper modelling results, there is concern as to the scale of land use change and associated socio economic impacts required (Appendix 6) and risk they could go beyond the actual target that could achieve the same objectives.

Further evidence and work will be undertaken to better understand the nutrient loading required to achieve the conservation objectives and understand the complex relationship between factors influencing the condition and health of the harbour.

It is therefore recommended that an **adaptive management** approach is followed and the main scenario that is taken forward for further assessment is 5p, reducing nitrogen loading to the harbour to 1500 tonne N/yr and OP loading to c22 tonnes OP/yr.

Interim Target 1: Case 5p: Reducing N to 1500 tonnes N/yr and reducing P to <c22 tonnes P/yr and operating Poole at c5mg/l N and c0.25mg/l TP.

This recommended interim target is taken forward and considered in the option appraisal below.

7 Options Appraisal to Deliver Water Quality Targets

This sections identifies the options for delivering a reduction in N loads to c1500 tonnes/N/yr and P to c22 tonnes P/yr, following the process outlined in Section 4.3-4.5. The objectives of the Consent Order investigations are to identify the most effective measures to take forward (Section 7.0) and appropriate mechanisms (Section 8.0) to achieve the environmental objectives for the site, following polluter pays principles (Section 4). Fair share calculations identify the maximum N or P loading from each sector that can be accepted to deliver the recommended target, (Section 7.1). They also identify the nutrient reduction that should be achieved from the baseline year, 2010/11.

The options available to achieve these objectives are broken down to diffuse, alternative and point source measures (Section 7.2 to 7.4) respectively. The cost of implementing each of these are estimated in Section 7.5. Each option is evaluated in line with the technical and practical feasibility, socioeconomic impact, proportionality and cost benefit Section 7.5. This section also considers if existing policy or regulatory powers are in place to deliver the measures.

The options are considered in line with the polluter pay principles and fair share. They also explore measures that may go beyond current planning assumptions. This will help to identify if HR objectives can be delivered using existing policy and regulation or if policy changes and or new regulations are required. Outcomes from the Consent Order work will help to inform the review of fair share and the approach used in PR24 and river basin management planning.

The agricultural sector have not delivered their fair share in N or P, whilst Wessex Water have delivered their fair share for N across the whole harbour and P for the fluvial environment, but not the whole harbour (including WWTW discharging to Poole Harbour itself).

The distribution of land use considered in the fair share analysis and ADAS Farmscoper investigations are based on 2010 Agricultural Census Data Table 7:1a and b.

Table 7:1a Agricultural Land Use Data (ADAS 2017

	2010 Agri Census Data	2015 Agri Census Data	% Change
Adult Dairy	21,145	21,547	1.9
Other	27,798	26,721	-3.9
Sheep	59,506	68,189	14.6
Pigs	42,580	22,054	-48.2
Poultry	17,963	19,924	10.9
Grass	30,613	30,951	1.1
Rough	4,441	4,439	-0.1
Winter Cereals	9,615	8,912	-7.3
Spring Cereals	4,968	5,331	7.3
OSR	3,848	3,642	-5.4
Maize	3,159	3,401	7.7
Other	2,663	2,172	-18.4
Farm Woodland	2,871	3,330	16
Total (ha)	62,178	62,178	

Table 7:1b Amalgamated Land Use Poole Harbour

Land use	2010 Land Use	2015 Land Use
Grassland	30,613	30,951
Arable	24,253	23,458
Rough Grazing	4,441	4,439
Farm Woodland	2,871	3,330
Urban	8629	8629
Non agricultural land *1	12193	12193
Total	**83,000**	**83,000**

*1: NMP . *2 military land, forestry plantations, heathland not in rough grazing

7.1 Fair Share delivery of targets

7.1.1 Nitrogen

Poole Harbour was designated as both a Sensitive Area [Eutrophic] under the Urban Waste Water Treatment Directive and a Polluted Water [Eutrophic] under the Nitrates Directive in 2001[1]. As a result of these designations, tertiary treatment for N was installed at Poole WWTW in 2008 and became fully operational in January 2009. The river catchments draining to Poole Harbour were defined as Nitrate Vulnerable Zones (NVZs) in which the application of nitrogenous fertilisers should be actively managed.

Fair share calculations (Section 4.4) for N loads entering the whole of the Poole Harbour catchment were undertaken under the Review of Consents. This concluded that the installation of N stripping at Poole WWTW to meet a maximum permit condition of 10mg/l N and the maintenance of a standstill position at Dorchester, Wareham, Lytchett Minster, Blackheath and Wool WWTW would provide a proportionate reduction in point source N load to the harbour (NMP Section 1.1). It recognised that these actions alone would not deliver favourable condition but further actions to deliver diffuse reductions would be required.

Following the RoC, the Nutrient Management Plan in 2013, outlined the “other actions” under Regulations 64(3) that were considered necessary to “secure that the permissions do not adversely affect the integrity of the site”. The NMP conclusion were that favourable condition may be achieved by reducing the N load entering the harbour from terrestrial sources to <1730 tonnes. This would be achieved by:

- Point source offsetting for growth to achieve a standstill/ N neutral position such that there would be no increased N load from WWTW and discharge from WWTW (including growth) would not exceed c328 tonnes/N/yr (NMP table 3.1:1).

- Agricultural N loads from high input agriculture (managed grassland and arable) should be reduce to c1200 tonnes/N/yr or for all rural land use to <c1280 tonnes N/yr ® (NMP Section 3.1:1).

To achieve the new target of 1500 tonnes N/yr and 22 tonnes P/yr, it has been necessary to review and update the fair share calculation. This has identified each sector contribution towards these targets and any nutrient load reduction that will be required. 2010/11 has been used for the baseline year, instead of 2009, because we have much greater confidence in the data used for this year.

The data sources used for this calculation are detailed below and in Table 7.1:

- WWTW: Wessex Water data as presented in NMP Annex5, with Poole WWTW discharging average concentration of 7.15mg/l N.
- Industrial updated spreadsheet calculations for Industrial permits in SAGIS SIMCAT.
- Small WWTW: SAGIC SIMCAT estimates.

- Arable: ADAS report forecast arable loads (Table 6) Cereal +general +horticulture.
- Livestock: ADAS sum of forecast livestock load (Table 6) for Pig+ Poultry+ dairy+ lowland+ mixed.
- Urban: SAGIS SIMCAT estimates.
- Atmospheric: NMP Technical Annex 4 table 3 (page A144).
- Small streams: estimated load entering Holes Bay and Outer Harbour.

Table 7.1:1 Updated Source Apportionment and Fair Share Calculations Based on 2010/11 baseline and target nitrogen loading of 1500 tonne N/yr.

			Estimated de-nitrification *8	Harbour loading (inc de-nitrification)		1500 N EA/NE agreed interim goal (t N/yr)		
Source Emmissions	(a) Source emmissions 2010 (or later) baseline t N/yr *9	(b) %age of total	©	(d) Loading to harbour	(e) %age of total load	(l) Sector contribution limit to the harbour (t N yr)	(m) Sector emmission contribution limit (to deliver harbour target following de-nitrification) (t N/yr).*10	(n) Sector emmisions reduction from baseline (t N/yr)
1. STW including Poole STW operating 2010 flows and quality + combined sewer overflow (3.4 tonnes N) *1	331.13	14%	1%	327.16	14%	206.74	**209.2**	120.42
2. Industrial (Fish farms & cress farms) *11	59.93	2%	2%	58.73	2%	37.11	**37.9**	21.62
3 Agriculture nitrogen emmissions (ADAS Nov 2017) *2	1784.00	73%	2%	1748.32	74%	1104.82	**1126.9**	643.50
4. Urban loading *7	123.39	5%	2%	120.93	5%	76.42	**77.9**	44.51
5. Atmospheric deposition direct to the harbour *3	43.33	2%	0%	43.33	2%	27.38	**27.4**	15.95
6. Boats and other harbour sources*4	uncertain							
7. Unsewered (including coldharbour) *5	15.77	1%	2%	15.45	1%	9.77	**10.0**	5.69
8. Non agricultural land [military land, forestry plantations, heathland not in rough grazing; mainly atmospheric deposition))] *6	60.97	2%	2%	59.75	3%	37.76	**38.5**	21.99
sub total	2418.52			2373.66		1500.00	1527.8	873.66

**1 WWTW load (predominantly water company) = estimated 2010/11 WWTW load taken from NMP with Poole WWTW operating at 7.15mg/l discharge quality + estimated combined sewer overflows estimated for Wessex Water in 2017 (3.4 tonnes), WWTW load excludes Godmanston and Stinsford WWTW *2Farmscoper modelling+B97, *3 Atmospheric deposition direct to Poole Harbour from APIS modelling (2014-16 data), p14 in James et al, 2018, *4 No accurate data exists for this source but recognised as potential source that needs to be reviewed and controlled to reduce nutrient input and bacterial input to the harbour from boats and related sources, *5; estimated un-sewered loads from Nutrient Management Plan Technical Annex Table 4b in Kite etal 2012 ,*6 N source emission estimated at 5kg/ha/yr based on source reviewed in Natural England 2000; applied to non-agricultural holdings areas of 12193 ha. *7 estimated as 14.3 kg N/ha/yr based on 8629 ha urban area in 2010 (see Nutrient Management Plan); including small streams entering holes bay, primarily sources from urban catchment. *8 estimated de-nitrification from inland waters Saunders & Kalf 2001. SAGIS-SIMCAT data already includes decay factor so it not duplicated. No de-nitrification is assumed to occur from any direct discharge to the harbour, de-nitrification from WWTW discharges are apportioned between inland rivers (2%) and direct discharges (0%) to give 1.2% assumed. *9 Data closest to 2010, or after, where 2010 data not available. Land area loads based on landward catchment area of 83,000 ha and Poole Harbour area of 3800 ha.*10: this is the emission limit for the sector which following de-nitrification is estimated to result in the given harbour nitrogen loading *11: Industrial emission's assuming 1mg/l uplift in nitrogen down stream of fish farms and zero uplift down stream of Water Cress; Based on full permit flow.*

The assumptions regarding this apportionment are detailed in the footnotes to the table.

The table above illustrates that, for the delivery of the interim target of 1500 tonnes of N WWTW fair share loads should not exceed c209 tonnes N/yr® and requires a further reduction of c120 tonnes of N from the sector (Table 7.1.1) beyond the c240 tonnes N/yr already delivered through Poole WWTW permit variation in 2009. *Of this c40 tonnes is being delivered to offset increased nutrient loads at Dorchester and an ODI for a further 51 tonnes N yr reduction is included in AMP7.*

The preferred modelling scenario 5p, identified that some further reductions are needed at Poole WWTW to meet macroalgae density targets. Modelling indicates Poole WWTW permit limit should be reduced from 10mg/l N to 5mg/l N®.

As previously outlined the main sectors that requires N reductions is agriculture, where contributions should not exceed c1127 tonnes N/yr®. Achieving this would result in an N load reduction of around c644 tonnes N (based on 2010 land use). This reduction is required from all agricultural land uses, detailed in Table 7:1a, amalgamated into arable and grassland (livestock), rough grazing and farm woodland (Table 7:1b). This does go further than the recommendations of the NMP.

Further load reduction are also required from industrial, urban, boats (and other harbour inputs) and non-agricultural sources, as detailed in Table 7.1:1®.

The recommendations are that N is reduced to 1500 tonnes and P to c22 tonnes P/yr.

This target is based on our current understanding of the catchment however, if future monitoring, modelling and further evidence shows that this reduction is not sufficient, then nitrate loads may need to be lowered further, potentially to 1000 tonnes/yr N. Any changes to the target beyond the current interim should be informed by data collected throughout the next RBMP3 cycle (2020-2026) and improved scientific understanding and modelling.

Interim N loading targets for Poole Harbour ®:

- Total N loads entering the harbour from non-marine sources should be reduced to 1500 tonnes/N/yr.

- Point source loads from WWTW should not exceed 209 tonnes N/yr.

- All agricultural N loads should be reduced to c1127 tonnes N/yr.

- Other N loads should be delivered as detailed in Table 7.1:1

7.1.2 Phosphorus

Phosphate stripping has been installed on many of the large WWTW discharging to fluvial sources entering the harbour, (following RoC and AMP recommendations). The main driver for these changes has been to deliver fluvial water quality objectives (Section 3.2.2.1). No fair share calculations have historically been carried out to deliver phosphorus targets within the transitional waters of the harbour, due to P not being widely considers as a limiting chemical within transitional and tidal waters. Recent macroalgae modelling results now indicate both P and N are limiting and OP should be reduced from c51 tonnes to c22 tonnes/yr OP from non-marine sources.

Current OP loads entering the harbour are estimated to be c50 to 51 tonnes OP/yr in 2010-12 and 2013-17 respectively. At full WWTW permit this is estimated to increase to 67.7 tonnes/yr OP (Section 5.2.2 and Appendix 4).

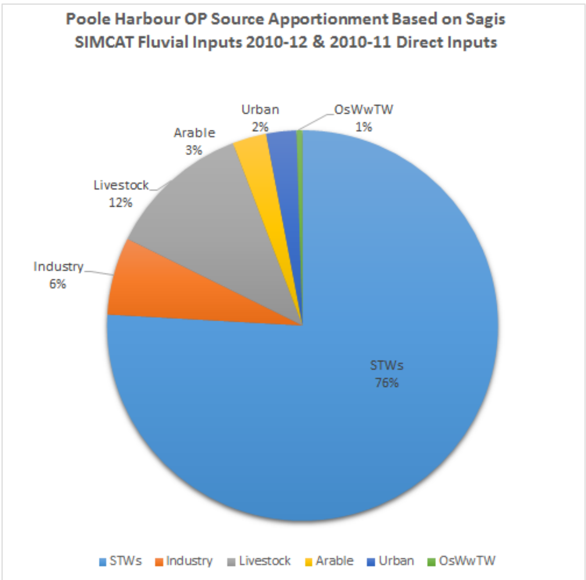
An estimate of the apportionment of these loads are outlined in Table 7.1:2 and Figure 7.1:1. As indicated in Section 5.2.2, OP/TP losses from all sectors are thought to enter river and harbour rapidly, with only minimal phosphorus loads, currently considered to move through the groundwater pathway. Unlike nitrate, no time lag adjustment was therefore required for the fair share calculations.

Table 7.1:2 Phosphorus Source Apportionment from fluvial inputs and direct harbour discharges & Fair Share to meet 22 tonne OP target

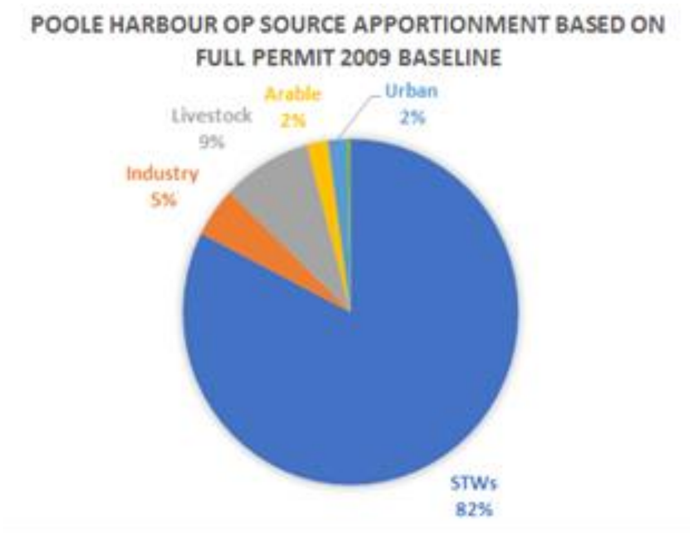
	Original load tonnes/yr	Contribution % (from SAGIS) 2010/12	Sector adjusted emmisions contribution limit (tonnes OP/yr) based on measured flows	Sector emmisions reduction from baseline (tonnes/OP/yr) based on measured STW & River flow
Livestock	6.18	12.29%	2.70	3.47
Arable	1.46	2.91%	0.64	0.82
Urban	1.30	3%	0.57	0.73
Industry	3.36	6.69%	1.47	1.89
STW	37.68	75.01%	16.50	21.18
OsWwTW	0.26	0.5%	0.11	0.15
Total	**50.24**	**100.00%**	**22.00**	**28.24**

Figure 7.1:1 OP Source Apportionment at 2010-12 and Full Permit uptake with 2009 permit conditions using 2010-12 SIMCAT model (Appendix 4)

2010-12 baseline



Full Permit



To calculate the phosphorus fair share for Poole, fluvial loads calculated in SIMCAT, ("Fluvial OP loads 2010/12 from SIMCAT" Annex 4; Table 3:2) were used to best represent fluvial inputs to the harbour in 2009. These were added to WWTW OP loads calculated for direct discharges to the harbour in 2010/11 ("OP loads 2010-11" Annex 4 Table 3.2).

The only material permit variation for P between 2009 and 2010 occurred at Dorchester WWTW, where the permit discharge limit was reduced from 2mg/l to 1mg/l TP. This adjustment was included in the updated SAGIS SIMCAT model. No correction was made for this in the fair share run, this decision was made as the current model is thought to accurately estimate the current Dorchester OP loads. This is because WWTW data from 2015-17 indicate Dorchester has TP:OP ratio of 0.44 and so in 2009 with a permit condition of 2mg/l, OP would have been c0.88mg/l. This is close to the discharge quality of 1mg/l included in 2010:12 SIMCAT model).

The modelled target required within the harbour is c22 tonnes OP/yr (Section 6.2 & 6.3). Because the harbour is represented as one water body, the apportionment has been carried out for the combined point and diffuse loading to the harbour (Table 7.1:2 & 7.1:3). The fair share calculation has similarly been carried out for the water body as a whole, rather than at the location of each WWTW as would occur in fluvial systems.

Results of the fair share calculations to deliver a water quality target of 22 tonnes OP/yr are detailed in Table 7.1.3. This shows the gap between the target and observed water quality during the baseline year (2010) is c28 tonnes OP/yr. From this, it can be seen that to meet the fair share target, WWTW loading should not exceed c16 tonnes and agriculture c3 tonnes.

Table 7.1:3 Apportionment of load and Fair Share Calculation to deliver 22 tonnes OP/yr

	Original load tonnes/yr	Contribution % (from SAGIS) 2010/12	Target Reduction (tonnes/OP/yr) based on measured STW & River flow	Sector Adjusted Contribution (tonnes OP/yr) based on measured flows
Livestock	6.18	12.29%	3.47	2.70
Arable	1.46	2.91%	0.82	0.64
Urban	1.30	3%	0.73	0.57
Industry	3.36	6.69%	1.89	1.47
STW	37.68	75.01%	21.18	16.50
OsWwTW	0.26	0.5%	0.15	0.11
Total	**50.24**	**100.00%**	**28.24**	**22.00**

We have greater confidence in the point source loads estimated in SAGIS SIMCAT model, rather than diffuse. This is because they are based on measured WWTW discharge flow and quality. Diffuse loads estimated in SAGIS SIMCAT in contrast are calculated to be:

Diffuse concentration = Annual average observed river water quality – point source concentration

The concentrations are then converted into loads using the observed flow. The diffuse loads are then apportioned using the PHYCHIC export coefficient approach.

It can be assumed that diffuse loads and thus the apportionment presented in SAGIS SIMCAT is somewhat under-estimated. This is due to a large proportion of diffuse losses occurring during high intensity rainfall events and as such at periods of high river flows. SAGIS SIMCAT uses an annual average approach which may not fully account for all terrestrial losses, this is not considered significant in the fluvial environment (where P is rapidly transported to the ocean) however when considering a receptor such as Poole Harbour this may be significant. This is a recognised limitation and fair share calculations should therefore be considered to be interim and updated as catchment monitoring and models improve.

Interim OP loading targets for Poole Harbour (non marine sources) to deliver each sectors fair share are as follow:

OP should be reduced to c22 Tonnes OP/yr ®.

WWTW OP discharges (including overflow) should be reduced to <16.5 tonnes OP/yr ®

Average annual diffuse losses (urban, agriculture) should be reduced to 3.91 tonnes OP/yr®

Industrial discharges should be reduced to c1.5 OP tonne/yr®

7.2 Diffuse Measures to deliver macroalgae targets

To work towards delivering the overall water quality objectives and initial targets (None of the four cases are predicted to achieve the macroalgae biomass target in any of the boxes or an average over the harbour as a whole. Some of the case outputs predict a macroalgae biomass of >1000g/m2, which is typically higher than the observed densities in recent years (see Figure 3.2.1). This is a result of the precautionary approach taken and that the model assumes optimum growing conditions as opposed to replication specific years. The output for the NMP case strongly indicates that the current NMP targets alone, will not be sufficient to deliver the biomass targets.

CPM modelling suggest the 2013 NMP N target <u>alone</u> of 1730 tonnes/yr (through reductions from agricultural diffuse sources) is not likely to achieve a reduction in macroalgae to the values of WFD Good class across the harbour.

Table 6.), diffuse agricultural N loads should be reduced to 1127 tonnes/yr and OP loads should be reduced to c 3 tonnes OP/yr. Using the same approach adopted in the NMP, the agricultural land area (Table 7.1a and b) is used to calculate the nutrient losses per hectare. (Table 7.2:1).

Table 7.2:1 Nitrogen and Orthophosphorus Leaching/loss target (based on 2010 Farm Census Data ADAS 2017) reproduced in Table 7.1:a)

	Nitrogen Target	Ortho-Phosphorus Target
Agricultural land area (ha) (2010)*1	62178	62178
Target tonnes	1127	3.5
Average leaching/loss target	18 N kg/ha	0.05 P kg/ha

*1: including all agricultural land uses (2010 data) with agricultural holding area of 62,178 ha; Tables 8 & 16 in Gooday et al, 2017

Diffuse N loads should be reduced to c1127 tonnes N/yr and N loads reduced to ≤18.1 kg/ha in combination with all other sources ®.

Diffuse load reduction can be achieved by reducing nutrient inputs or losses from the soil zone and or the transport of nutrients to surface or ground waters. ADAS were commissioned to identify what measures could be put in place to reduce diffuse agricultural N losses from the current forecast regulatory baseline of c1790 tonnes N/yr (or 1679 where countryside stewardship is in place) to 1200 tonnes N/yr (as recommended by the NMP). To do this, they used the Farmscoper modelling tool (Appendix 6), and following consultation with agricultural groups in the area, identified 6 scenarios and "bundles" of measures that could be implemented. These are summarised in Table 7.1a and b.

Scenario 1 represented the measures that are largely required under new farming rules for water, where the farmer is within a Nitrate Vulnerable Zone or receives funding from the Basic Payment Scheme, Countryside Stewardship or Environmental Stewardship. **Scenario 2** focusing on reducing nutrient application and or measures to reduce nutrient leaching over winter. **Scenarios 3-4** included other measures that farmers could implement. The Final 2 scenarios were focused on the measures that would be required to reduce nutrient losses further to achieve 1200 tonne N/yr target. They included reverting a proportion of arable land to low input grassland **(Scenario 5)** or reducing stocking densities **(Scenario 6).**

Further scenarios have been proposed (DS7-9) that could reduce diffuse N and P loads beyond those already modelled. The diffuse pollution reduction delivered by these measures have not been quantified, but are likely to be small compared to Scenarios 1-6 and could be evaluated if further model refinement is required.

Alternative modelling approaches have also been considered to look at other delivery options that can be put in place instead of DS1-6 or in addition to these scenarios to meet the slightly tighter agricultural target.

The measures included within each bundle and the nutrient reduction achieved by each scenario are summarised in Table 7.2.2a and b and

Figure **7.2.1**- Figure 7.2.2.The OP values have been estimated using the average TP:OP ratio observed in the Frome and Piddle from 2013-2017 of 0.65 (Appendix 4). Further discussion on the measures are given on Appendix 3 and Appendix 6.

Table 7.2.2a Diffuse N and TP Load Reductions achieved by Farming Scenarios 1-6 modelled by ADAS using Farmscoper Tool (assuming 95% uptake rate of 75% of agricultural land) and Additional measures considered (tonnes/yr).

Diffuse Scenarios		**Description**	**Nutrient load and tonnes/yr**	
			N	TP (OP)
Catchment Load			2300	71TP (51 OP)
Diffuse Agricultural Baseline			1797	28.3

			Scenario Offsetting	
			N	TP (OP)
DS1	Scenario 1	• Use a fertiliser recommendation system • Integrate fertiliser and manure nutrient supply • Do not apply manufactured fertiliser to high-risk areas • Avoid spreading manufactured fertiliser to fields at high-risk times • Do not apply organic manures to high-risk areas • Site temporary solid manure heaps away from watercourses • Move feeders at regular intervals • Fence off rivers and streams from livestock	21 (1.2%)	0.9 (0.59) (3.2%)
DS2	Scenario 2	• Fertiliser spreader calibration • Use clover in place of fertiliser N • Establish cover crops in the autumn • Early establishment of crops in the autumn	148 (8.7%)	4 (2.6) (14.5%)
DS3	Scenario 3	• Reduce dietary N intake • Adopt reduced cultivation systems • Use manufactured fertiliser placement technologies • Increase the capacity of farm slurry stores to improve timing of slurry applications • Store solid manure heaps on an impermeable base and collect effluent • Use liquid/solid manure separation techniques • Construct bridges for livestock crossing rivers/streams	34 (1.9%)	1.1 (0.72) (3.9%)
DS4	Scenario 4	• Establish 6m wide riparian buffer strips • Establish in-field buffer land/zero input margins on 3% of arable land • Allow grassland field drainage systems to degrade	23 (1.5%)	1.7 (1.1) (6.0%)
DS5	Scenario 5	• 45% land reversion to low input pasture from arable farms	106	1.9 (1.2)
DS6	Scenario 6	• 35% reduction in stock numbers on livestock farms.	265	3.4 (2.2)

DS7	Scenario 4 + buffer	• Scenario 4 + increased buffer size from 6-9m and increased in field buffer on arable land from 3-5%		
DS8	Reduce nutrient application	Reduce nutrient application by 10%, potentially below economic optimum		
DS9		Reduce manure application on high index soils		
DS10	Wetland Alternative	Re-direct river flows through wetland system to reduce N and phosphorus concentration	0.75/ha	0.02/ha

Table 7.2.2b Diffuse N and TP Loads predicted by ADAS Farmscoper modelling.

Diffuse Source (Agriculture) Measures	Total Diffuse Nitrate Loading (assuming no long term Agri Envi Scheme)	Nitrate reductions from ADAS baseline kg/N/yr	Nitrate Reduction from this scenario kg/y	Change from baseline	Diffuse Total Phosphate Loading kg/P	Total Phosphorus reductions from ADAS baseline (kg P/yr)	Total Phosphorus Reduction from this scenario kg/y
Baseline	1915647						
NMP	1403792.71						
ADAS Baseline Diffuse	1797000.00	0			28300		
Scenario 1	1776000	-21000	-21000	1%	27400	-900	-900
Scenario 2	1628000	-169000	-148000	9%	23400	-4900	-4000
Scenario 3	1594000	-203000	-34000	11%	22300	-6000	-1100
Scenario 4	1571000	-226000	-23000	13%	20600	-7700	-1700
Scenario 5	1465000	-332000	-106000	18%	18700	-9600	-1900
Scenario 6	1200000	-597000	-265000	33%	15300	-13000	-3400

Figure 7.2.1 N Reductions Delivered by Farmscoper Model Scenarios 1-6 (ADAS March 2018)

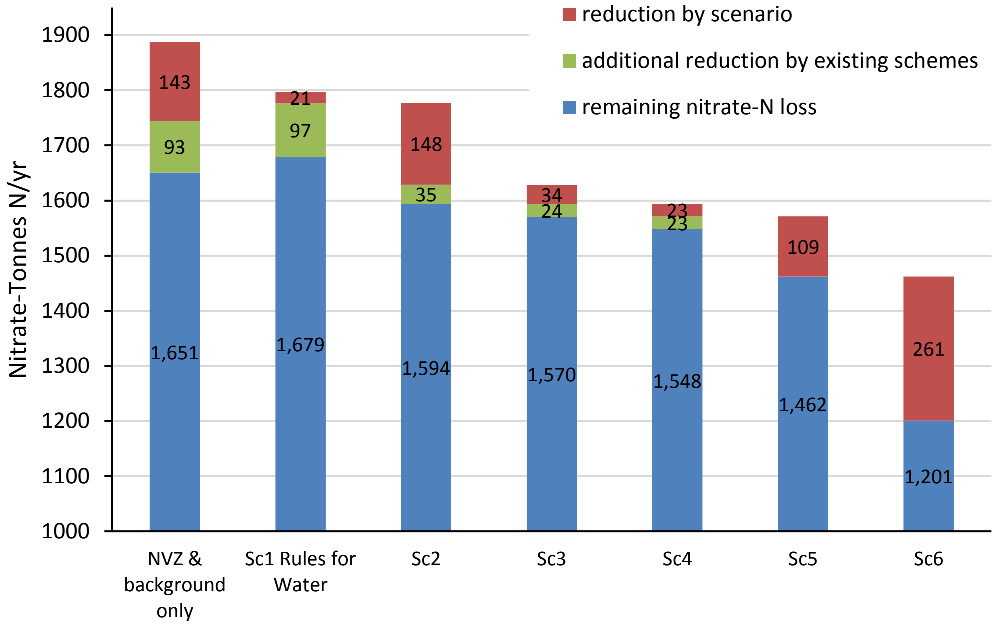
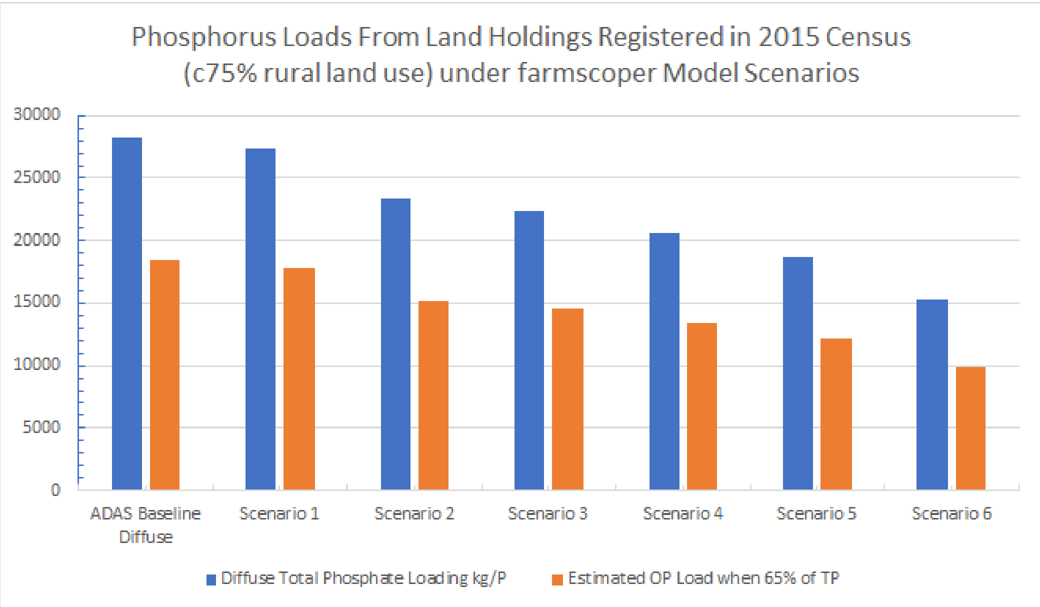


Figure 7.2.2 Phosphorus Reduction Achieved by Scenario 1-6 from ADAS Farmscoper runs.



Evidence also indicates that additional N loads enter the catchment through areal deposition (Appendix 3). This may equate to >10kg/ha across some parts of the catchment. Farmers do not typically including this source of N in their nutrient management planning. This results in an over application of fertilizer. It would therefore be recommended that farmers include a typical average aerial deposition figure within their planning ®.

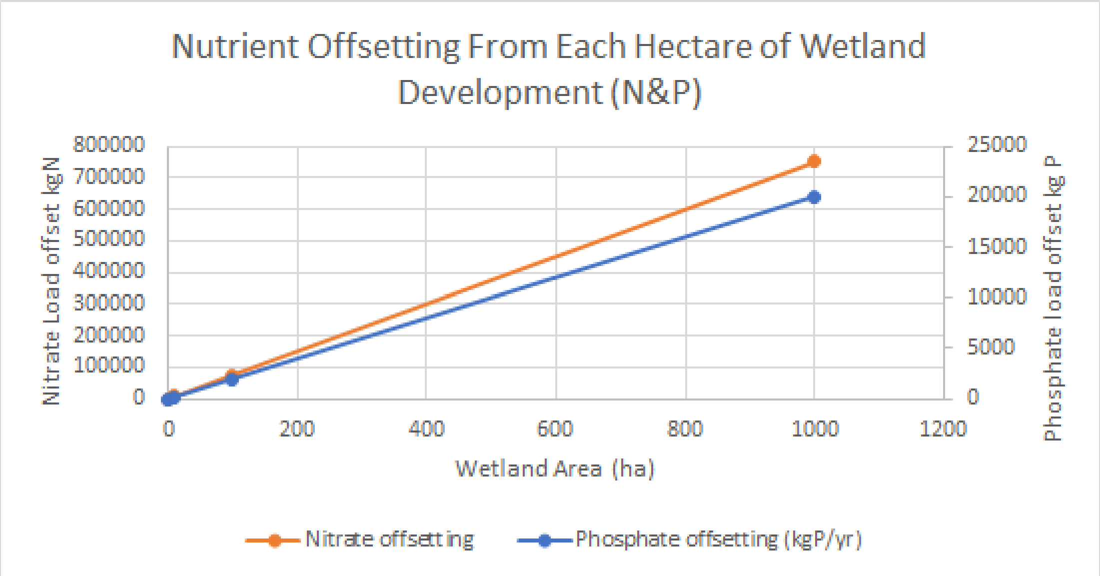
7.3 Alternative Measures to Deliver Diffuse Pollution Reduction: Wetland Creation (DS10)

Alternative measures, such as wetland creation could also deliver nutrient reduction alone or in combination with other measures. This option is considered under scenario DS10.

NE have identify the potential nutrient reduction that might be achieved through wetland systems (Appendix 3). Based on published research, this work has identified that a nutrient reduction of between 500- 1000 kg/N/ ha of wetland could be delivered and c 20kg P/ha if sufficient river flow was diverted through a well-developed and managed wetland system.

In assessing the effectiveness of wetland systems, an assumption has been made that each hectare of wetland will remove 750 kg/N and 20 kg/P. The nutrient offsetting provided by different land areas converted to wetland are estimated in Figure 7.3.1.

Figure 7.3.1 Nutrient Offsetting estimated to be provided by Wetland Creation



The development of wetlands are likely to have many water quality and environmental benefits. They may also have some adverse impacts, such as potentially increasing infiltration and evapotranspiration losses, which could adversely impact river flows during summer and times of water stress.

Prior to installing any wetland, further work will need to be undertaken to identify the most favourable locations for their construction. This will include but not limited to:

- opportunity mapping,
- detailed design
- risk assessment
- cost benefit
- Regulatory requirements

Funding for their installation may be sought through the new Water Environment Grant.

Around 50ha of wetland are already being planned across the Poole Harbour catchment (Appendix 3).

Small, constructed farm wetlands positioned in field margins and areas at risk of nutrient losses can also provide and buffer and a reduction in nutrient losses. The nutrient reduction delivered by these measure have not been quantified in this report as the main objective should be to maintain soil and nutrients in field. They could however be evaluated in the future when undertaking detailed option appraisal ®.

7.4 Point Source Measures to deliver macroalgae targets

Macroalgae modelling work indicates that further point source reduction will be required to deliver the overall water quality targets for the catchment (1500 tonnes/N/yr & 22 tonnes/OP/yr) and fair share reductions.

Wessex Water will now need to reduce their nutrient loads discharged to the harbour to 209 tonnes N/yr to achieve their fair share. This equates to a further c120 tonnes N/yr reduction from NMP target. Within this, the modelling indicate that it will be necessary to reduce the nitrogen permit limit at Poole WWTW to c5 mg/l to reduce the risk of deterioration within the water body.

OP loads discharged from WWTW and CSO's into the catchment should be reduced to c16.5 tonnes/yr to deliver WWTW fair share reductions. This is a reduction of c 39 tonnes OP from full permit scenario or 22 tonnes OP from 2010-12 baseline; (Section 7.1)].

A significant proportion of this should be delivered through installing P stripping (or alternative measures) at Poole WWTW. This is because Poole WWTW contributes c50% of the total OP to the harbour and because of the year round availability of nutrients from this source, has a significant impact on the ecology in the harbour (c23-25 tonnes OP/yr for 2010-12 and 2015-17 respectively and c37 tonnes OP under full permit assumptions) and the limited flushing with the outer harbour.

Some further opportunities to reduce point source nutrient loads across the catchment are detailed in Table 7.4:1-7.4:3. Some of the key measures to achieve fair share may include:

Nitrogen (Table 7.4:3)

- Poole WWTW discharged out of catchment and remaining big 6 WWTW [10]at 10mg/l to bring 100 N tonne/yr target (based on 2015/17 flows).
- Big 6 WWTW operating at 5mg/l and other WWTW operating at 10mg/l to deliver 124 N tonne/yr (based on 2015/17 flows).

Phosphorus (Table 7.4:2)

- Poole WWTW effluent being discharged out of the catchment and remaining big 6 WWTW[5] operating at 5mg/l N to reduce total WWTW loads to c 18.9 tonnes TP/yr: (c16 tonnes OP).
- Big 6 WWTW operating at 0.5mg/l TP bringing TP loads discharged to the harbour down to c 16.9 tonnes TP/yr <16 tonnes OP/yr (Poole, Wareham, Lytchett, Dorchester, Wool and Blackheath WWTW).
- ALL WWTW OP Load maintained at or below 2010-11 with the exception of Poole and Wareham WWTW operating near TAL (0.25 mg/l OP) giving total loading of c14.5 tonnes OP/yr.

Modelling scenarios 5p also required a reduction in fluvial OP inputs of 30% and assumes Studland WWTW and Brown sea Island discharge concentrations do not exceed 2mg/l OP (note: Brownsea Island discharges may already be attenuated by read bed treatment at the point of discharge) . A

[10] Poole, Wareham, Lytchett Minster, Dorchester, Blackheath, Wool WWTW

30% fluvial reduction in OP will need to be delivered by reductions in diffuse and point source sources. This equates to a reduction of c3 tonnes OP/yr from WWTW.

Measures already proposed under AMP 6 &7, are likely to reduce maximum permitted fluvial TP loads by 2.35 tonnes/yr (Table 3.1). In practice however this will only be reducing the P loading headroom as Dorchester WWTW as it already performs below its existing and proposed future permit condition. Consideration should therefore be given to further reducing OP loads entering the Wareham Channel to deliver this objective in conjunction (not addition) to delivering fair share ®.

Recommendations are therefore ®:

- **Waste Water Treatment works N levels should be reduced to 209 tonnes N/yr,**
- **OP<16 tonnes/yr**
- **Poole WWTW discharge should not exceed 5mg/l N & c 0.25 mg/l TP (c0.21 mg/l OP) (Case 5p).**
- **Exact permit conditions should be agreed through PR24 discussions following AMP 7 investigations, to ensure the WWTW does not compromise the ability to achieve Favourable Condition across the harbour.**
- **Any point source measures recommended to be implemented from these investigations should be implemented in AMP8.**

Table 7.4:1 Point Source Options. Nutrient reduction from 2015-17 and 2010-11 baseline scenario

Option		Nitrate load reduction from 2015-17 (tonnes/N/yr)			Total Phosphorus load reduction from 2015-17 (tonnes/TP/yr)				Tonnes/TP reduction (tonnes/T	Nitrate load reduction from 2010-11			Total Phosphorus Load reduction from 2010-11				TP reduction baseline year flow (2010-11) & 2015-17 quality	
	Option sub-reference	a (N)	b (N)	c (N)	d (TP)	e (TP)	f (TP)	g (TP)	h (TP)	I (N)	j (N)	k (N)	I (TP)	m (TP)	n (TP)	o (TP)		
		Zero discharge	10mg/l	5 mg/l	zero discharge	1mg/l	0.5 mg/l	0.25 mg/l	30% reduction	Zero discharge	10mg/l	5mg/l	Zero discharge	1mg/l	0.5mg/l	0.25mg/l	Zero discharge	0.25 mg/l
PS 1	Poole STW	132.90	0.00	55.63	31.78	16.33	24.06	27.92		99.53	-39.67	29.93	14.48	0.56	7.52	11.00	28.63	25.15
PS 2	Wareham STW		18.45	24.10		5.10	5.67	5.95			18.45	24.10	6.23	5.10	5.67	5.95	6.23	5.95
PS 3	Lytchett Minster STW		7.04	10.53		1.39	1.74	1.91			7.04	10.53	2.09	1.39	1.74	1.91	2.09	1.91
PS 4	Dorchester STW		90.13	107.38		-1.52	0.21	1.07			81.39	96.97	1.74	-1.37	0.19	0.96	1.74	0.96
PS 5	Wool STW		6.22	22.77		-0.40	0.01	0.22			15.71	19.16	0.36	-0.34	0.01	0.18	0.36	0.18
PS 6	Blackheath STW		6.22	8.41		1.46	1.68	1.79			11.58	15.66	3.54	2.73	3.13	3.34	3.54	3.34
PS 7	Total small STW load (excluding big 6)		21.56			4.52												
PS 8	30% reduction in fluvial discharged STW load to rivers								2.84									

Table 7.4:2 Combined Point Source Phosphorus Options

Discharge name	P load All STW @NMP baseline flow (2010-11) & 2015-17 concentration tonnes/P/yr	P load All STW @ 2015-17 flow and concentration tonnes/P/yr	Poole STW Discharged out of catchment others NMP baseline (2010-11) and concentration tonnes/P/yr	Poole STW Discharged out of catchment others 2015-17 flow and concentration tonnes/P/yr	P load tonnes/P/yr. Big 6 @0.5 mg/l & 2015-17 flows, remainder at 2015-17 flow and concentration	P load tonnes/P/yr. All STW at 1mg/l, Big 6 @ 0.5 mg/l (2015-17 flow and concentration)	TP load tonnes/yr. All Rural STW @ 1mg/l P, larges 6 STW at 0.25 mg/l	Large 6 Operate at 0.25 mg/l remainder at 2015-17 (Concentration mg/l P) tonnes/P/yr
Poole STW	14.478	31.782	0.000	0.000	7.727	7.727	3.863	3.863
Wareham STW	6.230	6.230	6.230	6.230	0.565	0.565	0.282	0.282
Lytchett Minster STW	2.086	2.086	2.086	2.086	0.348	0.348	0.174	0.174
Dorchester STW	1.744	1.931	1.744	1.931	1.725	1.725	0.862	0.862
Wool STW	0.356	0.423	0.356	0.423	0.411	0.411	0.205	0.205
Blackheath STW	3.541	1.901	3.541	1.901	0.219	0.219	0.110	0.110
Total small STW load (excluding big 6)	4.933	5.809	4.933	5.809	5.809	1.289	1.219	5.809
Total big 6 STW	28.433	44.352	13.956	12.570	10.994	10.994	5.497	5.497
Total Phosphorus (Tonnes TP/yr)	**33.37**	**50.16**	**18.89**	**18.38**	**16.80**	**12.28**	**6.72**	**11.31**
Wareham, Lytchet, Studland and Brownsea Island)	9.98	9.47	9.98	9.47	7.57	3.52	2.28	6.39
Difference from NMP Baseline STW flows & 2015-17 quality	**0.00**	**16.79**	**-14.48**	**-14.99**	**-16.56**	**-21.08**	**-26.65**	**-22.06**
Difference from 2015 to 2017 STW flows and quality	**-16.79**	**0.00**	**-31.27**	**-31.78**	**-33.36**	**-37.88**	**-43.45**	**-38.86**
Poole, Wareham, Lytchet, Studland and Brownsea Island)	2.00	1.89	2.00	1.89	1.51	0.70	0.46	1.28
Poole, Wareham, Lytchet, Studland and Brownsea Island)	2.99	2.84	2.99	2.84	2.27	1.06	0.68	1.92
Maximum STW load with 20% reduction in input to fluvial sources	31.37	48.27	16.89					
Maximum STW load with 30% reduction in input to fluvial sources	30.37	47.32	15.90					

Table 7.4:3 Combined Point Source N Options

Discharge name	N load Baseline quality (2010-11) v 2015-17 flows	N load All STW at 2015-17 flow and quality tonnesN/yr	N load All STW at 2015-17 flow and concentrationl, No Poole STW discharge N/T tonnesN/yr	Poole STW discharged out of catcment, Big 6 @10mg/l remainder at 2015_17 flow and quality	N load All STW at 10mg/l N, Big 6 @ 5mg/l (2015-17 flow and concentration) tonnes	P load All Rural STW @ BAT for N 10mg/l & larges 6 STW at 50% BAT (2015-17 flows)	Large 6 Operate at 25% BAT (2.5mg/lN) remaining at 2015-17 quality and flow tonnes N/yr
Poole STW	99.53	132.90	0.00		77.27	77.27	38.63
Wareham STW	29.74	29.74	29.74	11.30	5.65	5.65	2.82
Lytchett Minster STW	14.01	14.01	14.01	6.97	3.48	3.48	1.74
Dorchester STW	112.54	124.62	124.62	34.49	17.25	17.25	8.62
Wool STW	22.62	26.87	26.87	8.21	4.11	4.11	2.05
Blackheath STW	19.74	10.60	10.60	4.38	2.19	2.19	1.10
Total small STW load (excluding big 6)	29.57	34.51	34.51	34.51	12.95	12.95	34.51
Total big 6	298.19	338.74	205.85	65.35	109.94	109.94	54.97
Total Nitrate Load (tonnes/N/yr)	**327.76**	**373.26**	**240.36**	**99.86**	**122.89**	**122.89**	**89.48**
Total Load from inland STW (excludes Poole, Wareham, Lytchet, Studland and Brownsea Island)	181.79	193.92	193.92	78.92	35.30	35.30	43.60
Difference from 2010-11 discharge (NMP baseline) STW concentration & flows V scenario		-45.50	-87.40	-227.90	-204.87	-204.87	-238.28
Difference from 2015_17 concentration and flows V scenario	-45.50	0.00	-132.90	-273.40	-250.37	-250.37	-283.77
20% reduction from inland STW (excludes Poole, Wareham, Lytchet, Studland and Brownsea Island)	36.36	38.78	38.78	15.78	7.06	7.06	8.72
30% reduction from inland STW (excludes Poole, Wareham, Lytchet, Studland and Brownsea Island)	54.54	58.18	58.18	23.67	10.59	10.59	13.08

7.5 Cost Benefit

The costs of diffuse and point source measures are estimated below and presented in more detail in Appendix 9.

7.5.1 Diffuse Cost Estimates

ADAS calculated the cost of the diffuse measures scenario 1-4 (DS1-4), using the Farmscoper tool. Results from this work are outlined in Tables 7.5:1 and Appendix 6. This shows the cheapest cumulative cost for delivering diffuse N and TP reduction is the combined Scenarios 1 and 2. This results in a cost of £2/kg/N & £70/kg/TP respectively, assuming no agri-environment scheme are in place or total cost of £8/kg/N & £252/kg/TP with these schemes. When bundles 1-4 are included the cumulative cost rises to £10/kg/N & £274/kg/TP and £13/kg/N & £363/kg/TP respectively.

Table 7.5:1 Diffuse Costs and Benefits (from ADAS March 2018)

Table 13 – Costs and cost-effectiveness of the 4 measure implementation scenarios, with and without the agri-environment schemes (Environmental Stewardship, Catchment Sensitive Farming and Wessex Water Catchment Management). The table shows the annual average cost (where capital costs are amortised) and the cost per kilogram of pollutant saved. Data shown for capital and operational costs are the additional costs relative to the previous scenario, whereas the total cost (and costs per kilogram) are the cumulative costs.

Agri-Environment Scheme Implementation	Scenario	Additional Capital Cost (£m)	Additional Operational Cost (£m)	Cumulative Total Cost (£m)	Nitrate (£ kg^{-1} NO_3-N)	Phosphorus (£ kg^{-1} P)	Sediment (£ kg^{-1})
No	1	0.80	0.49	1.30	62	1,413	15.9
	2	0.00	-0.95	0.34	2	70	0.1
	3	1.26	-0.06	1.55	8	257	0.4
	4	0.03	0.54	2.12	10	274	0.4
Yes	1	1.13	2.26	3.38	29	620	1.0
	2	0.01	-1.75	1.63	8	252	0.4
	3	1.11	0.05	2.79	12	384	0.6
	4	0.02	0.36	3.17	13	363	0.5

7.5.2 Point Source Cost Estimates

The cost of each point source option detailed in 7.5:1 have been evaluated in terms of annualised cost to deliver a kilogram reduction in either N or TP. The 50, 100 and 200 year Net Present Value of each option has also been evaluated to enable further like for like comparisons of each option (Appendix 9). The Ecosystems Services analysis is further considered in Section 7.8.

Point source cost and benefits are detailed in Table 7.5:2 and show that for N, the cheapest 50year costs are installing N treatment to 10mg/l at Dorchester WWTW (£5/kg/N), then to 5mg/l (£7/kg/N) followed by tightening permit conditions at Poole WWTW to 5mg/l with costs of £14/kg/N.

The cheapest 50 year cost option for delivering TP reduction would be installing P treatment at Poole WWTW to 0.5mg/l at £40/kg/TP. If N and TP reduction were required the cheapest option may be to discharge effluent 5km offshore through 9km pipeline, with a tunnelling 50 year cost of

£24kg/N and TP or pipeline cut and fill cost of £6 kg/N+TP. These costs would increase and would need to be re-evaluated if any treatment of discharge water were required.

Table 7.5:2 N and TP Reduction Costs £/kg for Full Permit Variation for Scenario (where current water quality condition does not exist, 2015-17 is taken to be permit maximum from which N and TP Savings are Calculated for each Scenario), based on Net Present Value.

		N Scenarios N treatment Costs £/kg reduced from Current Permit to Proposed Scenario									TP Scenarios TP treatment Costs £/kg reduced from Current Permit to Proposed Scenario											
OPTION	Sub ref	a (N)			b (N)			c (N)			d (TP)			e (TP)			f (TP)			g (TP)		
		Zero Discharge Load tonnes N/yr			10mg/l N & 2010-11 flows			5mg/l & 2013-17 flows			Zero Discharge Load tonnes TP/yr			1mg/l TP tonnes TP/yr			0.5mg/l TP tonnes TP/yr			0.25mg/l TP tonnes TP/yr		
		50yr	100yr	200yr	50yr	100yr	200yr	50yr	100yr	200yr	50yr	100yr	200yr	50yr	100yr	200yr	50yr	100yr	200yr	50yr	100yr	200yr
PS 1	Poole STW	29	16	9				14	8	4	157	90	47	22	13	7	40	23	12	44	25	13
	Poole STW Cut and Cover trench*4	7	4	2							38	22	11									
PS 2	Wareham STW				26	15	8	42	24	13				13	7	4	48	28	15	67	39	21
PS 3	Lytchett Minster STW				57	33	17	82	48	25				69	40	21	99	58	30	153	89	47
PS 4	Dorchester STW				5	3	1	7	4	2				0	0	0	204	119	63	194	112	59
PS 5	Wool STW				24	14	7	40	23	12							441	256	135	488	283	149
PS 6	Blackheath STW				23	14	7	36	21	11				27	16	8	68	40	21	98	57	30
PS 7	Total small STW load (excluding big 6)																					

Note: Poole STW Tunnel will deliver combined offsetting of all nutrients. Costs have however been Calculated for N and TP offsetting independently (assuming no other benefit is achieved). Wareham STW will deliver permit limit of 15mg/l by December 2021. There are proposals to tightening TP permit limits at Cerne Abbas (0.8mg/l), Corfe Castle (1.3mg/l) and Piddlehinton (4mg/l) under PR19. Cut and cover options assumes 4km urban cut and 5km of rural cut @ £10M & £4M/km

7.6 Options Evaluation

7.6.1 Diffuse and Alternative option evaluation

A qualitative assessment of the diffuse pollution options are outlined in Table 7.6.1 below; using the approach detailed in Section 4.5.

This shows that diffuse bundles 1-4 are readily achievable. Bundles 2-4, may require new guidance or legislation if farmers were to be required to implement these measures. Unless it was assumed, and could be demonstrated that without the implementation of these measures farmers would be "causing" or "knowingly permitting pollution to waters". In this case, the Environmental Permitting Regulations (2010) Regulations 38(1) (a) and 12(1) (b) could apply (Section 3.2.1.1).

Alternatively if farmers agreed to implement these measures as a whole community, through a nutrient trading approach, meeting agreed rules and reporting and with inspection/enforcement regime for those who do not, this could deliver these measures. Bundle 3 is likely to have a greater socio economic impacts than 1, 2 and 4, because of greater capital investment required by farmers.

Table 7.6.1 Diffuse Options Evaluation (based on definitions outlined in Section 4.5)

Estimated Diffuse Agricultural Baseline		Technical Feasibility	Practical Feasibility	Socio economic impact	Proportionality within fair share	Cost Benefit	Cost £kg/N	Cost £ kg/TP	50 year Cost combined £/kg/N+TP	Regulatory Instrument in place?	Instrument required	Delivery Timescales
Diffuse Scenarios						£/kg.N		£/KG/TP				
DS1	Scenario 1	yes	High	Low	Yes	Yes	62	1413		Yes		2018+
DS2	Scenario 2	Yes	High	Low	Yes	Yes	2	70		No		2020-25
DS3	Scenario 3	Yes	High	Medium	Yes	Yes	8	257		No		2025-30
DS4	Scenario 4	Yes	High	Low	Yes	Yes	10	274		No		2020-25
DS5	Scenario 5	Yes	Medium	High	Yes	No				No		2025-30
DS6	Scenario 6	Yes	Medium	High	Yes	No				No	WPZ	2025-30
DS7	Scenario 4 + increased buffer											
DS8	Reduce nutrient application											
DS9												
DS10	Wetland Alternative	Yes	High	Low	Yes	Yes				No		2020-25

Implementation of these diffuse measures will reduce N and TP and will also have a significant benefit in reducing other diffuse pollutants, such as sediment, nitrous oxide, pesticides, faecal coliforms and the overall CO2 footprint (Table 7.6.2 a and b. Section 7.9).

Bundles 5 and 6 require change in land use from arable and high intensity pastoral farming to lower intensity pastoral farming, and includes a reduction in stocking numbers. The practical feasibility of these options is lower due to the potential cost and socio-economic impact resulting from the substantial changes in agriculture, unless applied through a nutrient trade type of approach. ADAS report (ADAS 2018; Appendix 6) stated that the implementation of Bundles 5 & 6 would have "significant impacts on the farming community within the catchment". Some mitigation of these impacts could be through future farming subsidies, (providing a public "good" is shown) or through catchment nutrient trading that could enable some reimbursement for farmers delivering low intensity agriculture. This option is discussed in more detail later.

Both Scenario 5 and 6 would lead to lower food production, although there would be some environmental, biodiversity and cultural benefits from the increased areas of low input grassland. Over time, farmers that are able to adapt and innovate may find ways to diversify and achieve the same pollutant reduction benefits, e.g. through creation of orchards, agro-forestry or tourism / nature opportunities (ADAS 2018). The predicted change in pollutant losses are shown in Table 7.6.2a & b. below. The ecosystem services are further discussed in Section 7.9.

Table 7.6.2 Reduction in Diffuse Pollutants Resulting from Implementation of Diffuse Scenarios 1-4 (From ADAS 2018)

a)

Table 12 - Reductions in annual average agricultural pollutant loads in the Poole Harbour catchment, calculated with 2015 agricultural census data, due to the 4 measure implementation scenarios, and any additional benefits from agri-environment schemes (Environmental Stewardship, Catchment Sensitive Farming and Wessex Water Catchment Management). The table shows the total load reduction under each scenario relative to losses with NVZ regulations and other background implementation.

Agri-Environment Scheme Implementation	Scenario	Nitrate ($t\ NO_3$-N)	Total Phosphorus (t P)	Sediment (t)	Ammonia ($t\ NH_3$-N)	Methane ($t\ CH_4$)	Nitrous Oxide ($t\ N_2O$)	Pesticides (Units)	FIOs (10^{12} cfu)	Energy Use ($t\ CO_2$-e)
NVZ regulations & background		1,797	28.3	15,134	1,115	4,041	465	2,770	2,925	65,578
No	1	1,776	27.4	15,052	1,102	4,041	460	2,770	2,454	65,392
	2	1,628	23.4	11,502	1,098	4,041	451	2,751	2,451	59,277
	3	1,594	22.3	10,859	1,084	4,002	448	2,813	2,316	57,060
	4	1,571	20.6	9,388	1,077	4,002	446	2,546	2,310	56,021
Yes	1	1,679	22.8	11,720	1,099	4,055	444	2,691	2,335	64,187
	2	1,594	21.8	10,567	1,095	4,055	439	2,698	2,351	58,314
	3	1,570	21.0	10,213	1,082	4,016	436	2,729	2,246	56,520
	4	1,548	19.5	8,975	1,075	4,016	435	2,503	2,225	55,489

b)

Table 16 - Reductions in annual average agricultural pollutant loads in the Poole Harbour catchment, calculated with 2015 agricultural census data, due to the land use change scenarios and methods implemented as part of Scenarios 1- 4. The table shows the total load reduction under each scenario relative to Scenario 4.

Scenario	Nitrate ($t\ NO_3$-N)	Total Phosphorus (t P)	Sediment (t)	Ammonia ($t\ NH_3$-N)	Methane ($t\ CH_4$)	Nitrous Oxide ($t\ N_2O$)	Pesticides (Units)	FIOs (10^{12} cfu)	Energy Use ($t\ CO_2$-e)
5	106	1.9	1,512	-6	-241	-11	0.73	-34	6,938
6	371	3.4	1,514	289	1,142	45	0.73	750	12,927

Similarly the installation of wetlands are likely to result in reduction of other pollutants and increased bio-diversity (Section 7.3).

7.6.2 Point Source Option Evaluation

A similar analysis of point source options has been undertaken. The results from this are outlined in Table 7.6.3

Table 7.6.3 Point Source Options Evaluation (based on definitions outlined in Section 4.5)

Estimated Diffuse Agricultural Baseli		Technical Feasibility	Practical Feasibility	Socio economic impact	Proportionality within fair share	Cost Benefit	50 year Cost £kg/N	50 year Cost £ kg/TP	50 year Cost combined £/kg/N+TP	Regulatory Instrument in place?	Delivery Timescales
Point Source Scenarios											
PS 1a & 1d (N&	Poole STW 9km tunnel to sea	Yes	Medium	Medium	No	yes	29	157	24	Policy	2025-30
PS1a (N&TP)	Poole STW cut and fill pipe to sea	Yes	Medium	Medium	No	yes	7	38	6	Policy	2025-30
PS 1b (N)	Poole STW @10mg/l N	NA	NA	NA	NA	NA	NA	NA	NA	NA	Current
PS 1c (N)	Poole STW @5mg/lN	Yes	High	Low		Yes	14			Yes	2025-30
PS 1e (TP)	Poole STW TP limit @1mg/l	Yes	Medium	Low		Yes		22		Yes	2025-30
PS 1f (TP)	Poole STW TP limit @ 0.5mg/l	Yes	Medium	Low		Yes		40		Yes	2025-30
PS1g (TP)	Poole STW TP limit @ 0.25mg/l	Yes	Medium	Low		Yes		44		yes	2025-30
PS 2b (N)	Wareham STW @10mg/l N	Yes	Medium	Low		Yes	26			yes	2025-30
PS 2c (N)	Wareham STW @5mg/lN	Yes	Medium	Low		Yes	42			yes	2025-30
PS 2e (TP)	Wareham STW TP limit @1mg/l	Yes	Medium	Low		Yes		13		yes	2025-30
PS 2f (TP)	Wareham STW TP limit @ 0.5mg/l	Yes	Medium	Low		Yes		48		yes	2025-30
PS2g (TP)	Wareham STW TP limit @ 0.25mg/l	Yes	Medium	Low		Yes		67		yes	2025-30
PS 3b (N)	Lytchett STW @10mg/l N	Yes	Medium	Low		Yes	57			yes	2025-30
PS 3c (N)	Lytchett STW @5mg/lN	Yes	Medium	Low		Yes	82			yes	2025-30
PS 3e (TP)	Lytchett STW TP limit @1mg/l	Yes	Medium	Low		Yes		69		yes	2025-30
PS 3f (TP)	Lytchett STW TP limit @ 0.5mg/l	Yes	Medium	Low		Yes		99		yes	2025-30
PS3g (TP)	Lytchett STW TP limit @ 0.25mg/l	Yes	Medium	Low		No		153		yes	2025-30
PS 4b (N)	Dorchester STW @10mg/l N	Yes	Medium	Low		Yes	5			yes	2025-30
PS 4c (N)	Dorchester STW @5mg/lN	Yes	Medium	Low		Yes	7			yes	2025-30
PS 4e (TP)	Dorchester STW TP limit @1mg/l	NA	NA	NA	NA	NA	NA	NA	NA	NA	Current
PS 4f (TP)	Dorchester STW TP limit @ 0.5mg/l	Yes	Medium	Low		No		204		yes	2025-30
PS4g (TP)	Dorchester STW TP limit @ 0.25mg/l	Yes	Medium	Low		No		194		yes	2025-30
PS 5b (N)	Wool STW @10mg/l N	Yes	Medium	Low		Yes	24			yes	2025-30
PS 5c (N)	Wool STW @5mg/lN	Yes	Medium	Low		Yes	40			yes	2025-30
PS 5e (TP)	Wool STW TP limit @1mg/l	NA	NA	NA	NA	NA	NA	NA	NA	NA	Current
PS 5f (TP)	Wool STW TP limit @ 0.5mg/l	Yes	Medium	Low		No		441		yes	2025-30
PS5g (TP)	Wool STW TP limit @ 0.25mg/l	Yes	Medium	Low		No		488		yes	2025-30
PS 6b (N)	Blackheath STW @10mg/l N	Yes	Medium	Low		Yes	23			yes	2025-30
PS 6c (N)	Blackheath STW @5mg/lN	Yes	Medium	Low		Yes	36			yes	2025-30
PS 6e (TP)	Blackheath STW TP limit @1mg/l	Yes	Medium	Low		Yes		27		yes	2025-30
PS 6f (TP)	Blackheath STW TP limit @ 0.5mg/l	Yes	Medium	Low		Yes		68		yes	2025-30
PS6g (TP)	Blackheath STW TP limit @ 0.25mg/l	Yes	Medium	Low		Yes		98		yes	2025-30
PS 7b (N)	All small STW (excluding big 6) STW @10mg/l N	Yes	Medium	Low		No	230			yes	2025-30
PS 7c (N)	All small STW (excluding big 6) STW @5mg/lN	Yes	Medium	Low		Yes				yes	2025-30
PS 7e (TP)	All small STW (excluding big 6) STW TP limit @1mg/l	Yes	Medium	Low		Yes				yes	2025-30
PS 7f (TP)	All small STW (excluding big 6) STW TP limit @ 0.5mg/l	Yes	Medium	Low		Yes		11		yes	2025-30
PS7g (TP)	All small STW (excluding big 6) STW TP limit @ 0.25mg/l	Yes	Medium	Low		Yes				yes	2025-30

7.6.3 Other reduction

Much of urban and non-agricultural nutrient loading will be derived from atmospheric sources. Government action on reducing agricultural and industrial aerial emissions in the future will start to reduce these loading and contribute to the solution.

Further urban reductions can be delivered through resolving misconnections between foul and clean water soakaways. Implementation of Sustainable Urban Drainage systems will also reduce run-off and nutrient input to the surface water system and harbour.

7.7 Recommended options to deliver the Water Quality improvements/Targets

Currently around 2300 tonnes N/yr and 51 tonnes OP/yr enter the Poole Harbour catchment from non-marine sources. An assessment of the macroalgae modelling results (Table 7.7:2) show that the macroalgae targets can most easily be delivered by reducing both N and OP load entering the harbour; Cases 5p. This case outlines the need to reduce N to <c1500 tonnes N/yr and OP to c22 tonnes OP/yr (Table 7.7.1) and how all sectors will now need to make further N and OP reductions.

These targets are "interim" and will be reviewed and refined in the future when our understanding of the ecology and water quality inter-relationship improve (Section 6.3-6.5). This will not be before 2027.

Table 7.7:1 Summary of Interim N and OP Target loads across Poole Harbour and reductions required to deliver water quality objectives ®

Nutrient	Maximum Sector contribution tonnes N/yr		Sector Reduction tonnes OP/yr	
	Nitrogen (tonnes/yr)	**Nitrogen reduction**	**OP (tonnes/yr)**	**OP reduction**
Total Current load (2013-17)	c2300		c51	
Interim Target load not exceeding	c1500		c22	
Agriculture load*1 not exceeding	c1127 N c24 kg/ha*2 18 kg/N/ha all rural land use	c643 t/yr from 2010 land use	c3*3	c4.5*3
WWTW Point Source load*1 not exceeding	<c209 tonnes N/yr	120 tonne N/yr	<c16.5 OP	c21.5 OP

*1 based on fair share reduction and NMP recommendations, *2 NMP: Annex 7 based on Arable and managed grassland area included in 2010 census land use. *3based on SAGIS-SIMCAT modelling.

Agriculture should delivered their fair share reductions, through implementing the measures which have the least socio-economic impact [(Section 7.2 and 7.6). Where required, this could be delivered in combination with alternative approaches, such as wetland schemes (Section 7.3 and 7.6).

Wessex Water now also need to make some substantial N and OP reductions to achieve their fair share contribution (Table 7.7:1). Modelling results indicate that this will need to include installing further nitrogen and phosphorus treatment at Poole WWTW or exporting this discharge out of catchment to an appropriate location. The reason further treatment at Poole WWTW is likely to be required is because:

- Water is discharged to an embayment (Holes Bay) which has limited flushing with the outer harbour. The OP and N load from the WWTW to this embayment is significant.
- The very large OP load discharged from the WWTW compared with the wider catchment, (c50% of the total catchment load in 205-17).
- Constant (high) proportional nutrient load entering Holes Bay from the WWTW throughout the year, enabling macroalgae growth when other light and temperature conditions are also met.

Increasing the level of treatment at Poole WWTW, will reduce seasonal nutrient availability and start to limit growth in Holes Bay and the Outer Harbour. It will however take many years for any water quality improvements to be realised due to the P stores in the harbour muds and gradual leaching of these chemicals that will result. A reduction in sediment entering the harbour via the WWTW will also have wider ecosystem benefits.

Nutrient reductions from industry (including fish farms and cress farms) may also be required to meet their fair share (Section 6.3) ®.

An appraisal of the measures that are likely to be least onerous for each sector (to deliver their fair share water quality improvements) are detailed in Table 7.7.3a and b.

The diffuse scenario which includes alternative measures, indicates that the diffuse fair share can be achieved by:

- widespread implementation of nutrient management efficiencies measures: DS 1-4,
- alternative wetland development of c380 ha (figure iterated to deliver N target),
- In-combination with reducing stocking numbers by 17% and arable production by 23% (50% of DS 5-6).

Because of the need for land use change, this is still likely to have a moderate to high socio economic impact. If however farmers took ownership of the issues and developed a nutrient trading approach, farmers who maximise their nutrient efficiencies, potentially by changing land use and or crop production through reducing nutrient application rates, might be compensated financially by higher input farmers (Section 8.1)

Point source fair share can be delivered through:

- Nitrogen treatment at Poole WWTW to 5mg/l and Phosphorus to 0.25 TP (based on 2010-11 flows).
- Nitrogen treatment at Wareham to 15mg/l (as in AMP) at 2010-11 flows.
- Nitrogen treatment at Dorchester to 15mg/l at 2010-11 flows.
- Continued offsetting 40 tonnes N at Dorchester, or increased treatment at Dorchester to < 10mg/l N.

Table 7.7:2 Option Appraisal for Modelling Cases.

Macroalg:	N&TP loading tonnes		Measures		Technical Feasibility	Practical Feasibility	Socio economic impact	Proportionality within fair share	Regulatory Instrument in place?	Delivery Timescales
	Total TP	Total N	Diffuse measures	Point Source						
5a	26.3	821.4		PS1a	Yes	Medium	High	No	No	2025-30
5b	58.1	958.8			Yes	Medium	High	No	No	2025-31
5c	58.1	973.1			Yes	Medium	High	No	No	2025-32
5d	22.8	913.8			Yes	Medium	High	No	No	2025-33
5e	20.1	2094.0			Yes	Medium	Medium	No	No	2025-35
5f	30.8	880.7			Yes	Medium	High	No	No	2025-33
5g	24.2	932.1			Yes	Medium	High	No	No	2025-33
5h	25.5	908.9			Yes	Medium	High	No	No	2025-33
5 i	23.7	991.0			Yes	Medium	High	No	No	2025-33
5j	23.9	1000.8			Yes	Medium	High	No	No	2025-34
5k	21.5	1724.9	DS10	PS1g (TP)	Yes	Medium	Low	Yes	No	2025-35
5l	20.4	1632.3	DS10	PS1a & 1d	Yes	Medium	Low	Yes	No	2025-36
5M	12.3	1724.9			Yes	Medium	High	No	No	2025-37
5N	10.3	1724.9			Yes	Medium	High	No	No	2025-38
5o	21.5	1500.0	DS10	PS1g (TP)	Yes	Medium	Medium	Yes	No	2025-38
5p	22.1	1500.0	DS10	PS1g (TP)	Yes	Medium	Medium	Yes	No	2025-38

Table 7.7:3 Combined Measure to Deliver Fair Share and Water Quality Targets: Including alternative wetland scheme

Measure	Baseline	Total N (kg/y)	Adjusted N Load (kg/y)	Diffuse N fair share met	Point Source N fair share met	OP (kg/y)	Adjusted OP load (kg/y)	Diffuse OP fair share met	Point Source OP fair share
	Baseline (c2013_17)	2300000				51200			
	Target 1: Scenario 5p	1500000				22000			
DS1	ADAS Scenario 1 *1	-21000	2279000	No	No	-585	50615	No	NO
DS2	ADAS Scenario 2*1	-148000	2131000	No	no	-2600	48015	No	NO
DS4	ADAS Scenario 4 *1	-23000	2108000	No	No	-1105	46910	No	NO
DS3	ADAS Scenario3 *1	-34000	2074000	No	No	-715	46195	No	NO
	Dorchester STW operate at 15mg/l N (2010-11 baseline)	-65300	2008700	No	No	0	46195	No	NO
	Poole STW operate at 5mg/l N (change from operating in 2010-11 baseline year flow and quality) and P treatment to 0.25mg/l (using 2015-17 baseline quality)	-29900	1978800	No	No	-25150	21045	No	NO
	Wareham STW operating at 15mg/l (2010-11 baseline)	-12840	1965960	No	No	0	21045	No	Yes
	Wessex Water Poole Harbour offsetting 40 tonnes for Dorchester through agricultural measures	-40000	1938800	No	Yes	-1170	19875	No	Yes
Alt 1	380 ha Wetland @ 750kgN, 20kg/P offsetting per effective ha of wetland	-285000	1653800	No	Yes	-7600	12275	YES	Yes
50% of DS5	23% reversion of high input arable to low input	-53000	1600800	No	Yes	-618	11658	YES	Yes
50% of Ds6	17% reduction in stocking numbers	-132000	1468800	yes	Yes	-1105	10553	YES	Yes
	*1 TP adjusted using OP:TP Ratio of					0.65			
	Total point source reduction	-148040	N kg			-26320	OP kg		
	Total diffuse source reduction	-696000	N kg			-14328	OP kg		

Table 7.7:3 b Table showing the need for alternative measures to deliver diffuse pollution reduction or an increased percentage of stocking reduction and land reversion.

Measure	Baseline	Total N (kg/y)	Adjusted N Load (kg/y)	Diffuse N fair share met	Point Source N fair share met	OP (kg/y)	Adjusted OP load (kg/y)	Diffuse OP fair share met	Point Source OP fair share met
	Baseline (c2013_17)	2300000				51200			
	Target 1: Scenario 5M	150000				20500			
DS1	ADAS Scenario 1 *1	-21000	2279000	No	No	-585	50615	No	NO
DS2	ADAS Scenario 2*1	-148000	2131000	No	No	-2600	48015	No	NO
DS4	ADAS Scenario 4 *1	-23000	2108000	No	No	-1105	46910	No	NO
DS3	ADAS Scenario3 *1	-34000	2074000	No	No	-715	46195	No	NO
	Dorchester STW operate at 15mg/l N (2010-11 baseline)	-65300	2008700	No	No	0	46195	No	NO
	Poole STW operate at 5mg/l N (change from operating in 2010-11 baseline year flow and quality) and P treatment to 0.25mg/l	-29900	1978800	No	No	-25150	21045	No	Yes
	Wareham STW operating at 15mg/l (2010-11 baseline)	-12840	1965960	No	No	0	21045	No	Yes
	Wessex Water Poole Harbour offsetting 40 tonnes for Dorchester through agricultural measures	-40000	1925960	No	Yes	-1170	19875	No	Yes
PS1f	Poole STW operate at 0.5mg/l TP (change from operating at 2015_17 flow and quality)		1925960	No	Yes	-25150	-5275	No	Yes
PS1g	Poole STW operate at 0.25mg/l TP (change from sceanrio PS1f whilst operating at 2015_17 flow and quality)	0	1925960	No	Yes	-1170	-6445	No	Yes
DS5	ADAS Scenario 5	-106000	1819960	No	Yes	-1235	-7680	No	Yes
DS6	ADAS Scenario 6	-106000	1819960	no	Yes	-1235	-7680	Yes	Yes

7.8 Timescales and deliver targets:

Measures that improve the quality of water discharged directly to surface waters, or which reduce run-off entering such waters will have an immediate and direct impact on water quality within rivers and the harbour. Other measures which improve the quality of the water that pass through the groundwater flow pathway to rivers may take years or decades to fully realise water quality improvements. It is also likely to take a number of years for nutrient stores within river and harbour sediments to be leached and become depleted.

The lag between the environmental response and on the ground action must not be used as a reason for delay and the aim across the catchment must be to ensure **current land use practices do not cause pollution or long term harm to water quality or the environment**.

Some measures farmers will need to implement to improve their soil and nutrient management practices can be implemented rapidly as they are low cost, require little or no capital investment (Section 7.9). Other measures, particularly those included is DS3, will require more capital investment and financial planning and will need to be implemented over a longer period of time. The timeline for implementation of different measures will need to be agreed.

For consistency, it may be sensible, to align farm delivery timeframes with those of water companies. Measures that can be implemented rapidly could be implemented under AMP7 period (2020-2025). Measures that require more capital and financial planning could be implemented as early as possible, in AMP 8, (2025-2030). Piloting of some approaches may be necessary during the first few years of AMP7.

Based on our current understanding of N loads and losses, base load nutrient losses from agriculture are estimated to be around c160% of target. If it was agreed that the diffuse agricultural target should be delivered within the AMP7 and 8 timeframes (2020-30), this could be achieved by an annual average 6% reduction in N leaching over this period. The following glide path might achieve this, (Table 7.8:1 and Figure 7.8:1).

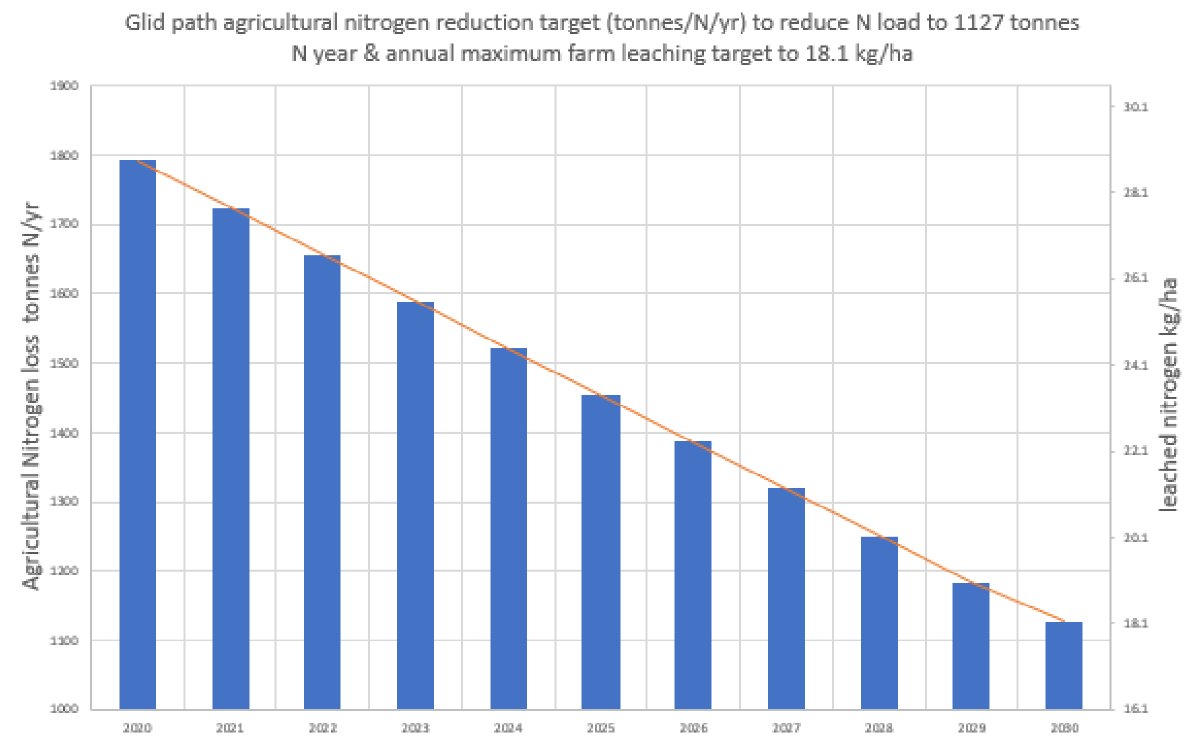
Table 7.8:1 Farming Water Quality Delivery Timescales and Glide Path

Year	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Maximum nutrient loss glide path (annual loss/target loss)	159%	153%	147%	141%	135%	129%	123%	117%	111%	105%	100%
Yearly target/credit tonnes/N/yr	1792	1724.31	1656.7	1589	1521.5	1454	1386.2	1318.59	1251	1183.4	1127
Annual reduction (tonnes/yr)	91.93	67.62	67.62	67.62	67.62	67.62	67.62	67.62	67.62	67.62	56.35
Glide path leaching target (kg/ha) (assuming land area of 62178ha; Adas Gooday et al, Nov 2017, Tables 8 & 16)	28.8	27.7	26.6	25.6	24.5	23.4	22.3	21.2	20.1	19.0	18.1

Note: 2021= assumed losses where Environmental Stuardship Schemes are being implemented

The overall target may also need to be updated in light of change in land area put into high input agriculture changes and or as science is improved. This may result in these figures going up or down.

Figure 7.8:1 Glide Path to Deliver Diffuse Pollution Reduction Target



7.9 Ecosystem Services of Preferred Measures

Implementation of diffuse measures DS1-4, will reduce N and TP but also have a significant benefit in reducing other diffuse pollutants, such as sediment, nitrous oxide, pesticides, faecal coliforms and the overall CO2 footprint.

Bundles DS5 and DS6 require change in land use from arable and high intensity pastoral farming to lower intensity pastoral farming, and includes a reduction in stocking numbers. The practical feasibility of these options is lower due to the potential cost and socio-economic impact resulting from the substantial changes in agriculture. The ADAS report (ADAS 2018; Appendix 6) states that these would have “significant impacts on the farming community within the catchment”. Some mitigation of these impacts could be through future farming subsidies, (providing a public “good” is shown) or through catchment nutrient trading that could enable some reimbursement for farmers delivering low intensity agriculture.

Both Scenario DS5 and DS6 would lead to lower food production, although there would be some environmental, biodiversity and cultural benefits from the increased areas of low input grassland. Over time, farmers that are able to adapt and innovate may find ways to diversify and achieve the same pollutant reduction benefits, e.g. through creation of orchards, agro-forestry or tourism / nature opportunities (ADAS 2018). The predicted change in pollutant losses was shown in Table 7.6.1:2a & b.

The development of wetlands are likely to have many water quality benefits, increased biodiversity and wider environmental benefits. They may also have some adverse impacts, such as increasing infiltration and evapotranspiration which could adversely impact low flow catchments. Small, constructed farm wetlands positioned in field margins and areas at risk of nutrient losses can also provide and buffer and a reduction in nutrient losses.

An ecosystem services assessment of some of the preferred measures identified above are highlighted in Table 7.9:1.

Table 7.9:1 Ecosystem Services Assessment of Preferred Scenarios to Deliver Diffuse and Point Source Nutrient Reductions

Category		DS1-4 *1 ADAS Scenario's 1-4	DS5 Scenario 5 45% land reversion to low pasture from arable	DS 6 Scenario 6-35% reduction in livestock numbers on livestock farms	PS1f Poole operates at 0.5mg/l TP	PS1g Poole operating at 0.25mg/l TP	PS1 Poole operations @ 5mg/lN,0.25 mg/l TP(potentially beyond fairshare)	Alt 1 wetland- 380 ha wetland@750kg/N, 20kg/P offsetting per effective ha of wetland
Provisioning services								
Fresh water	o	o	o	o	^	^	^	^^
Food (e.g. crops, fruit, fish etc.)	o	o	v	v	^	^	^^	^
Fibre and fuel (e.g. timber, wool, etc.)	o	^	o	o	o	o	o	^
Genetic resources (used for crop/stock breeding and biotechnology)	o	o	o	o	o	o	o	o
Biochemicals, natural medicines, pharmaceuticals	o	o	o	o	o	^	o	o
Ornamental resources (e.g. shells, flowers, etc.)	o	o	o	o	o	o	^	o
Water for non-consumptive use	o	o	o	o	o	o	o	v
Regulating services								
Air Quality regulation	o	^	o	o	o	o	o	^
Climate regulation (local temperature/ precipitation, greenhouse gas sequestration)	o	o	o	^	o	o	o	^
Water regulation (timing and scale of run-off, flooding, etc.)	o	^	^	^	o	o	o	^^
Natural hazard regulation (i.e. storm protection)	o	o	o	o	o	o	o	o
Pest regulation	o	o	o	o	o	o	o	o
Disease regulation	o	^	o	o	o	o	o	^
Erosion regulation	o	^	^	^^	o	o	o	^
Water purification and waste treatment	o	^^	^^	^^	^^	^^	^^	^^
Pollination	o	o	^	^	o	o	o	^
Noise and Light regulation	o	o	o	o	o	o	o	o
Cultural services								
Cultural heritage	o	o	o	o				o
Recreation and tourism	o	o	^	^	^	^	^	^
Aesthetic value	o	^	o	o	^	^	^	^^
Spiritual and religious value	o	o	o	o	o	o	o	o
Intellectual and scientific, educational	o	o	o	o	o	o	o	^
Inspiration of art, folklore, architecture, etc	o	o	o	o	o	o	o	o
Existence Values	o	o	o	o	o	o	o	^
Social relations (e.g. fishing, grazing or cropping communities)	o	^	v	v	^	^	^^	^
Supporting services								
Soil formation	o	^	^^	^^	o	o	o	^
Primary production (in river)	o	^	o	o	o	o	o	^
Nutrient cycling	o	^	^	^^	^	^	^	^^
Water recycling	o	^	o	o	o	o	o	^
Photosynthesis (production of atmospheric oxygen)	o	o	o	o	o	o	o	^
Provision of habitat	o	^	^^	^	^	^	^^	^^

Key

significant	^^	Benefit
noticeable	^	
no net change	o	
noticeable	v	
significant	vv	Disbenefit

8 Mechanisms, timescales and confidence to Deliver Favourable Conservation Targets.

Modelling has shown that a significant reduction in N and OP is required from both diffuse and point sources to meet catchment water quality objectives. Recommendations outlined above have identified the type of measures that could be implemented to deliver the water quality improvements required. Mechanisms for their delivery are considered below.

8.1 Mechanisms to deliver diffuse pollution reductions and measures.

High level options to deliver diffuse pollution reduction can be summarised as follows:

Option 1: Status Quo (Voluntary and existing enforcement): with current resourcing

Option 2: Fully implement existing legislation (EL) with appropriate resourcing

Option 3: EL + Voluntary Pledge + partner agreed EA Inspection and enforcement approach

Option 4: EL + Voluntary Pledge + New Regulatory Requirements

Option 5: EL+ WPZ

8.1.1 Option 1: Status Quo (Voluntary and existing enforcement)

As part of the Nutrient Management Plan (2013), EA, NE, NFU and CLA developed a position statement where all parties agreed that farmers across the Poole Harbour should be implementing **all reasonable measures**, to maximise soil and nutrient management efficiencies and deliver the catchment water quality targets.

http://webarchive.nationalarchives.gov.uk/favicon.ico

These partners together with Wessex Water then developed Wessex Diffuse Pollution Plan Agriculture (2015) (Appendix 7), which outlined how they will work together to deliver the water quality and ecological targets within the Poole Harbour catchment and wider Wessex Area.

Active partnership working and the involvement of water companies, CSF, Poole Harbour Catchment Initiative (PHCI) has assisted in delivering nutrient reduction in the catchment. This is primarily through the provision of expert farm advice, increasing the awareness of environmental and water quality issues across the catchment, improved research and the delivery of on farm infrastructure improvements. Voluntary engagement and delivery of the water quality targets put forward by the NMP are however, in part driven by the presence of regulation.

Environmental Land Management Schemes (ELMS's), following the principles of public money for public good, will be used to help farming to deliver best practice and maximise their nutrient management efficiencies. The outline elements of ELM's include:

Tier 1: This tier could focus on **encouraging environmentally sustainable farming and forestry** and include actions to create environmental benefits that we know the majority of farmers could take across their farmed and forested land. Whether that's using cover crops or planting wildflower margins, this tier could pay farmers across the country to adopt (or continue) practices that can generate valuable outcomes, focusing on those practices that are most effective when delivered at scale.

Tier 2: this tier could be designed to support land managers in the delivery of **locally targeted environmental outcomes**. This tier would target agreed priority outcomes, making sure the right things are delivered in the right places. As such, it may need to use some form of spatial targeting and local planning. Many of the outcomes this tier will deliver may rely on **collaboration between land managers.** It could therefore include a variety of mechanisms for encouraging and rewarding collaboration and join-up between farmers, foresters and/or other land managers.

Tier 3: this tier could be focused on delivering **landscape scale land-use change projects,** where such projects drive added value over and above what can be delivered through tiers 1 and 2. It would coordinate projects that are critical in helping us meeting ambitious environmental commitments such as net zero. This would be fully aligned with activity under the government's Nature for Climate fund for afforestation and peatland restoration.

Where farming has not gone far enough in delivering their targets, the EA can use its significant powers to ensure land use activities do not cause pollution (Section 3.2.1.1) and influence farmers to take up ELMS's measures and advice from other stakeholders of how they can reduce their pollution loading further. Funding to enforce these regulations have however been significantly reduced in the last decade and due to this shortfall, the EA can only commit to a limited number of compliance visits annually, across the whole of Dorset, Wiltshire, Somerset South Gloucester and west Hampshire each year. These constrains result in EA engagement being reactive to pollution incidents. They can be subject to further reductions as a result of additional incident pressures (drought, flood, pollution etc.). Very little resource is therefore available for auditing, enforcement and proactive engagement with farmers. The status quo option is unlikely to deliver the water quality improvements required unless EA enforcement resources were significantly increased (Option 2 or above).

ADAS Farmscoper modelling estimates that the voluntary approach together with incentives through Environmental Stewardship/Countryside Stewardship schemes, have delivered c20% of the diffuse N target (a reduction of c120 tonnes/yr, based on 2010 land use). These reductions are temporary and any change in the current grants, or agricultural commodity markets could result in the majority of these savings being lost. Modelling indicates that only a 4% reduction from the original N loading, c21 tonnes N reduction will result through the implementation of the New Farming Rules for Water.

This reduction could increase greatly if farmers fully implemented new farming rules and, for example, manure was not spread on soil with high P index and where there is no crop need. EA enforcement approach with regard to this needs to be further refined®.

8.1.2 Option 2: Fully Implement existing legislation (EL) + existing enforcement: with appropriate resourcing

Feedback from informal engagement of an earlier draft of this document indicates that farmers and their representatives, would support the stronger enforcement of existing legislation before any new legislation is put in place. This will result in water quality improvements across the catchment.

Some of the regulatory tools available to the EA to deliver water quality improvements are outlined in Section 3.2:1.1. New Farming Rules for Water extend the requirements of farmers, particularly in nutrient management and soil protection. Key measures from these rules are outlined below:

- Plan in advance each application of organic manure and manufactured fertiliser to meet **and not exceed soil and crop nutrient needs.**
- Manure and manufactured **fertiliser should not be stored or applied** on land within 10m of inland freshwater or coastal waters, **where there is significant risk of pollution**, 50m of spring or borehole.
- Manure and manufactured fertiliser should not be applied when soil is waterlogged, frozen, or there is significant risk of causing pollution.
- You should **take all reasonable precautions to prevent significant soil erosion** and runoff from application of fertilisers, cultivation practices, harvesting and poaching by livestock.
- Protect against soil erosion by livestock.

To deliver these mechanisms, the EA will need to visit farms to identify their compliance with existing regulation. They may also need to use modelling tools such as the NLT ®, and Farmscoper, to calculate the N and P nutrient loss from each farm holding or group of farm holdings and to assess if the water quality targets are being delivered. These tools will also identify if farmers nutrient application proposals to meet "crop need" are likely to cause nutrient loss in excess of the target. In these circumstances, they will need to apply nutrients below the “economic optimum” to achieve the **environmentally acceptable economic optimum yield**, unless alternative measures can be put in place.

EA Land and Water teams have been trying to follow the principles outlined in Wessex Diffuse Pollution Plan (Appendix 7), however for the EA to fully implement these powers, additional support and resource will be required within the Poole Harbour catchment. With around c370 farms that are greater than 20ha, it is estimate that between 1.5-2FTE® of enforcement resource would be required in the first 3-5 years to fully enforce all regulations and for the EA to visit c80% of farms over 20 ha. After this, the resource effort is likely to reduce to c1-1.5 FTE®.

The overall aim of this work should be to deliver the targets set out in Section 7.6, within the timeframes suggested in Section 7.7.

8.1.3 Option 3: EL + Voluntary Pledge + partner agreed EA Inspection and enforcement approach

As a result of consultation with the NFU, a proposal for a nutrient trading scheme or farmer pledge was suggested as a mechanisms for delivering diffuse water quality objectives to achieve the targets across the catchment. This proposal would take the principles outlined in the NMP (and agreed position statement with EA, NE, NFU and CLA in 2013), of farmers agreeing to ensure their average nutrient losses would not exceed a maximum leaching target, either on their own or strategically in partnership with other farms.

This would provide flexibility within the catchment by allowing farmers that want to continue to apply “soil and crop need” and who meet wider requirements of FRfW and other regulations, to “buddy up” combine their leaching target and achieve the average required leaching target for the catchment.

The key outcome of this approach would be the opportunity for lower nutrient input land to become more commercially viable, by farmers receiving payment from more intensive operations for offsetting of their loads. This could make diffuse scenario DS 5 and 6 more cost beneficial and attractive to farmers. It would also incentivise existing intensive farms to maximise their nutrient management efficiencies, so they have to buy fewer nutrient credits and or diversify and either reduce intensity across part or the whole of their farms. This option would also deliver wider benefits and potentially “buy in” by farmers and their representatives, to the solutions to deliver nutrient targets (Section 7.5 and 7.6).

The vision set out in the NFU response and subsequent engagement is that farmers across the Poole Harbour catchment would become some of the **most efficient users of nutrient across the world**.

A high level schematic of how nutrient trading might work was put forward by the NFU and is presented in Figure 8.1.3:1 and 2.

Figure 8.1.3:1 Nutrient Trading Approach (NFU slides 2018)
a)

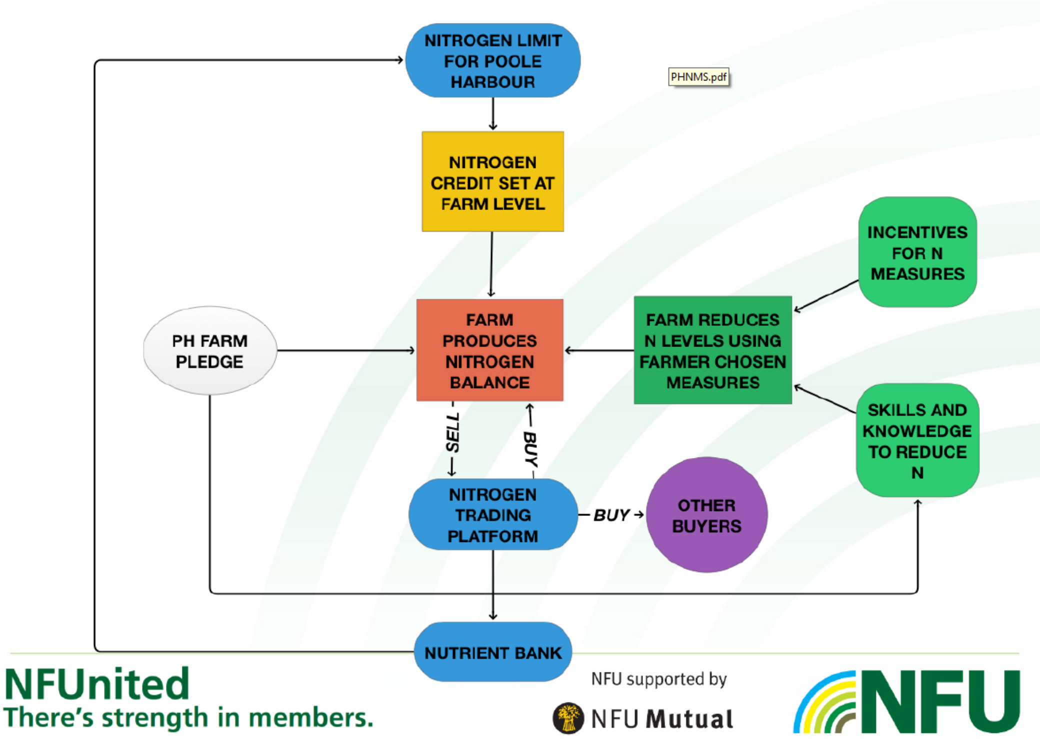
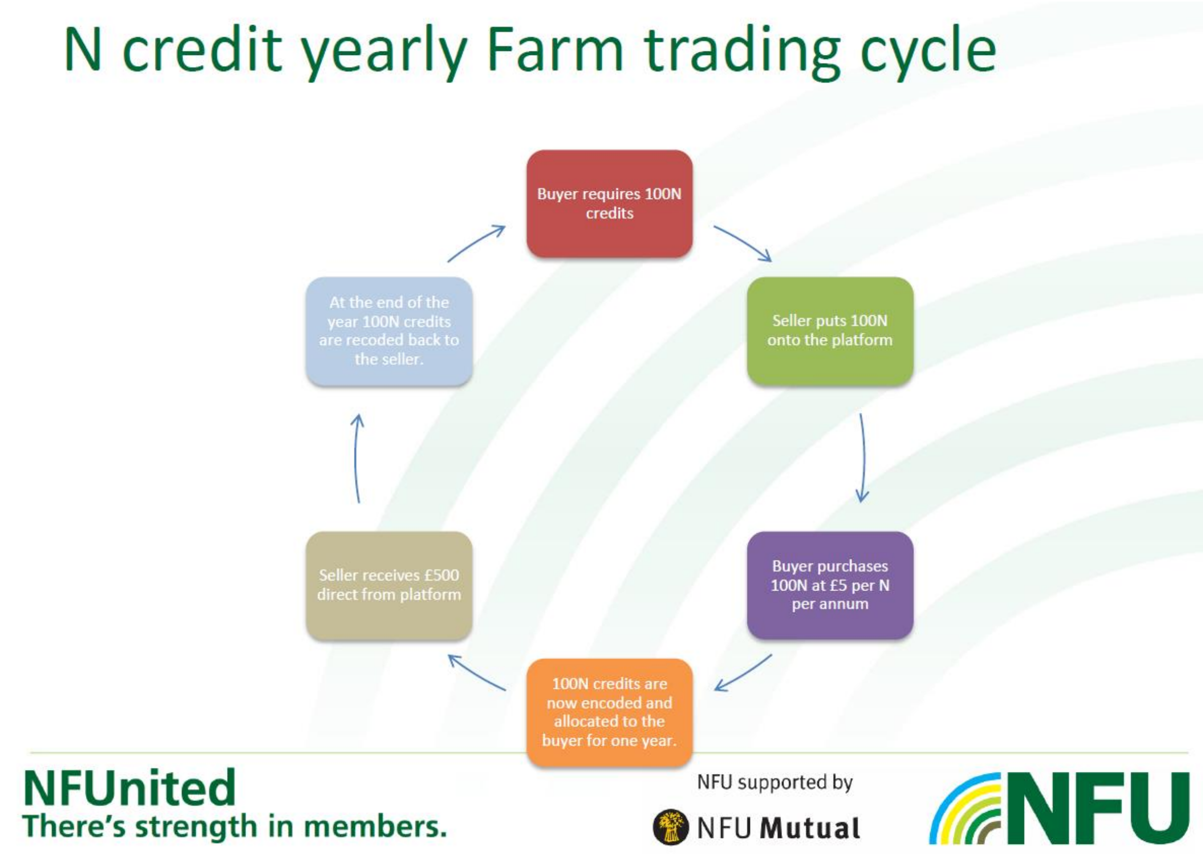

NITROGEN LIMIT FOR POOLE HARBOUR
PHNMS.pdf
NITROGEN CREDIT SET AT FARM LEVEL
INCENTIVES FOR N MEASURES
PH FARM PLEDGE
FARM PRODUCES NITROGEN BALANCE
FARM REDUCES N LEVELS USING FARMER CHOSEN MEASURES
SKILLS AND KNOWLEDGE TO REDUCE N
SELL
BUY
NITROGEN TRADING PLATFORM
BUY
OTHER BUYERS
NUTRIENT BANK
NFUnited
There's strength in members.
NFU supported by
NFU Mutual
NFU

Figure 8.1.3:2 Nutrient Trading Approach: Worked Example (NFU slides 2018)
a)



The NFU have gained support for this idea from CLA, Wessex Water and many other partners. They have also presented the idea to Defra Water Quality (Agriculture) and now obtained funding from Esmee Fairburn under "Natural Capital Project Funding" to further develop the scheme.

The Environment Agency have been working with NFU and farmers representatives to discuss how such a scheme could be implemented and the key principles that would need to be included to increase confidence in the outcomes being delivered. These our outlined in "guiding principles" for nutrient trading. The key elements of this, which would need to be included in any such scheme, and are now referred to as **minimum farming rules** are outlined below and discussed in further detail in Section 8.1.3.1 to 8.1.3.6:

- **Target:** The average nutrient loss across each farm holding, should not exceed the maximum leaching target set out in this document. Where the farmer is part of an EA agreed scheme, following the minimum farming rules they may follow a **Glide Path** to deliver the water quality **targets** within an agreed **timescale.** The target is set out in this report and it is proposed that the target should be met by 2030.
- **Nutrient planning to deliver environmental economic optimum yield;** Farmers need to start to calculate the nutrient losses that are likely to result from their proposed nutrient plan (required under NVZ regulations and FRfW). In particular considering the yield they seek to achieve, soil and nutrient management measures they propose to implement and the impact this will have on nutrient losses from their farm holding. They should then adjust their nutrient application rates, measures they propose to implement, to a point where they can maximise crop yield without causing harm to the environment, the **Environmental Economic Optimum yield.**

- **Whole Farm Nutrient Balance**: Farmers across the Poole harbour catchment should then calculate[11] the average nitrogen losses that are modelled to have occurred from the previous year's nutrient plan and farm measures that were implemented the previous season. They should then calculate the nutrient losses that are forecast to occur from their proposed nutrient plan for the following season. They should then compare this figure with the catchment target and adjust their plan until the target is met. Where the farm is part of a nutrient trading scheme, they may buy or sell nutrient credit so as to meet their glide path target.
- **Farm regulatory compliance**; Specific regulations have come into force over the last 20 years to ensure farm infrastructure and practices will not in themselves result in a point or diffuse pollution risk, (Section 3.3.1.1). To achieve the N target across Poole, it will be essential for **all farmers** to URGENTLY become fully compliant with these regulation. It should therefore be a pre-requisite that farmers, including those that want to join any nutrient trading and potentially, water company catchment offsetting scheme, to undertake an annual self-assessment of their current level of compliance and put in place a plan to resolve any areas of non-compliance within an agreed time period. Farms outside such schemes should also undertake this annual assessment.
- **Farm Annual Reporting**: Farmers should report the measures they have implemented to maximise their nutrient efficiency and deliver their EEOY, nutrient losses, nutrient plan and whole farm nutrient balance annually to the Environment Agency or any agreed independent 3rd party, who may be appointed to validate farm compliance within a nutrient trading scheme.
- **Catchment Reporting:** The Environment Agency or for an agreed nutrient trading scheme, an independent third party should annually **amalgamates this farm level data at the water body scale** so that the progress in delivering the catchment targets can be monitored and any issues that may be arising identified and resolved.
- The **tools and techniques** used to calculate farm nutrient losses, whole farm nutrient balance and nutrients trade, should be scientifically robust and agreed by the Environment Agency.

These are all further discussed below:

8.1.3.1 Target and Glide Path

The interim water quality targets required to deliver macroalgae density within the harbour are detailed in Section 7.6. These highlight that agricultural N losses from arable and managed grassland to surface or groundwater's should be reduced from around 1797 (no Agri-Environment schemes) or 1679 tonnes /N/yr (assuming Agri Environment Schemes are implemented, Appendix 6; Table 12), to **c1127 tonnes N/yr from all agricultural holdings**[12]. This equated to a final **maximum leaching target** of c18.1 N kg/ha based on 62,178 ha [13]of land within agricultural holdings in 2010 Agricultural Census.

[11] By agreed modelling technique, across all their agricultural land holding in the Poole Harbour Catchment, under typical (average) climatic conditions.

[12] agricultural holdings required to submit census returns (on request) under the **Agricultural Statistics Act 1979**. The definition of Agriculture under this act, comes from the **Agricultural Act 1947**

[13] Tables 8 & 16 in Gooday et al, 2017

Ultimately the N credits available to farmers should be calculated as detailed in Equations 8.1.3 and farm holding target as details in Equation 8.1.4:

Annual Nutrient Loss & Credit Calculation

Catchment level credit and target Equation 8.1.3 (taken from Appendix 7 of NMP):

All high and low input land recorded in census data for farm holdings (Table 7.1a and b)

Catchment target =	Agricultural target (kg)	÷ Agricultural land area	= maximum leaching target kg/ha
	= 1127000 kg	÷ 62178 ha	= c18.1 kg/h

*1 As reported in ADAS Nov 2017; updated from NMP Appendix 7 to include woodland and rough grazing in farm level calculation.

Example **Farm Holding Target** Equation 8.1.4

Farm holding target = Farm holding Land Area (ha) * Catchment target (kg/ha)

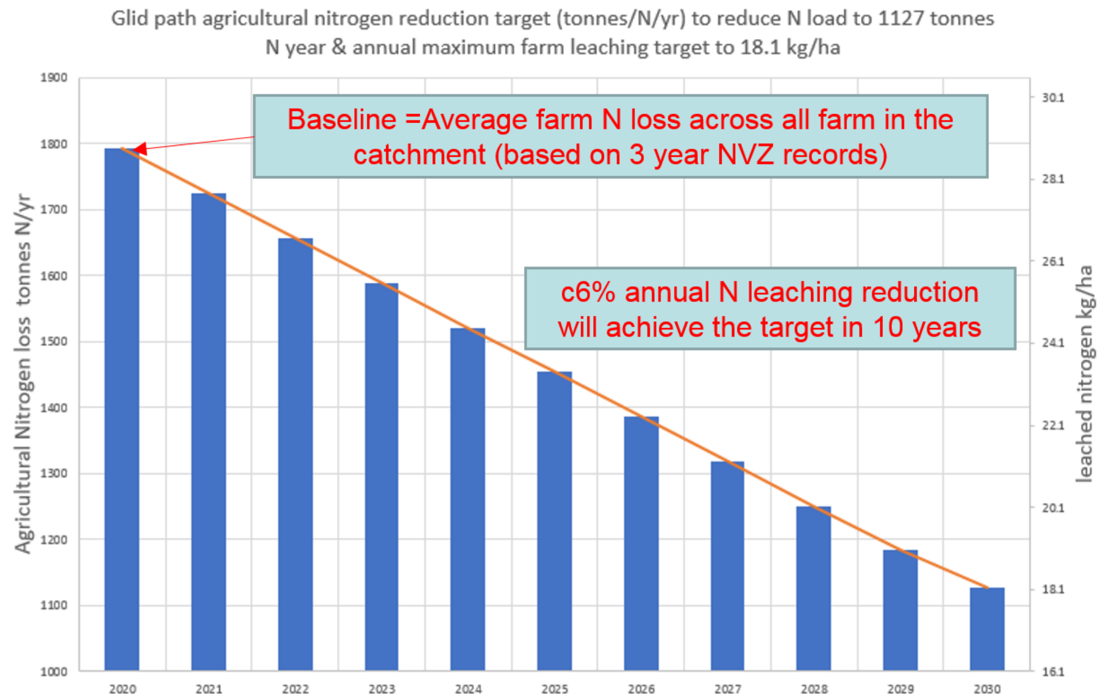
For a farm of 150 ha in size, their farm holding target will be:

Farm holding target (kg/N/yr) : 150 * 18.1 = **2715 kg/N/Yr**.

If the agricultural target cannot be delivered by the agricultural community sooner, it may be reasonable for farmers that are part of an EA approved nutrient trading scheme, that demonstrate **earned recognition** by implement the **minimum farming rules** outlined as part of this option (Section 8.1.3.1 to 8.1.3.6), to deliver the target by 2030.

Farmers that are part of such a scheme should ensuring their average nutrient loss over their agricultural holding, does not exceed the annual glide path (Section 7.8, Figure 8.1.3:1 below), considering also any nutrient credit bought and sold.

Figure 8.1.3:1 Proposed Glide Path



Where in any year, a farms average nitrogen losses across their holding, exceed the glide path target, they will need to buy nutrient credits to meet the target. Where their nitrogen loss is below their target, they can sell any excess nitrogen credit.

Agricultural OP losses also need to be reduced to deliver their fair share. Farmscoper modelling indicate that this will occur, if N targets are met (Section 7.1 and 7.6).

Farmers that are not part of an EA approved scheme and as such are not demonstrating earned recognition by following the minimum farming rules set out in this report should meet and be assessed against the final water quality target, 18.1kg/ha N.

Farmers must remain compliant with wider pollution prevention regulations.

The glide path profile set out in this report, will need to be re-calculated at the start of the scheme, based on the average farm holding N losses (kg/ha) across the year for 3 years prior to the scheme starting, evidence using NVZ records. This should be calculated as detailed in Equation 8.1.5:

Equation 8.1.5:

Average baseline farm nitrogen loss = $(F_1 + F_2 + \ldots F_n) \div (Fha_1 + Fha_2 + \ldots Fha_n)$

F_1 = Farm 1 total nitrogen loss kg/yr, from typical farming practices for 3 years preceding the scheme.
Fn= Nth Farm total nitrogen loss kg/yr, from typical farming practices for 3 years preceding the scheme.
Fha $_1$ = Farm 1 land holding size, hectares (all land uses).
Fha n = nth Farm land holding size, hectares (all land uses).

The average baseline farm nitrogen loss is then assumed to be the N loss and glide path for Yr 0. A linear reduction from this point until 2030 can be calculated to determine the glide path target for each year.

Target: Farmers should ensure their nutrient losses do not exceed the nitrogen leaching target of 18.1kg/ha N. Farmers in an EA approved nutrient trading scheme which is implementing and overseeing farm compliance with minimum farm rules, shall deliver their water quality targets by 2030, following or exceeding the glide path laid out in this plan (Section 7.3, 8.3.1 and Figure 8.1.3:1). DR 1

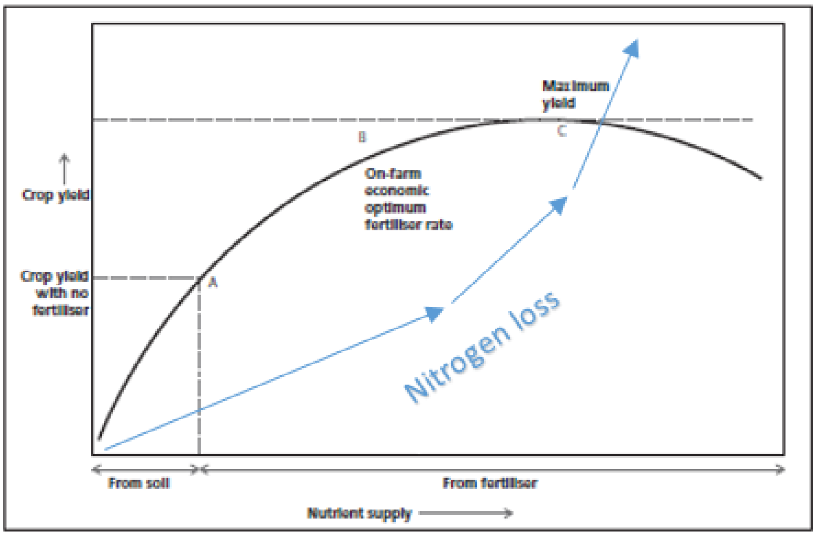
The glide path target should be recalculated once all participating farms have completed their baseline farm N loss as detailed in equation 8.1.5.

8.1.3.2 Nutrient planning to deliver Environmental Economic Optimum Yield;

Currently under Farming Rules for Water, and NVZ requirements, farmers are required to ensure their nutrient application, does not exceed crop and soil need. Crop need has historically been based on the nutrient application rate required to achieve the economic optimum yield, considering the value of the crop achieved and cost of nitrogen and other nutrients applied (Figure 8.1.3:2).

Figure 8.1.3:2 A typical nitrogen response Curve (from RB209) with corresponding nitrogen loss

A Typical Nitrogen Response Curve



Farmers define the yield they are seeking to achieve and use nutrient planning guides such as RB209, or advice from agronomists or fertilizer manufacturers to identify the amount of nutrient they should apply to achieve this yield. There has been no requirement for farmers to calculate the nutrient losses that may result from the nutrient plan farmers aim to implement and so no assessment of the environmental impact of this plan.

From Figure 8.1.3:2 it is clear that there is not a linear relationship between crop yield and nutrient supply and loss. The rate of nutrient loss increases non-linearly, when trying to achieve higher yields, as shown on the schematic.

For farmers across Poole Harbour catchment to bring their nutrient losses below the maximum leaching target or glide path, it will be essential that as part of farm nutrient planning, they calculate the nutrient losses that are likely to result from their planned application rate, in a typical year[14]. They should then adjust their application rates and measures they propose to implement, to a point where they can maximise crop yield without causing harm to the environment, the **Environmental Economic Optimum Yield (EEOY).**

Key considerations in assessing EEOY, will be considering the impact the farming activity will have on surface and groundwater water quality (and Environmental Quality Standards, Drinking Water Standards and maximum leaching rates set out in this report) as well as the impacts on flora and fauna.

Farmers should calculate the nutrient losses that are likely to result from their proposed nutrient plan, and farm measures they propose to implement and adjust the application rate and measures so as to achieve their maximum yield that will not have a detrimental impact on the environment, the Environmental Economic Optimum Yield. DR 2.

8.1.3.3 Whole Farm Nutrient Balance

To understand what nitrogen losses are occurring across a farm holding, farmers will need to undertake a **whole farm nutrient balance** assessment. This should take into consideration their non-permitted point source nitrogen losses, discharges and diffuse losses to surface

[14] Under average climatic conditions.

and groundwater, across all land uses within their holding. It should include losses occurring across all land, including zero or low nutrient input land, such as woodland, heathland, rough grazing and field verges, as well as all high nutrient input land. The total nitrogen loss across their farm holding should be compared against their **farm holding target**, to identify if it has been met (Equation 8.1.4, Section 8.1.3.1). Farmers inside an approved nutrient trading scheme can compare their losses against the glide path target, and farms outside such a scheme who have not demonstrated earned recognition, will need to meet the final target.

Because, farm plans can change during a year, it will be necessary for this whole farm nutrient balance to be carried out for the nutrient plan:

- <u>implemented</u> the previous season and for their
- <u>planned</u> measures and nutrient plan for the next season

Farmers should then ensure both have and do meet this target. Farmers inside an agreed nutrient trading scheme will be able to buy or sell nutrient credit to meet this target.

Whole Farm Nutrient Balance: Farmers across the Poole harbour catchment shall annually model (by agreed modelling technique), the nitrogen losses that will have leached (under average climatic conditions) to surface and groundwater from: a) The nutrient plan and measures they <u>implemented</u> the previous season. b) The nutrient plan they <u>propose</u> to implement the following year These should meet their farm target. **DR3**

8.1.3.4 Farm Annual Nutrient Reporting; Improved understanding of nutrient losses and progression to targets

Estimates of the current farm N load and losses for the study area have primarily been calculated using agricultural census data, CSF returns and informed assumptions regarding nutrient application rates, offtake and modelled losses, using Farmscoper.

Farmers across the catchment are required under NVZ regulations and Nitrates Directive to plan each nutrient applications, ensuing it does not exceed crop need or farm Nmax under NVZ rules. They should keep records of their nutrient plans and application rates each year and maintain these records for 7 years for inspection. Farmers are not currently required to automatically submit these records to the Environment Agency or any other party, unless requested to do so.

It is now essential that in the future, NVZ type data farmers are legally obliged to retain are collected centrally and used to:

- Update the total nitrogen lost to surface and groundwater and used to adjust the glide path targets.
- Track progress in farmer's delivery of the target, at a river water body scale.
- Enable informed decision making by stakeholders within the catchment to facilitate delivery of the targets and resolution of local issues that may arise in meeting these objectives.

To achieve this, it is therefore recommended that each farm holding in the Poole Harbour catchment should annual send their whole farm nutrient balance (Section 8.1.3.3), nutrient plan required to deliver Environmental Economic Optimum Crop Yield (Section 8.1.3.2) and comparison with the farm glide path target (Section 8.1.3.1) to the Environment Agency or an agreed 3rd party in an agreed format.

Where an independent 3rd party is appointed to oversee any nutrient trading scheme, they should collate the farm data provided at a river water body scale and present this data annually in an agreed format to the Environment Agency and or a Board appointed to oversee any nutrient trading scheme. This annual reporting will help to ensure agricultural targets are met and any issues experienced in delivering these targets can be resolved in a timely way.

Where a 3rd Party is appointed to oversee a nutrient trading scheme, this 3rd party should advise the Environment Agency annually the farms that are part of any nutrient trading scheme and compliant with the rules of that trading scheme.

Farm Annual Reporting: Farmers shall report their **whole farm nutrient balance/ farm holding target, Farm nutrient plan and nutrient trading** (in an agreed format) to the Environment Agency or agreed 3rd party annually. **DR5** **Catchment River Water Body Reporting;** Where an independent 3rd party is appointed to oversee any nutrient trading scheme, they should collate the farm data provided at a river water body scale and present this data annually to the Environment Agency in an agreed format. **DR6a** **3rd Party** should advise the Environment Agency of the farms taking part and abiding by the rules of any nutrient trading scheme. **DR7**

8.1.3.5 Wider Farm Regulatory Compliance

Environment Agency recent farm inspections across the Poole Harbour catchment and neighbouring River Axe catchment, have identified 72-95% non-compliance respectively, with one or more forms of nutrient related regulation (Section 3.3.1.1).

The purpose of this regulation is to ensure farm infrastructure and practices will not in themselves, result in a point or diffuse pollution. The rules make sure there is no un-controlled release of nutrients and chemicals to surface and groundwater's. They also ensure there is sufficient manure, slurry and dirty water storage in place so that nutrients are applied to land only when there is a crop need and ground conditions are suitable.

For the agricultural sector to achieve its nutrient loss targets, it will be essential for all farmers to URGENTLY become fully compliant with wider farm regulations.

Any nutrient trading scheme, should therefore be implemented alongside a drive (and program) by the farming community to become fully compliant with regulation, especially those related to soil and nutrient management. The timescales for this must be much tighter than proposed by the glide path. It would therefore be proposed that the farming community and Environment Agency shall be seeking to deliver 100% compliance with wider farm regulations by 2025.

All farmers should complete an annual self-assessment of their current regulatory compliance and put in place a plan to resolve any areas of non-compliance within EA agreed period of time **DR5**. Farmers in an EA approved nutrient trading scheme may return their self-assessment to the organisation overseeing the scheme (DR6). Farmers outside such schemes, should return their self-assessment to the EA.

8.1.3.6 Tools and Techniques

A scientifically robust modelling tool will need to be used by farmers to calculate the nutrient losses that are likely to result from their proposed application rates and farm measures (Section 8.1.3.2) and also to calculate their whole farm nutrient balance (Section 8.1.3.3).

The Environment Agency Nitrate Leaching Tool (NLT) has been designed to calculate field and farm nutrient losses and can be used for this purpose. Subject to licencing agreements the NLT can be made available to the farming community for their use. Farmers may however wish to develop or utilise an alternative tool. The Environment Agency will need to approve any such tool as being fit for purpose and scientifically robust before it is used.

Any nutrient trading scheme will need to deliver the requirements outlined above. The wider scheme design around this can be developed by the farming community. It is likely that this will include identifying:

- The tools and approach used to determine Environmental Economic Optimum Yield
- The tools and approach to calculating the whole farm nutrient (nitrogen) balance and loss.
- How farm nutrient plans will be submitted, audited, managed and used.
- How/if farm data submission to government can be combined so where possible farmers can submit one return annually which can be used for multiple purposes.
- How low risk farming activities can be incentivised and poor practices presenting high risk discouraged or regulated.
- How and when nutrient trading shall take place (and rules around this)
- How nutrient trading shall link with other farm payment so as to avoid duplication.
- How farm nutrient trades shall be audited (in delivery of offsetting)
- How farm nutrient trading will be incentivised
- What action/sanctions partners agree should be applied to farms that:
    - Fail to comply with current regulation
    - Do not submit annual nutrient data required
    - Do not engage and trade to ensure farm level N does not exceed their target.
    - Do not plan and deliver nutrient plans to achieve farm level targets (in combination with trades).

It will also be necessary for the multiple-benefits delivered by N offsetting to be captured and potential funding streams aligned to facilitate N trading and delivering of wider environmental and flood reduction benefits that will result from this activity.

Any details of any nutrient trading scheme that is piloted or implemented should be agreed by the Environment Agency.

8.1.4 Option 4: EL + Nutrient Trading + New Regulatory Requirements

This option would be delivered in the same way as nutrient trading approach outlined above, (8.1.3), but with the Environment Agency using existing powers in a different way or seeking new powers to implement and directly oversee delivery.

- **Farm Target:** Farmers should ensure their nutrient losses do not exceed the maximum leaching target set out in is document, 18.1 kg/ha N. Where subsequent to EA engagement they agreed to join an approved scheme and adopt and implement all the rules outlined in this document, the EA may agree to these farms following an agreed glide path to deliver the water quality **targets** within an agreed **timescale.** The target is set out in this report and the maximum timeframe would be 10 years, delivering the target by 2030.
- **Nutrient planning to deliver Environmental Economic Optimum Yield (EEOY);** Farmers need to calculate the nitrogen losses that are likely to result from the yield they seek to achieve and proposed "nutrient plan" they propose to implement (as required under NVZ regulations and FRfW). Where the losses exceed any catchments targets, environmental quality standards or drinking water standards, they should adjust their nutrient plan (and yield and nutrient application rates and measures they implement) to so as to deliver the maximum yield they can achieve without having an adverse environmental impact, through nutrient losses to surface or groundwater and or soil erosion (their Environmental Economic Optimum Yield).
- **Whole Farm Nutrient Balance**: In preparing their nutrient plan to deliver their EEOY, all farmers within the Poole harbour catchment should calculate (by agreed modelling technique), their whole farm point and diffuse losses that are likely to result from the nutrient plan and farm measures a) they <u>implemented</u> the previous season and b) <u>plan</u> to implement the following season. They should adjust their nutrient management plan to achieve their farm holding target. When the farm is part of an EA agreed scheme, they may buy or sell nutrient credit from fellow members so as to meet their glide path target, so long as their nutrient application does not exceed crop need and or are causing pollution to other nearby receptors.
- **Farm regulatory compliance**; Specific regulations have come into force over the last 20 years to ensure farm infrastructure and practices will not in themselves result in a point or diffuse pollution risk, (Section 3.3.1.1). To achieve the N target across Poole, it will be essential for **all farmers** to URGENTLY become fully compliant with these regulation. It should therefore be a pre-requisite that farmers, including those that want to join any nutrient trading and potentially, water company catchment offsetting scheme, to undertake an annual self-assessment of their current level of compliance and put in place a plan to resolve any areas of non-compliance within an agreed time period of time. Farms outside such schemes should also undertake this annual assessment.
- **Farm Annual Reporting**: Farmers should report the measures they have implemented to maximise their nutrient efficiency and deliver their EEOY. They should also report their nutrient plan and nutrient balance annually to the Environment Agency or for any agreed nutrient trading scheme to an independent 3rd party, who may be appointed to validate farm compliance within a nutrient trading scheme. This reporting is essential to track the progress in delivering the water quality objectives and providing confidence to partners that the target will be met in a timely way.
- **Catchment Reporting**: The Environment Agency or for an agreed nutrient trading scheme, an independent third party should annually **amalgamates this farm level**

data at the water body scale so that the progress in delivering the catchment targets can be monitored and any issues that may be arising identified and resolved.

- The **tools and techniques** used to calculate farm nutrient losses, whole farm nutrient balance and trade nutrients should be scientifically robust and agreed or specified by the Environment Agency.

To achieve this it is likely the EA would need to write to all farmers across the catchment, formally requesting this data under the relevant regulations. The EA will then use this data to identify the risk presented by each farm and will visit and develop an individual plan with each farm to deliver these objectives and wider compliance.

Where required existing regulatory powers will be used to deliver wider regulatory compliance and ensure farmers do not cause pollution (Section 3.3.1.1).

8.1.5 Option 5: EL+ WPZ

The final approach would be to apply for new regulatory powers to deliver Poole Harbour SPA conservation objectives across the catchment. This is likely to be implemented through a Water Protection Zone (WPZ).

A WPZ would bring in to law, the key recommendations made 8.1.3 and 8.1.4.

It may also restrict some practices that are known to present a very high pollution risk, such as leaving land bare over winter.

8.1.6 Appraisal of Mechanisms

The advantages and disadvantages of the mechanism detailed in Section 8.1:1 to 8.1.5 are outlined below in Table 8.1.6:1.

If the appropriate resources are put in place to enforce existing and any future regulations, the confidence in delivering the overall water quality and environmental targets will increase with each option considered. However fundamental to farmers achieving their target, will be setting a progression goal, as outlined in Section 8.1.3.1.

Where farmers work within an EA approved nutrient trading scheme, following minimum farming rules outlined in Option 3, this may be a **glide path**, allowing a maximum of 10 years to achieve the target, by 2030. Where outside such a scheme, farmers will not be demonstrating earned recognition and will need to be assessed against the final water quality target.

In delivering this target, farmers will need to understand the impact their existing and any future farming practices have on the environment and plan only to deliver their **environmental** acceptable **economic optimum yield**. They should then carrying out **whole farm nutrient balance/loss** calculations as detailed in 8.1.3.2 and 8.1.3.3 respectively. Because of the very challenging nature of the target that has been set in the catchment, it will be essential that **existing regulations**, put in place to improve farm efficiency and prevent point or diffuse pollution, are fully implemented by the whole farming community, (Section 8.1.3.5).

To enable the impact of the agricultural sector to be fully understood and monitored through time, farm level data will need to be submitted to the EA or alternative agreed independent 3rd party annually. This data should be amalgamated at a water body scale and presented annually to the regulators and wider stakeholders, Section 8.1.3.4. The tools farmers use to undertake these tasks will need to be scientifically robust, Section 8.1.3.6.

It will also be essential **all agricultural holdings** within the Poole Harbour catchment will need to engage and follow these requirements. The EA shall need to focus their regulatory compliance visits on farms that have not demonstrated they are working towards, full regulatory compliance and achieving the water quality targets.

The integration of these key actions are considered to be the **minimum farming rules** which will need to be implemented as part of any nutrient trading scheme (Option 3), or new regulations (Option 4-5).

Appropriate water quality and environmental monitoring and modelling will also need to continue to observe how the measures put in place impact on each of these factors. Modelling will also help to ensure the targets are appropriate given our scientific understanding at the time.

How the **minimum farming rules** are implemented is open to debate. If integrated with the nutrient trading approach proposed by the NFU, the “good will” of the farming community are likely to be maintained and the agricultural community would take ownership for delivering the water quality targets. It would leave how the target is delivered open to farmers, with the opportunity to follow a glide path approach. It could offer further financial income to low nutrient input farmers and encourage higher input farmers to reduce their nutrient losses rapidly so as to minimise the nutrient credits they may need to purchase. It may also encourage farmers to achieve wider environmental outcomes, such as reducing flood risk, reducing carbon loading and so result in wider improvements in water and air quality and flora and fauna.

A nutrient trading approach would however need some increase in the EA enforcement resource within the catchment. Subject to the agricultural community agreeing to include the minimum farming rules outlined above as part of any nutrient trading scheme, this resource could largely be focused on ensuring farmers not in an agreed scheme are compliant with wider regulations and are not exceeding the nutrient loss targets. A proportion of the EA regulatory resource would however still need to undertake similar visits to farmers within any agreed scheme, to ensure it is working effectively.

The implementation of new regulations (Option 4-5), in contrast, may result in a loss of “good will” by farmers, and farmers being less inclined to take ownership of the issues themselves. Because of this, it is likely to require a much greater increase in EA regulatory resource compared with Option 3.

A stepped approach is therefore recommended to achieve the water quality targets set out in this consent order. Initially seeking to deliver the objectives through mechanisms outlined in Options 3, implementing a nutrient trading approach, with the **minimum farming rules** set out in Section 8.1.3.1 to 8.1.3.6, together with the EA enforcing its existing regulations.

If the agricultural community do not agree to implement the minimum farming rules as part of any scheme, there would be little confidence the target would be achieved.

In these circumstances it would be recommended the EA move to option 4, using its existing powers to request the data and actions detailed in Section 8.1.3 and 8.1.6 to be supplied. Where necessary the EA should seek new powers to require farmers to move to the target set out in this report and implement specific measures that will maximise nutrient management efficiencies and minimising the risk to the water environment (Option 4). A Water Protection Zone may be the most efficient ways to achieve this, Option 5.

When implementing Option 4-5, the EA resources would be focused on enforcing farm compliance with existing and new laws, rather than working in partnership with the agricultural community as would be the primary focus in Option 3. It is therefore likely to require much more regulatory resource than Option 3.

As significant work has already been undertaken in developing the principles of Option 3 and a nutrient trading scheme, approximately 6 months could be given to finalising these principles and rules and a further 6 months to identify the tools that will be used in the scheme. A period of piloting should be undertaken through 2021 and into 2022, before the scheme was fully implemented in autumn of 2022 (when land preparation for following years cropping commences).

Annual review of the scheme is proposed as part of the minimum farming rules and formal review should be undertaken by the regulator in consultation with any agricultural delivery board in 2024, 2027 and 2030.

Roll out could take place to the whole of the catchment once the approach and tools to use have been piloted. The purpose of this would be to ensure all the tools and rules function appropriately.

To deliver this approach, further financial resource will be required to:

- Enforce existing and future regulations
- Set up, operate and audit the nutrient trading scheme.
- Develop, operate and maintain tools to calculate farm and catchment scale nutrient loss and to trade N.
- Manage the delivery of consent order recommendations and findings.

The NFU have already obtained funding to develop the first part of the scheme. The aim should be for the long term nutrient trading approach to become self-financing.

When implementing options 3 and 4, the Environment Agency will need to set out its enforcement approach within the catchment in a Regulatory Position Statement, Local Enforcement Position or alternative to be proposed by the Environment Agency.

If this action, fails to drive improvement in observed and modelled water quality and diffuse pollution reduction, within a reasonable period of time, the next step would be to implement a full WPZ (Option 5).

Table 8.1.6:1 Appraisal of Mechanisms for implementing diffuse measures to achieve water quality targets across Poole Harbour catchment

Estimated Diffuse Agricul	Technical Feasibility	Practical Feasibility	Socio economic impact	Proportionality within fair share	Cost Benefit	Regulatory Instrument in place?	Instrument required	Pro's	Cons	Delivery Timescales
Diffuse Scenarios					£/kg.N					
Option 1: Status quo: Voluntary & existing enforement effort	yes	High	Low	Yes	Yes	Yes			Very low confidence that this will deliver the target	2020+
Option 2: Fully Implement existing legislation (EL) + existing enforcement: with appropriate resourcing	Yes	High	Low	Yes	Yes	yes	Additional EA Environment Officers required to enforce existing regulations Agreed enforcement approach	Using existing regulation which is supported by community Enforcement resource may be lower than advisory effort & will drive large improvement in farm level compliance	May not be sufficient to deliver target alone.	2020-25
Option 3: EL + Voluntary Pledge + partner agreed EA Inspection & enforcement approach	Yes	High	Medium	Yes	Yes	yes	EA minimum rules will need to be implemented as part of the scheme. Additional EA Environment Officers required to enforce existing regulations Agreed enforcement approach Database tool for submission of farm level data Nutrient trading mechanism, rules & governance set up Modelling tool to model nutrient losses as farm and catchment scale	Using existing regulation which is supported by community Maintain current "good will" of farmers Facilitate diversification and funding for low input farming Facilitate wider sustainable agriculture Community led	Will require long term management of nutrient trading scheme (and cost). If delivered with EA minimum rules, it is more likely to succedd but the EA will need to be resourced to influence change and undertake compliance visits at farms not in the scheme and a preportion of those in the scheme. IF not delivered effectively and EA are not resourced to deliver agreed enforcement approach the option will fail.	2020-30
Option 4: EL + Voluntary Pledge + New Regulatory Requirements	Yes	High	Medium	Yes	Yes	No	Additional EA Environment Officers required to enforce existing regulations Agreed enforcement approach Database tool for submission of farm level data Nutrient trading mechanism, rules & governance set up Modelling tool to model nutrient losses as farm and catchment scale	Using existing regulation which is supported by community Maintain current "buy in" by farmers Facilitate diversification and funding for low input farming Community led	May loose good will of some farmers by increased regulation New regulation is not supported by community unless it can be demonstrated to be needed	2020-25
Option 5: EL+ WPZ	Yes	Medium	High	Yes	No	No		Enforcement resource may be lower than advisory effort BUT increase will be required to deliver WPZ. Overal resource to deliver may be lower than advice led stystem if WPZ rules are clear and can be easily enforced. Greater confidence in delivery of the target in the long term.	May loose some good will from farmers already delivering	2025-30

9 Stakeholders and Engagement

A summary of the engagement undertaken to date is outlined below:

1. Based on a National template a bespoke key messages briefing note has been produced which included a Project plan and Engagement plan.
2. June 2017: The Briefing note containing key messages, a proposed project plan and a Stakeholder engagement plan for the consent order work was circulated mid-2016 to the Poole Harbour Catchment initiative delivery group via (Catchment coordinator). Some discussions about engagement process followed.
3. December 2016; Project manager and Technical leads attended PHCI meeting in December 2016 to present the plan and some of the key issues and to ask for input notably and data they may hold or know of.
4. During 2016-17 some Farmer Group meetings attended by Doug Kite and Giles Bryan for general discussion and consult on potential options to include in the ADAS Farmscoper 1 contract
5. Mid December 2017: outputs from Farmscoper shared with Farmer group and PHCI and wider EA and NE for feedback on ADAS report outlining potential options to model.
6. Jan 2017; a fact finding site visit to Poole Harbour catchment was made in Jan 2017 by Defra, NE, EA and NGO's senior management to see the issues and discuss progress first hand. Various support materials were provided.
7. PHCI (Nicola Hopkins) periodically appraised of progress of work and discuss any issues.
8. April 2018; 1st Draft Consent Order consultation of technical report and consent order recommendations circulated for comment and shared with PHCI.
9. May 2018: Further engagement with farmers regarding ADAS Farmscoper modelling May 2018.
10. 22 May 2018: EA Presentation to farming group of consent order draft recommendations, evidence base and discussions on how the nutrient targets might be achieved.
11. April/May 2018; Informal discussions have taken place with Wessex Water and key recommendations from this report were shared.
12. 2018-2020 Wessex Water PR19 Investigations and Measures Scoping for AMP7.
13. April-Sept 2018; Consultation with Wessex Water on cost appraisal of options included in consent order recommendations (including long sea outfall)
14. June 2018; EA poster presentation "Delivering Favourable Status across Poole Harbour Catchment" at Poole Harbour conference.
15. 2020 – Current Wessex Water AMP 7 delivery, including catchment offsetting measures and approach.
16. Dec 2018: EA consultation of farming group and water company on nutrient trading options -Draft nutrient trading
17. 2018- Current: review of targets with Natural England.
18. 2018 to current: EA and NFU and partners developing the "Guiding Principles" around any nutrient trading approach.

19. 2020 PHNMS Delivery group meetings refining further nutrient trade scheme rules. Further plans to attend farming group meeting arranged by NFU and Catchment Co-ordinator.

Subject to DEFRA's comments on this report, the EA and NE would propose to continue to work with partners to formally implement the recommendations of this report.

10 Conclusions

10.1 Current Conservation Status

The overall WFD status of Poole Harbour, is "moderate" as a result of the dissolved inorganic N concentrations and the macroalgae condition classified in 2016. When applying UK TAG guidance (in 2017), six major areas of the harbour are classified as unfavourable (declining) condition (Figure 2.2.1a and b). The interest features of Poole Harbour SPA including supporting habitat are mostly in unfavourable, often unfavourable declining, condition (Section 2).

There is an urgent need to reduce the nutrient load entering the Harbour and the need to implement measures to reduce the load. Now is the time to start working towards improving the condition of Poole Harbour SPA, while acknowledging that achieving the conservation objectives of the Harbour may take many years to achieve.

10.2 Updated Evidence and Future Targets

A review of the nutrient loading evidence for the catchment, indicates that the long term forecast for N entering the harbour from current land use practices and discharges and non marine sources, are in the order of 2300 tonnes N/yr and c51 tonnes OP/yr.

Based on an updated macroalgae model, to achieve a macroalgae density of <500g/m^2, nutrient entering the harbour from non-marine sources should be reduce to:

- <1500 tonnes N/yr and
- c22 tonnes OP/yr

10.2.1 Fair share targets:

Fair share calculation identify the following sector nitrogen and phosphorus loading targets should be achieved (Section 7).

Agriculture: agricultural nutrient losses should be reduced to:

- < 1127 tonnes N/yr, [c18.1 kg/ha based on high and low input land within farm holdings recorded in 2010 census (62178 ha or land)]
- c3 tonne OP/yr (based on annual average SIMCAT calculations)

Waste Water Treatment Works: Wessex Water need to reduce their nitrogen and phosphorus loads from WWTW to:

- <209 tonnes N/yr (from c327 tonnes N/yr)
- <16 tonnes OP/yr (no historic fair share)

Industrial discharges further investigations should be undertaken to better estimate industrial discharge loads to the harbour and in particular fish farm and water cress loads. Current source apportionment indicates that:

- industrial discharges should be reduced to 38 tonnes N/yr a reduction of c22 tonnes N/yr

Other diffuse reduction; other sectors need to meet their fair share target as follows:

- Reducing urban losses to c78 tonnes/yr N, a reduction of c45 tonnes
- Reducing un-sewered loads to c10 tonnes/yr N, a reduction of c5 tonnes
- Reducing non-agricultural land loads to c39 tonnes/yr N, a reduction of c22 tonnes

Targets are catchment wide. They are based on best available evidence and modelling, and will be subject to change as the scientific understanding is increased and methods are improved. They are therefore classed as ***interim targets for RBMP3 period up to 2027.***

It is acknowledged that while evidence suggests that reducing nutrients to this interim target will substantially reduce dense mats of green macroalgae, there may be a need for a further longer term reduction to c1000 tonnes/N/yr to secure the restoration of the harbour and achieve the conservation objectives of Poole Harbour SPA. The necessity of this more stringent target will be subject to review, informed by evidence, monitoring and modelling during progress toward the c1500 tonnes/N/yr interim target.

The implement of the interim target and associated measures should not be constrained by this, given the urgent need to lower nutrient loads entering the Harbour, the time it will take to deliver the interim target, start the restoration of the Harbour and move towards achieving Poole Harbour SPA conservation objectives.

10.3 Options to deliver these targets

10.3.1 Diffuse pollution reductions:

The measures outlined below are indicative of the type of measures that could be put in place and scale of change that is required by farmers to deliver their farm holding targets. The final decision will remain with farmers and the farming community, unless certain measures are ultimately brought in by a Water Protection Zone.

Farmscoper modelling, identified that agricultural loads could be reduced to 1200 N tonne/yr, if an extensive bundle of measures 1-6 were implemented across farm holdings in the catchment. This is less than target load of 1127 tonnes N/yr and will not deliver the diffuse target (Table 7.7:3b). The target could however be delivered by increasing the land area reverted to low input land use or increasing the proportion of stock reduction (bundles 5&6). An alternative that could be considered and which would provide increased bio-diversity, would include the installation of wetlands. A well-constructed and maintained wetland system, can reduce N & P by c750kg/N/ha and c20 kg/P/ha respectively. So to deliver the remaining 73 tonnes N would require the installation of 110 ha of wetland on top of DM1-6.

Land reversion and reducing stocking will have a large socio-economic impact. To reduce this, the scenario modelled in Table 7.7:3a, assumes only 50% of bundles 5 and 6 are put in place and the shortfall in N and P reduction would be met through further installation of wetlands. To achieve this, 380 ha of wetland would be required alongside DM1-4 and stocking reduction and land reversion of 17 and 23% respectively.

The desire to reduce agricultural intensity across the Poole Harbour catchment and the socio economic impact of this, might be greatly influenced by the way in which overall target reductions are implemented (Section 10.4) and potentially the schemes available to offset the costs; such as ELMS 1-3. Ultimately farmers may need to decrease their stocking levels or revert some high input land which may present a higher pollution risk to low input, to meet their farm level targets and obligations.

10.3.2 Point Source Reductions in Nutrient Load

Macroalgae modelling has identified that Poole WWTW has a significant influence on the macroalgae growth within Holes Bay and the Outer Harbour. This is because of the large OP loads relative to other nutrient sources (c50% of the total OP catchment loading) and because of the availability of N & OP from this source during key periods of macroalgae growth.

Substantial point source nitrogen and phosphorus load reductions are therefore required from this WWTW. With maintenance of load equivalent using c2010-11 flows and revised permit limit of c5mg/l N and 0.25mg/l TP.

Further N and OP load reductions will be required from Wessex Water's other WWTW, which discharge directly or indirectly to the harbour to meet their fair share target. Wessex Water should identify how this will be achieved and apply for permit variation changes to deliver these objectives.

Investigations currently being undertaken in AMP7 will help to inform this decision making. Any changes that are required should be included in PR24 and implemented in AMP8 (2025-2-30).

10.3.3 Other reduction

There remain some uncertainty regarding overall nitrogen and phosphorus load derived from non WWTW, permitted discharges. It would be recommended that a further review is undertaken to calculate the average nutrient loading that comes from these sources and to assess if any further permit reduction is required to meet HR targets.

Much of nutrient loading derived from urban and non-agricultural land comes from atmospheric deposition. Government action on reducing agricultural and industrial aerial emissions in the future will start to reduce these loading and contribute to the solution.

Further urban reductions can be delivered through resolving mis-connections between foul and clean water soakaways. Implementation of Sustainable Urban Drainage systems will also reduce run-off and nutrient input to the surface water system and harbour.

Connection of rural systems to mains sewerage network, may deliver reductions in un-sewered loads. Alternatively individuals should ensure any infrastructure is maintained in accordance with manufacturer's guidance. Stakeholders could also offset nutrient loading by implementing appropriately managed and audited catchment management schemes.

10.4 Mechanisms and timescales to deliver water quality objectives

10.4.1 Diffuse Pollution Mechanisms

It is unlikely that diffuse pollution reduction targets will be delivered unless:

- Appropriate resources are put in place to enforce existing and any future farm regulations.
- Farmers start to understand the impact their activities have on the water environment, annually calculate the nitrogen losses that result from their farm holding and change their management practices and reduce these losses to meet catchment target. To achieve this farmers should undertake the **minimum farming rules** detailed in this document. This includes the need for farmers to:
    - Become fully compliant with **existing regulations.** To undertake an annual self-assessment of their current level of compliance and implement a plan to resolve any

areas of non-compliance within the time period specified by the regulator (unless otherwise agreed in writing).

    - Ensure the nutrient loss from their farm holding, do not exceed the **maximum leaching target** and their farm holding target. If they are a members of an EA approved nutrient trading scheme, they should meet the annual **glide path target,** which will deliver the catchment target by 2030.
    - Annually calculate the nitrogen losses that under average climatic conditions are forecast to result from their nutrient plan and soil and nutrient management measures they implemented the previous season and propose to implement the following season. They should plan only to deliver their **environmental** acceptable **economic optimum yield**.
    - Calculate their **whole farm nutrient balance/loss** annually to identify if they have met their maximum leaching target or glide path target and or if they need to implement more measures, change their nutrient plan, or if in an agreed nutrient trading scheme they need to buy or sell nutrient credit so as to deliver their annual target (Section 8.1.3.2 and 8.1.3.3).
- Farmers **annual report** a) the measures they have implemented to maximise their nutrient efficiency and deliver their Environmental Economic Optimum Yield, b) nutrient losses, nutrient plan and nutrient balance annually to the Environment Agency or for any EA approved nutrient trading scheme, to an independent 3rd party overseeing the scheme.
- The Environment Agency or for an agreed nutrient trading scheme, an independent third party should annually **amalgamates this farm level data at the water body scale** so that the progress in delivering the catchment targets can be monitored and any issues that may be arising identified and resolved.
- The **tools and techniques** used to calculate farm nutrient losses, whole farm nutrient balance and trade nutrients should be scientifically robust and agreed or specified by the Environment Agency.

A “nutrient trading” approach proposed by the NFU to encourage and incentivise farmers to deliver their farm and catchment level water quality targets will help to maintain the current **good will** of many farmers. For this to work however, there should be a requirement for all farmers to undertake the **minimum farming rules**, tasks set out above.

Under a nutrient trading scheme, this approach is likely to result in all farmers improving their nutrient efficiency so farmers below the glide path can sell more nutrient credit and farmers above the glide path have to buy less credit to meet their farm holding target. Some farmers may also change their business model, becoming low input farmers by reducing the level of intensification and implementing alternative measures, such as installing wetland to maximise the nutrient credits they can sell to other farmers across the catchment.

To deliver the agricultural sector target, it will also be essential **all agricultural holdings** within the Poole Harbour catchment engage and follow these requirements. The EA will need to focus its farm regulatory enforcement resources on farms that are not part of any agreed nutrient trading schemes to ensure they are meeting the maximum leaching target and are fully compliant with wider regulations. A smaller part of its resource should however review the compliance of farms within any agreed scheme.

Farmscoper modelling indicate that implementation N reduction measures, together with point source improvements, are likely to deliver the OP targets. N can therefore be considered as the main nutrient that is modelled and traded, but advice should continue to be given to deliver a reduction in both N & P®. This should be reviewed through time.

The glide path should deliver the maximum leaching target by 2030. This can be achieved if farmers reduce their losses by around 6% a year (based in Farmscoper derived initial baseline). It should be for farmers to identify the measures they put in place to deliver their glide path target and regulatory compliance. In principle low cost measures should be implemented rapidly (within the first year following publishing this plan). Measures that requiring greater capital and financial planning may take a number of years to implement.

Progress in delivery the agricultural fair share target should be monitored regularly. A nutrient trading scheme should review the progress made by its members annually. A formal review of the progress being made should take place in c April 2024, April 2027 and 2030. If the glide path targets are not being met, consideration should be given to implementing a WPZ.

A stepped approach is therefore recommended to achieve the water quality targets set out in this consent order. Initially seeking to deliver the objectives through mechanisms outlined in Options 3, implementing a nutrient trading approach, with the **minimum farming rules** set out in Section 8.1.3.1 to 8.1.3.6, together with the EA enforcing its existing regulations.

If the agricultural community do not agree to implement the minim rules as part of any scheme, there would be little confidence the target would be achieved.

In these circumstances it would be recommended the EA move to option 4, using its existing powers under EPR (2016)(61)(1) and other legislation potentially in different ways to request the data and actions detailed in Section 8.1.3 and 8.1.6 to be supplied. Where necessary the EA should seek new powers to require farmers to move to the target set out in this report and implement specific measures that will maximise nutrient management efficiencies and minimising the risk to the water environment (Option 4). A Water Protection Zone may be the most efficient ways to achieve this, Option 5.

10.4.2 Point Source Improvement Mechanisms

Significant reductions in nutrient loads discharged from Poole WWTW are required to deliver requirement on nutrient loading in Holes Bay. Permit conditions will be determined following completion of investigations under AMP7 and in PR24. Current modelling indicate that a refined N limit of 5mg/l N and 0.25mg/l TP may be required at 2010/11 flows, or the WWTW effluent discharged out of catchment. If flows increase a “maintenance of load” approach should be adopted.

10.4.3 Final WQ targets

The environmental improvements in the harbour that result from the implementation of these measures, are likely to take years/decades to be observed. This is because of the delay in N reaching the harbour once it has been leached from the soil and due to the significant P store that is understood to be within the harbour sediment. As a result, ecological improvements within the harbour will be delayed as these nutrient stores are depleted. This is however not a reason to delay the implementation of current best practice.

To deliver this approach, further financial resource will be required to:

- Enforce existing and future regulations
- Set up, operate and audit the nutrient trading scheme.
- Develop, operate and maintain tools to calculate farm and catchment scale nutrient loss and to trade N.

- Set up and manage processes for receiving, compiling and analysing farm data sent to the EA.
- Manage the delivery of consent order recommendations and findings.

The aim would be that in the longer term, nutrient trading, if adopted would become self-financing.

The overall water quality targets recommended by this consent order should also be subject to review by looking at scientific evidence that comes to light over the next 10 years, as well as the ecological and water quality monitoring and results from any improved modelling evidence. Any need to revise the target should be justified by this evidence, monitoring and modelling, but it should be recognised that it may be necessary for the nitrogen target to be tightened to around 1000 tonnes N/yr as we move through RBMP4, beyond 2030.

11 Recommendations

Natural England advise that to achieve the conservation objectives of Poole Harbour Natura 2000 site the ecological functioning of the harbour needs to be restored from an opportunistic macroalgae-dominant system to an eelgrass/saltmarsh-dominant system. This will provide confidence in securing favourable condition where water nutrient status and its biological effects are involved. Natural England has indicated to achieve this, it is likely to be necessary for the nutrient status to be brought down to the levels that existed in the early 1960s to 1970. This period equates to a landward nutrient inorganic nitrogen load of about 1,000 t/yr or less. Modelling evidence identifies that further reductions in phosphorus inputs would limit macroalgae abundance. This, however, may not be adequate to prevent a continued occurrence of dense macroalgae mats in some parts of the harbour or favour restoration of an eelgrass/saltmarsh-dominant system.

However there remains some uncertainty regarding the relative role nutrients and other physical factors discussed in Section 6.4 have on eelgrass and saltmarsh habitat. It is therefore proposed that an **adaptive management** approach is taken forward, setting a strong nitrogen limit, reducing total nitrogen loads from non marine sources to 1500 tonnes N/yr, combined with a phosphorus limit of 22 tonnes OP/yr, as interim targets

This is modelled to deliver the UKTag macroalgae density target required within the harbour and is likely to result in further improvements in eelgrass and saltmarsh, and will make meaningful improvements to restoring the condition of the harbour.

Further investigations should be undertaken to determine the role these other factors have on the eelgrass and saltmarsh habitat between 2021-2027. Any new scientific understanding and the results of ecological and water quality monitoring and improved modelling results should then be used to review the likely effectiveness in delivering the wider conservation objectives. It will also help to identify if any further measures (including tightening of the water quality targets) will be required to deliver these objectives.

The interim targets will deliver timely and significant reductions in nutrient emissions to the catchment feeding Poole Harbour as soon as reasonably practicable. The recommendations of this document will make meaningful improvements toward these requirements and follows the "**adaptive management**" principles agreed between EA and NE for achieving Natura 2000 targets.

To try and deliver favourable status across the Poole Harbour catchment, it will be necessary for the following measures to be put in place. These recommendations should be reviewed through time, as our understanding improve. They should therefore be considered to be **interim for RBMP3 period to the end of 2027**.

11.1 Recommendations to achieve interim target (TR)

Nutrient limits entering the Harbour should be reduced as follow:

TR1: Nitrogen loads entering the harbour from fluvial, point source discharges and atmospheric deposition (excluding marine input) should be lowered to 1500 tonnes inorganic N/yr.

TR2: Phosphorous loads (Orthophosphate-phosphorous) from non-marine sources, should be reduced to c 22 tonne P/yr.

Fair share nutrient emissions limits:

TR3: non permitted agricultural point and diffuse inorganic nitrogen loads, modelled to be lost from the soil zone through all land use within agricultural holdings[15] (grassland, arable, woodland, rough grazing heathland etc.) should be reduced to c1127 tonnes N/yr[16], equivalent to a **maximum nitrogen leaching target of** c18.1 kg/ha N from all agricultural land use reported in 2010 census (land area of 62,178 ha[17]).

TR4: Total diffuse Agricultural P loads that enter the harbour, from farm holdings across the catchment should be reduced to c3 tonne OP/yr. This equates to c0.05kg/ha [18]based on 2010 land use[16], (using annual average approach adopted by SIMCAT)[19]. The need for farm level glide path target for P (in a similar way to N), should be reviewed when overall farm compliance and catchment targets recommended by this report are reviewed.

TR5: WWTW point source inorganic nitrogen loads should be reduced to 209 tonnes N/yr.

TR6: WWTW phosphorus loads should be reduce to c16 tonnes Orthophosphate-phosphorous P/yr to meet fair share.

TR7: Non WWTW permit discharges of inorganic nitrogen loads (almost all from aquaculture – fish farms and watercress farms) should be reduced to c38 tonnes N/yr and orthophosphate phosphorous should be reduce to c1.5 tonnes OP/yr. The exact figure should be subject to further investigations of these permitted discharges.

TR8: Urban nutrient losses should be reduced to c78 tonnes/yr N and 0.6 tonnes OP/yr, un-sewered loads to 10 tonnes N/yr, non-agricultural land loads to c39 tonnes/yr N (Table 7.1:1).

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[15] agricultural holdings required to submit census returns (on request) under the **Agricultural Statistics Act 1979**. The definition of Agriculture under this act, comes from the **Agricultural Act 1947**

[16] it will take years or decades for diffuse water quality improvements to be observed in the harbour but agricultural activities carried out today should not adversely impact the environment in the future.

[17] Tables 8 & 16 in Gooday et al, 2017

[18] Modelling suggests P target will be achieve by delivering N reduction target. No farm specific glide path shall initially be set, but this will need to be monitored and reviewed through time.

[19] the average agricultural load forecast through annual average approach (SAGIS SIMCAT) is considered as an underestimation of total agricultural loads AND it is considered that OP load reductions shall be achieved through the implementation of measures to deliver N reductions required. A farm level OP target is not initially recommended, but may be required following first years submission of farm returns and or if it identified that reduction in OP are not keeping track with N reductions. This should be reviewed in April 2024.

TR9: Nutrient load emission limits should be met or the actions required secured within an appropriate water planning decision timeframe. It would be suggested that any review and planning for this work should be undertaken for PR24 and implemented by 2030.

TR10: There should be no net increase in nutrient load entering the harbour as a result of residential and commercial planned growth within the catchment.

TR11: The Environment Agency and Natural England should formally review the measures put in place to deliver Habitats Regulations objectives across the Poole Harbour catchment by the end of RBMP3 in 2027. Any recommended changes to the measures and where appropriate, water quality targets should be agreed by the EA and NE in consultation with wider stakeholders.

11.2 Diffuse and Point Source Measure Recommendations (DR and PR respectively)

DIFFUSE RECOMENDATIONS

Within 6 months of publishing this document, farmers will need to implement these recommendations to demonstrate they are applying all reasonable measures to prevent pollution. Where they do not, the Environment Agency may consider farmers are "knowingly permitting" pollution [Environmental Permitting Regulations (2010) Regulations 38(1) (a) and 12(1) (b)], and farm compliance shall be assessed again the final water quality standards being sought by this document.

DR1: **Maximum Leaching Target/Glide Path:**

a)Farmers that take part in an EA approved nutrient trading scheme, which implements the minimum farm rules outlined in this consent order document (Section 8.1.3.1 to 8.1.3.6), shall implement measures appropriate to their farming business to bring their nutrient losses below the maximum leaching target of 18.1 kg/ha N (TR3) by 2030. To achieve this farmers should bring their annual nutrient losses below the annual glide path target and their farm holding target outlined in Section 7.3 and Figure 8.1.3:1. The farm may buy or sell nutrient credit to achieve this objective.

b) The glide path profile for any EA approved nutrient trading scheme, shall be re-calculated at the start of the scheme as detailed in Section 8.1.3.1 and Equation 8.1.5.

c)Farmers that do not take part in an EA approved scheme and as such are not clearly demonstrate they are implementing the minimum farming rules recommended by this document and or gained earned recognition, will need to ensure their nutrient losses do not exceed the maximum leaching target of 18.1 kg/ha.

DR2: Nutrient Planning; Farmers need to start to calculate the nutrient losses that are likely to result from their proposed nutrient plan (required under NVZ regulations and FRfW). In particular considering the yield they seek to achieve, soil and nutrient management measures they propose to implement and the impact this will have on nutrient losses from their farm holding. They should then adjust their nutrient application rates, measures they propose to implement, to a point where they can maximise crop yield without causing harm to the environment, the **Environmental Economic Optimum yield.** (Section 8.1.3.2).

DR3: Whole Farm Nutrient Balance: Farmers across the Poole harbour catchment shall annually calculate (by agreed modelling technique), the nitrogen losses to surface and groundwater that under average climatic conditions will result from their nutrient plan and farm measures:

- implemented the previous season and
- planned for the following season.

They should ensure these losses do not exceed the maximum leaching target set out in this report. Where the farmer and farm holding is a member of an EA agreed scheme, implementing the minimum farm rules (and or other agreed scheme rules), they may adjust their whole farm nutrient balance for any nutrient credit purchased or sold and ensure they do not exceed the annual glide path target (Section 8.1.3.3). No nutrient application should however be above crop need.

DR4: Farm regulatory compliance; Farmers should not cause or knowingly permit the entry of polluting matter (nitrogen and phosphorus) to inland freshwaters or coastal waters, otherwise they commit an offence [Environmental Permitting Regulations 2016 Regulations 38(1) (a) and 12(1) (b)]. All farmers across the Poole Harbour catchment should be fully compliant with Nitrates Pollution Prevention Regulations 2015 (NVZ Regulations), Reduction and Prevention of Agricultural diffuse Pollution Regulations 2018 known as New Farming Rules for Water - GOV.UK (April 2018), Water Resources (Control of Pollution) (Silage Slurry and Agricultural Fuel Oil) Regulations 2010 (SSAFO) and other relevant regulations and Directives.

All farmers should complete an annual self-assessment of their current regulatory compliance and put in place a plan to resolve any areas of non-compliance within EA agreed period of time. Farmers in an EA approved nutrient trading scheme may return their self-assessment to the organisation overseeing the scheme (DR6). Farmers outside such schemes, should return their self-assessment to the EA.

DR5: Farm Annual Reporting: Farmers should annually report a) the measures they have implemented to maximise their nutrient efficiency, b) their nutrient plan, to achieve their Environmental Economic Optimum Yield (DP2), c) their whole farm nutrient balance/ losses (DP3) and d) current regulatory compliance and plan to resolve any areas of noncompliance to the Environment Agency. For any farm within an EA approved nutrient trading scheme (or similar), this data may be reported to an independent 3rd party overseeing the scheme (see DR 6a).

DR 6: Catchment Reporting:

DR6a: 3rd Party Reporting: Where an independent 3rd party is appointed to oversee an EA approved nutrient trading scheme, they should collate the farm data provided at a river water body scale[20] and present this data in an anonymised format annually to the Environment Agency and or a Board appointed to oversee any nutrient trading scheme. This annual reporting shall help to ensure agricultural targets are met and any issues experienced in delivering these targets can be resolved in a timely way

DR6b: The EA should develop a database and tool to collate farm data supplied by farmers outside any nutrient trading scheme, (DR 1-5), and track farm compliance with existing regulations, delivery of minimum farm rules and maximum leaching targets.

DR 7: Where a 3rd Party is appointed to oversee a nutrient trading scheme, this 3rd party will advise the Environment Agency annually the farms that are part of any nutrient trading scheme and are compliant with the rules of that trading scheme.

[20] or for small water bodies an agreed appropriate scale that will provide spatial catchment resolution of compliance whilst also providing a level of anonymity of farm data

DR8: The **tools and techniques** that will be used in DR2-DR7 above, should be scientifically robust and agreed by the Environment Agency.

DR9: If a nutrient trading scheme is taken forward, all farmers should meet a minimum regulatory requirement to enter this scheme. This should be agreed in writing between the EA and scheme management group. Farmers should be discouraged from decrease their efficiency before entering or when in such a scheme and should not exceed crop need, defined under Farming Rules for Water. Any nutrient trading scheme should be to incentive improved nutrient management efficiency, rather than intensification.

DR10: Evidence indicates significant areal or atmospheric deposition of nitrogen takes place across the Poole Harbour catchment (Appendix 3). This is modelled to be greater than 10kg/ha. Farmers should consider if an adjustment to their nutrient plan should be made to account for this source of nitrogen.

DR11. Farmers, subject to obtaining appropriate agreements and permits, may implement:

- farm wetlands to intercept high nitrogen and phosphorus run-off and prevent it entering surface waters or
- on stream wetlands which may direct high nutrient surface water flows through the wetland before discharging back to surface waters to offset their current nutrient losses across their farm holding or to increase the nutrient credit they can sell within a nutrient trading scheme.

DR12. Prior to installing any wetland, an option appraisal and risk assessment should be undertaken to a) identify the opportunities and location where wetlands might be developed b) identify the design and management of such wetlands that will be required c) identify the risks that might result from their installation and how these might be mitigated d) the agreements and permits that should be obtained before such wetlands are put in place. Natural England, EA and LA should work together to identifying any strategic opportunities for the installation of wetlands to deliver wider environmental benefits. The agricultural sector should take ownership for farm scale wetland opportunity mapping, risk assessment and implementation.

Atmospheric emissions

DR13. Government action on reducing agricultural and industrial aerial emissions in the future will start to reduce nutrient leaching from urban, agricultural and non-agricultural land. These measures might be enforced across the Poole harbour area to increase the speed these benefits are delivered.

Urban emissions

DR14: Further urban reductions in nutrient loading should be delivered through:

- Water company and local authority resolution of mis-connections between foul and clean water drainage,
- Local Authorities reducing surface run-off from new development sites by conditioning the need for effective Sustainable Urban Drainage schemes as part of future development plans, and implementation of other appropriate measures by the Local Authorities and wider partners.
- Reducing run-off from existing urban infrastructure and roads and intercepting nutrient loads prior to their discharge to surface and groundwater's.

- Reducing the use of fertilizers and chemicals on local authority controlled or owned land, such a parks, sports and leisure sites.
- Local Authorities updating their Supplementary Planning Documents in light of these recommendations.

Un-sewered wastewater

DR15: Further investigations should be undertaken to identify the opportunities for further first time rural sewage connection projects to reduce nutrient loads from septic tanks and other rural discharges.

DR16: All new or upgraded non-sewered domestic discharges within the Poole Harbour catchment should include a basic level of treatment to bring discharge nitrogen concentrations to <11.3 mg/l N (Drinking Water Standards). This should be implemented by EA and conditioned in any planning permissions granted by the Local Planning Authorities. Existing systems should be maintained in accordance with manufacturer's guidelines.

POINT SOURCE

The following measures should be implemented by Wessex Water and other sectors to achieve their fair share. Water company improvements shall be implemented through Asset Management Planning process and the EA shall need to review other large consents within a 6year review cycle.

PR1: All Waste Water Treatment Works (WWTW) Nitrate and Orthophosphate phosphorus loads discharged to the catchment (surface and groundwater) and entering the harbour should be reduced to meet water company fair share targets (Section 7.0 & Section 11). Any catchment nutrient offsetting delivered by agriculture on behalf of the water company can be included in these calculations, where it is demonstrated that farmers participating in these schemes have gone beyond their own fair share targets identified in this report, in delivering any offset claimed.

PR2: Significant reductions in nutrient loads discharged from Poole WWTW are required to deliver both nutrient reduction within the harbour and the reduction in macroalgae density across the harbour. Permit conditions should be set in PR24, following AMP7 investigations and implemented in AMP 8, unless otherwise agreed with the regulator. It is anticipated that a revised permit limit for Poole WWTW, will need to meet or exceed, a maintenance of load equivalent using 2010-11 flows and permit limit of ≤5mg/l N and 0.25mg/l TP.

PR3: All WWTW discharging to ground, shall be included within water company fair share and achieve at least 10mg/l N discharge quality unless it can be demonstrated that attenuation of the discharge, to this quality is achieved by the time it reaches the water table.

PR4: Nutrient reductions from industrial discharges (primarily fish farms and cress farms) are also likely to be required to meet sector fair share targets (Section 7.0). Before the exact quantitative reduction can be determined, the Environment Agency should investigate the discharge loading that result from the largest non-water company discharges. Appropriate permit reductions should then be implemented or measures put forward and implemented by permit holders to achieve the reduction in discharge load required and targets set out in this report.

PR5: Maintenance of load conditions should be applied to any permit variation, so that CO fair share targets is delivered or maintained.

Ecosystem process (EP) restoration recommendations

Measures are required to widely restore natural systems in the harbour and its catchment area that intercept and lock or remove nutrients. These include:

EP1: developing and updating catchment wide river and floodplain rehabilitation plan for extension of Environmental Permitting rules for river works affecting SSSI rivers to the wider main river system that also addresses beaver colonisation and wetland restoration and creation

EP2: Review and where required update the Shoreline Management Plan or addendum considering saltmarsh re-creation and restoration.

EP3: Review and where required update of the Poole Harbour Aquatic Management Plan considering restoration of ecosystem and processes.

EP4: Review and where required update other plans within the Poole Harbour catchment which may align with the recommendations of this report and which may impact nutrient uptake or release from and to the catchment and or ecosystem processes, biodiversity and or saltmarsh and seagrass habitats within the harbour.

11.3 Mechanisms to deliver Point and Diffuse Targets (MR)

Diffuse pollution reductions should be delivered following a tiered approach.

MR1: Farmers have legal responsibility to ensure they are not causing or knowingly permitting pollution across their farm holding. Delivery of these obligations may be assisted by the implementation of an EA approved nutrient trading scheme (Section 8.1.3) proposed by the NFU, which focuses on delivering the water quality targets and full regulatory compliance of the scheme participants. In so doing, any such scheme shall include within it, the EA **recommended minimum farming rules** detailed in DR1-8 and wider recommendations DR9-12 above. It would be recommended that any such nutrient trading scheme should be implemented in full across whole of the Poole Harbour catchment by October 2022. The baseline for the "glide path" should be updated between March 2022 and October 2022, using all participating farm baseline whole farm nutrient balance/loss calculations (equation 8.1.5).

MR2: Piloting of any nutrient trading scheme should be undertaken through 2021 and into spring of 2022. Final tools and rules and reporting requirements should be agreed with the Environment Agency by July 2022 and fully implemented in October 2022.

MR3: Annual progress reports for any nutrient trading scheme should be submitted to the regulator and partners in the spring of each year. A formal progress report should be published in April 2024 for the EA and NE to formally review by December 2024.

MR4: To deliver the agricultural sector target, it will be essential **all agricultural holdings** within the Poole Harbour catchment engage and follow the requirements of this report. The EA should focus its farm regulatory enforcement resources on farms that are not part of an EA approved scheme (MR1), or not complying with these rules (as identified by local intelligence or field observations). c10-20% of EA regulatory farm visits within the catchment, should be spent on farms within any nutrient trade scheme. The purpose of this will be to validate the compliance of these farms with the minimum farming rules set out in this document and any EA agreed nutrient trading scheme.

MR5: The regulatory compliance of farmers that are not part of an agreed scheme, shall be assessed against the final water quality targets set out in this report (TR3 & DR1).

MR6: If a nutrient trading scheme cannot be developed which agrees to implement the minim farm rules (detailed in DR1-8 and wider recommendations DR9-12 above) within 6-12 months of publishing this report, there would be little confidence the target would be achieved. In these circumstances it would be recommended the EA move to use more fully its regulations to achieve the obectives set out in this report (Section 8.1.4). Under this scenario, the EA shall try and deliver the target by using its existing powers to require farmers to annually undertake the tasks and report data detailed in Section 8.1.3 and 8.1.6 and diffuse recommendations of this report.

MR7: The EA shall formally review progress in delivering agricultural targets by December 2024. Where confidence remains low that the targets will be fully delivered by 2030, the EA should seek new powers to deliver Habitat Regulation objectives and a Water Protection Zone may be the most efficient ways to achieve this, Option 5, (Section 8.1.5).

Point Source

MR8: Point source WWTW N & P reductions should be implemented through the Asset Management Planning process. Point source measures that can rapidly be implemented should be delivered under AMP7 or early in AMP8. Schemes that may require significant capital investment, such as if Poole WWTW was to be discharged out to sea, should be implemented late in AMP8 or early in AMP9 as agreed in writing between the water company and regulator.

MR9: The EA review of any non-water company discharges should take place within RBMP3, with any permit variations implemented by 2030.

11.4 Future Monitoring and Modelling Recommendations (MoR)

MoR1: Water quality monitoring should continue across the Poole Harbour at sufficient locations and time resolution to identify how nutrient sources vary through time and to assist in interpreting changes in macroalgae growth that results from this. The monitoring undertaken by EA and partners should be co-ordinated to deliver the most efficient and effective network and dataset.

MoR2: Ecological monitoring by aerial survey and ground surveys should continue, following guidance from Ecological and Coastal Monitoring Service (ECMAS), annually and where necessarily seasonally, to understand how growth responds spatially and in density to changes in water quality and wider environmental variables and pressures. The minimum ecological elements that should be monitored include: Macroalgae, Sea Grass, sub-tidal Sea Grass, and Saltmarsh.

MoR3: Further research should be undertaken to understand the inter relationship between nutrient concentrations, salinity, light, sedimentation, and physical modifications within the harbour [depth (sea level change), currents, erosion etc.], in controlling wider sea grasses and salt marsh species diversity and health, within the harbour. Results from this work should determine if changes to the nitrogen and phosphorus targets are required and or additional measures beyond nutrient reduction need to be implemented to achieve wider conservation objectives. These measures should be informed by this research.

MoR4: The CPM macroalgae model should be refined within AMP7 timescales to further improve our confidence in modelling recommendations and forecasts and its representation, particularly of the Wareham Channel (Annex 1 and 2). This could include linking CPM to Telemac model and increasing the functionality of the tool to model growth sea grass and Saltmarsh, where technically feasible.

MoR5: Where sufficient data is available to calibrate the model, future modelling work should try and refine the spatial resolution of the CPM model to a resolution that may enable modelling of specific important feeding embayment's and other physical and quality controls that may impact on protected species.

MoR6: Further modelling tools should be developed/utilised to identify the measures required to deliver improvement in sea grass and saltmarsh across the harbour necessary to maintain a diverse food supply and habitat required for birds.

MoR7: A **monitoring and modelling plan** should be produced by NE and EA by December 2021 to identify how water quality and ecological data collected across the Poole Harbour catchment will be used to review progress in delivering HR objectives. It shall also identify any shortfalls in such data collection and recommend further research, monitoring and modelling that may be required to deliver the objectives of this report and fill any current gaps.

MoR8: A technical working group should be set up to consider how the development of new measures to reduce nutrient leaching and improve farm nutrient management efficiencies can be incorporated in modelling tools. This group should also agree the effecticeness of such measures in offsetting nutrient leaching and approve the inclusion within the modelling tool.

11.5 Timetable of Actions

The above recommendations should be implemented within the timeframes recommended in Table 11.5:1 to delivery HR objectives within the Poole Harbour Catchment.

Table 11.5:1 Action Plan Gant

				2021		2022		2023		2024		2025	2026	2027	2028	2029	2030	2031 +
Recommendation	**Action**	**Lead**	**Regulator**	**Q1&2**	**Q3&4**	**Q1&2**	**Q3&4**	**Q1&2**	**Q3&4**	**Q1&2**	**Q3&4**							
Target Recommendations																		
TR1 & TR2	Target loads implemented	EA																
TR11	Formal review of targets																	
Diffuse Agriculture																		
TR3 & 4, DR1a	Agricultural Fair Share delivery	Agri	EA															
MR6, DR8, DR9, DR10	Nutrient Trade Agree Rules & mini pilot	Agri/EA	EA															
MR1, MR2, DR6a	Nutrient Trade pilot and role out	Agri	EA															
MR3, DR6 & 7	3rd Party Annual Reporting	Agri	EA															
DR1 & DR10	Glide path implemented (for approved EA schemes)	Agri	EA															
DR1b	Farm baseline N loss calculated & glide path baseline updated	Agri	EA															
DR2	Environmental Economic Optimum Yield	Agri	EA															
DR3, DR10, DR11	Whole farm nutrient balance	Agri	EA															
DR4	Farm regultory compliance	Agri	EA															
DR5	Farm Annual Reporting	Agri	EA															
DR 6b	EA collation of farm data	EA	EA															
DR8	Tools used in nutrient trading	Agri	EA															
DR 11 & 12	Wetland opportunity Mapping	NE/EA/LA	EA/NE															
MR4, MR5	Regulatory Enforcement	EA	EA															
MR6	Use EA Regs to drive change	EA	EA															
MR7	Formal Review Agricultural Delivery	EA	EA															
Water Company																		
TR5. TR6, PR1, MR8	Point source fair share delivery	WxW	EA															
DR15	First time rural WWTW	WxW	EA															
PR2	Poole STW N & P reduction	WxW	EA															
PR3	Groundwater discharges	WxW	EA															
Non Water Company Discharges																		
TR10	Offsetting of N & P from growth	LA/WxW	NE/EA															
TR7, PR4, MR9	Industrial fair share achieved	EA	EA															
TR8 & DR14	Reducing urban nutrient losses	LA	EA															
DR16	Non W.Co foul discharges	EA/LA	EA/LA															
PR 5	Apply maintenance of load principles to permit variations	EA	EA															

Recommendation	Action	Lead	Regulator	2021 Q1&2	Q3&4	2022 Q1&2	Q3&4	2023 Q1&2	Q3&4	2024 Q1&2	Q3&4	2025	2026	2027	2028	2029	2030	2031 +
Ecosystem Services																		
EP1, EP3	catchment rehabilitation plans & aquatic management plans	NE/EA	NE/EA															
EP2	review shoreline management plan	EA/NE	EA/NE															
EP4	Review other plans	ALL																
Monitoring & Modelling																		
MoR7	Monitoring Plan	NE				?												
MoR8	Technical group reviewing measures	EA/NE/WxW	EA															
MoR1	WQ monitoring	EA/NE																
MoR2	Ecological Monitoring	NE/EA																
MoR3, MoR5	CPM/Telemac Modelling	EA/NE																
MoR4	Research Physical impacts on eelgrass and seagrasses etc	NE/EA																
MoR6	Further modelling tools	EA/NE																

KEY

	Investigating action
	Implementing measure
	Measure fully implemented
?	Key milestone/ review
EA	Environment Agency
NE	Natural England
WxW	Wessex Water
W.Co	Water company
Agri	Agricultural community
LA	Local Authority
TR	Target recommendations
DR	Diffuse recommendation
PR	Point source recommendation
EP	Ecosystem recommendation
MR	Mechanisms to deliver recommendation
MoR	Monitoring and modelling recommendation

References

1. Accornley, R., Jonas,P., Witt, S., etal; 2008. Poole Harbour SPA: Habitats Directive Assessment
2. Bryan etal, Strategy for Managing Nitrogen across Poole Harbour Catchment to 2035.
3. Gooday etal March 2018; Poole Harbour Scenario Modelling
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7. Kite, & Nicholson, 2018 Background information for understanding the catchment situation on nitrogen nutrient enrichment in the Poole Harbour Natura 2000 site: Kite & Nicholson 2018
8. Edwards 2018; Summary of Poole Harbour dynamic Combined Phytoplankton and Macroalgae (CPM) Modelling- Calibration Study.
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16. Wessex Water, Wareham N Removal Challenge Paper (2017)
17. Wessex Water, Poole Harbour N Savings Estimate (Nov 2016)

Appendix 1: Summary of Poole Harbour dynamic Combined Phytoplankton and Macroalgae (CPM) Modelling- Calibration Study. Edwards 2018

This annex can be found as a separate document

Appendix 2: Water Quality and Macroalgae Modelling of Poole Harbour: Estimated the required reduction in nutrient to achieve acceptable densities of Macroalgae; James, Edward and Bryan 2018.

This annex can be found as a separate document

Appendix 3: Background information for understanding the catchment situation on nitrogen nutrient enrichment in the Poole Harbour Natura 2000 site: Kite and Nicholson 2018

This annex can be found as a separate document

Appendix 4: Phosphorus Sources Across the Poole Harbour Catchment and Apportionment; Total Inorganic Phosphorus (TP) and Orthophosphorus Bryan 2018.

This annex can be found as a separate document

Appendix 5; Trends in total oxidised nitrogen (TON) in surface waters in the Poole Harbour catchment, 1976 to 2016; Environment Agency Wessex Area Analysis and Reporting Team. Draft October 2016

This annex can be found as a separate document

Appendix 6: Poole Harbour Scenario Modelling ADAS March 2018.

This annex can be found as a separate document

Appendix 7 Wessex Diffuse Pollution Reduction Plan (Agriculture)

This annex can be found as a separate document

Appendix 8: Reducing Nitrate in Poole Harbour: Supplementary Planning Document

This annex can be found as a separate document

Appendix 9 Cost Benefit for Diffuse and Point Source Options

This annex can be found as a separate document

Appendix 10 Updated Water Quality Targets for MPAs Version 1.2 Benjamin Green 21/10/2015

This annex can be found as a separate document

Appendix 11 Modelling Approach, Assumptions and Definitions

This annex can be found as a separate document

Appendix 12 Nitrogen Source Apportionment and Fair Share Calculations

This annex can be found as a separate document

Appendix 13: Science evidence on the nutrient loadings required to achieve the Conservation Objectives for Poole Harbour Special Protection Area (SPA) – Natural England’s review

This annex can be found as a separate document

Appendix 14: What Water Paleo Ecology Tells us about the history of Poole Harbour: Summary of Sarah Crossley PhD.

This annex can be found as a separate document