

**Appendices for
Hampshire Avon Diffuse Water Pollution Plan
For Phosphorus and Nitrate**

Final

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Appendix 1 Hampshire Avon Long Term Water Quality

Water quality in the Hampshire Avon Catchment is monitored at a high resolution and frequency. When interpreting the recommendations for the Consent Order Review it is important to understand the current condition of the catchment. Much of the data used in the review is based on modelled output and having an awareness of the observed water quality is important. The following section outlines the observed water quality at key points in the catchment. The main locations with comprehensive data are presented below.

Water Quality - Sample Location

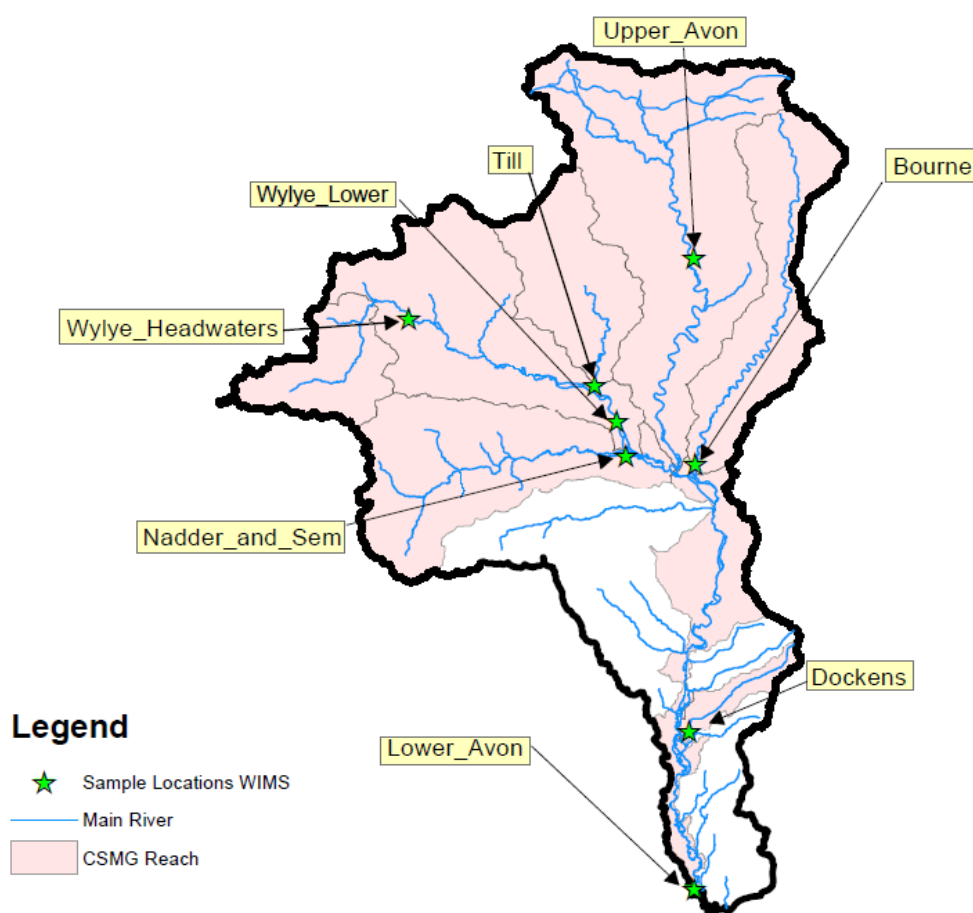


Figure 1 : Sample locations used for water quality trends and CSMG compliance. (See Copyright Statement 1&2)

1.1 Upper Avon

Much of the upper Avon, flows over Chalk bedrock, at the top of the catchment the chalk gives way to upper Greensand formations. The majority of the soil in the catchment are shallow, well drained calcareous silty soils over chalk, the upper reaches give way to well drained fine silts, clays and loamy soils.

The SSSI unit covers all the main river and is classified and Unfavourable – No Change. Long term, water quality trends are given in Appendix**, this shows a steady reduction in OP concentrations since the 1970s where average concentration's of ~0.35mg/L were common (Netheravon sample point). In the three years up to 2019 the average OP concentration from monitored data was 0.07mg/L (Sub Castle sample point). This shows that the Upper Avon is failing the CSMG target.

Table 1 : CSMG Targets for the Upper Avon

Long term (near natural) CSMG targets	Agreed NE CSMG targets	WFD Good	WFD High
	0.05	0.074	0.040

Time Series Plot - Restricted (0180 Orthophosph mg/l)

08-01-2016 to 28-12-201

50210209; HAMPSHIRE AVON AT STR SUB CASTLE

Restricted (0180 Orthophosph mg/l)

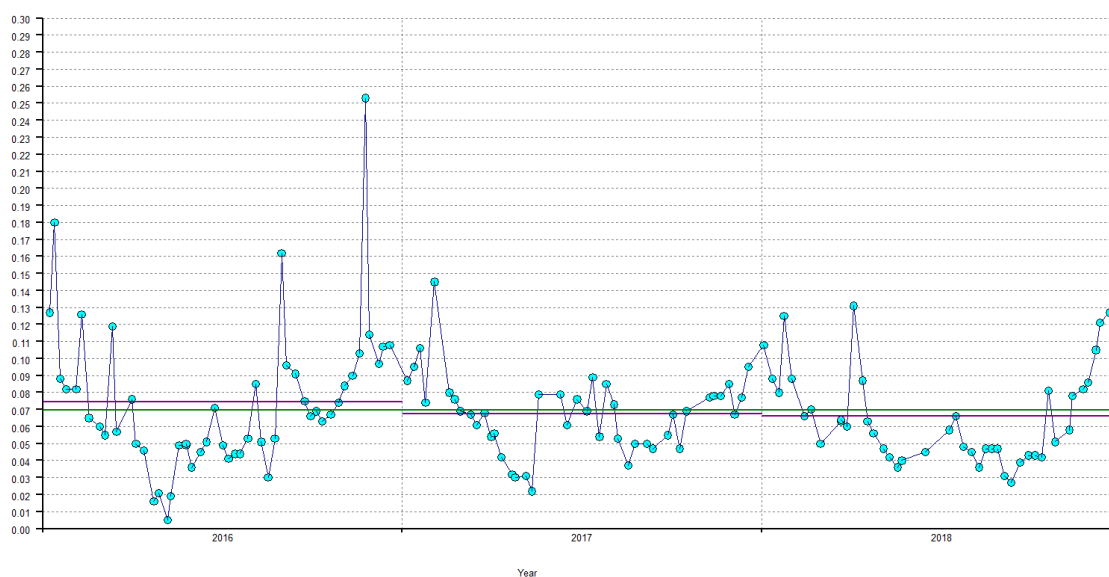


Figure 2 : Water quality data for the Upper Avon between 2016 and 2018

1.2 Lower Avon

The upper section of the river is dominated by chalks with the lower section (below Fording Bridge) is made up of siliciclastic clay rock and sandstones. The soil in the reach are varied with those overlying the chalk are dominated by shallow silts, the lower section gives way to a mixture of well drained loams, sands and gravels with chalky and gravelly river alluviums. The lower Avon SSI unit covers all of the river and is currently classified as Unfavourable – No change. Long term, water quality trends are given in Appendix**, this shows a steady reduction in OP concentrations since the 1970s where average concentration's of ~0.35mg/L were common. This has shown a steady decline to present day, with the three years up to 2019 the average OP concentration from monitored data was 0.067mg/L. This shows that the Upper Avon is failing the CSMG target.

Table 2 : CSMG Targets for the Lower Avon

Long term (near natural) CSMG targets	Agreed NE CSMG targets	WFD Good	WFD High
0.03	0.05	0.083	0.045

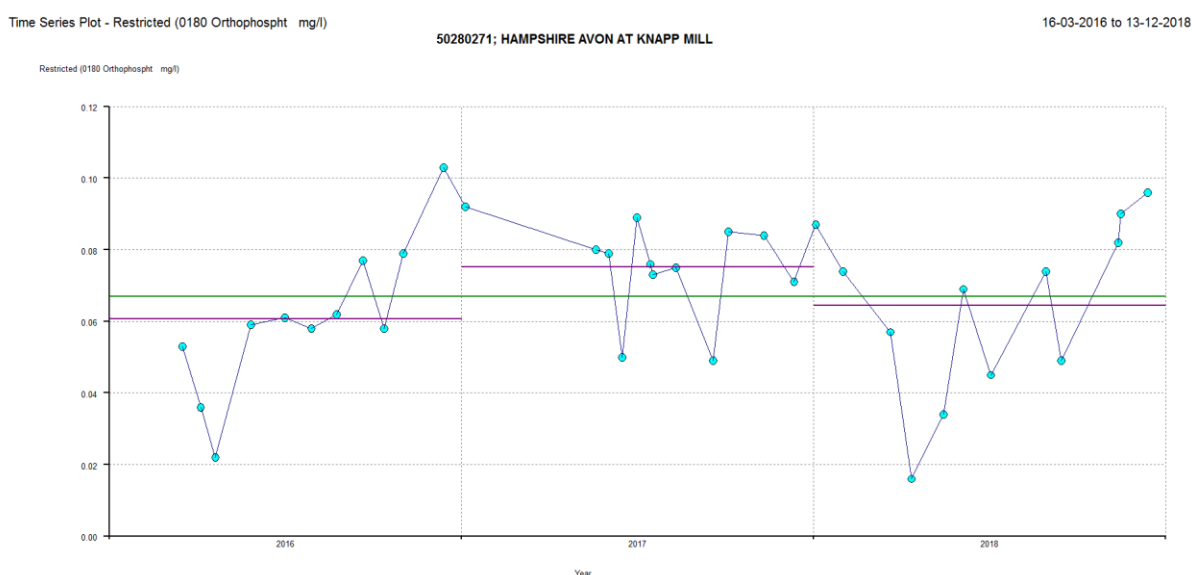


Figure 3 : Water quality data for the Lower Avon between 2016 and 2018

1.3 Wylfe upper

The Upper Wylfe catchment is dominated by Chalk and Greensand geology. The soils vary in the catchment with the well-drained calcareous clays, silts and loams.

The river SSSI unit covers around 1km of the river in the upper Wylfe CSMG section and is classified as Unfavourable – No change. Long-term water quality trends are given in appendix* and show a reduction in OP concentrations in 2002. Prior to this, concentrations regularly exceeded 0.25 mg/L. In the three years since 2016, the average concentration of ~0.06 mg/L which shows that the Upper Wylfe is not meeting the CSMG targets.

Table 3 : CSMG Targets for the upper Wylfe

Long term (near natural) CSMG targets	Agreed NE CSMG targets	WFD Good	WFD High
0.03	0.04	0.079	0.043

Time Series Plot - Restricted (0180 Orthophosph mg/l)

50230145; RIVER WYLFY AT SOUTH NEWTON

08-01-2016 to 28-12-2018

Restricted (0180 Orthophosph mg/l)

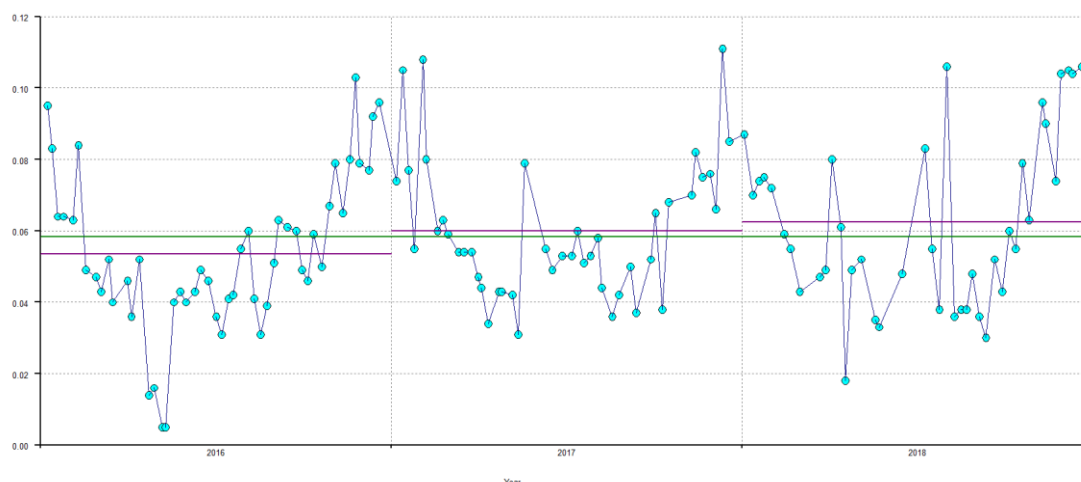


Figure 4 : Water quality data for the upper Wylfe between 2016 and 2018

1.4 Wylfe lower

The Lower Wylfe catchment is dominated by Chalk with some occurrence of Greensand at the top of the catchment. The soils are dominated by shallow silts.

The river SSSI unit covers all of the river in the upper Wylfe CSMG section and is classified as Unfavourable – No change. Long-term water quality trends are given in appendix* and show a reduction in OP concentrations in 2002. Prior to this, concentrations regularly exceeded 0.45 mg/L. In the three years since 2016, the average concentration of ~0.14 mg/L which shows that the Upper Wylfe is not meeting the CSMG targets.

Table 4 : CSMG Targets for the lower Wylfe

Long term (near natural) CSMG targets	Agreed NE CSMG targets	WFD Good	WFD High
0.03	0.05	0.078	0.042

Time Series Plot - Restricted (0180 Orthophosph mg/l)

50240461; RIVER WYLFY AT NORTON BAVANT

10-03-2016 to 06-12-2018

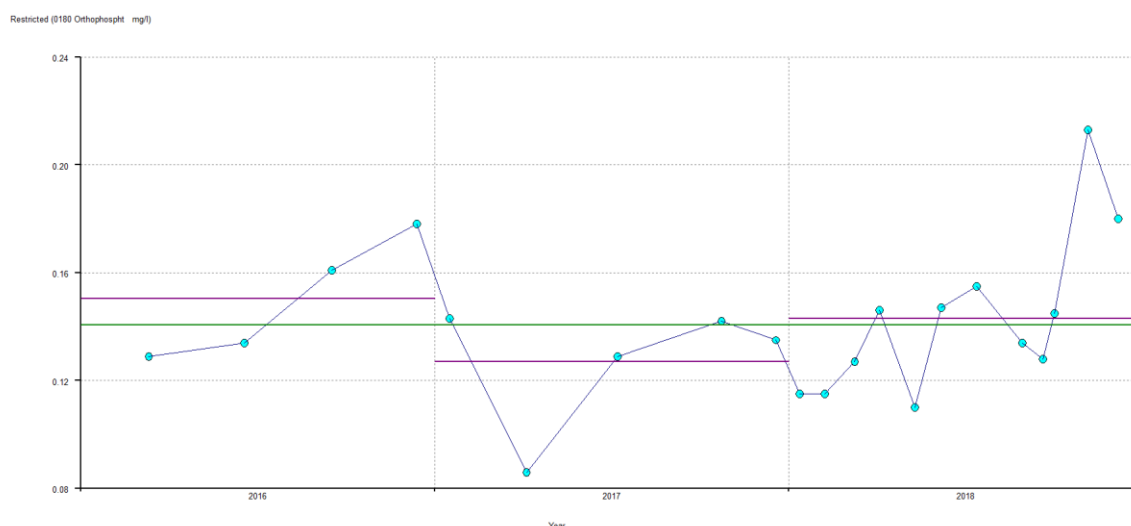


Figure 5 : Water quality data for the lower Wylfe between 2016 and 2018

1.5 Nadder and Sem

The bedrock of the catchment is varied with argillaceous rock, limestones, greensands and chalks. The soil type in the catchment is also varied with both well drained and wet soils being made up of clays, loams and sand.

The SSSI unit cover approximately 18km of river in the lower section of the CSMG area and is classified as Unfavourable No-Change. Long-term water quality trends are given in appendix* and show that OP concentrations have been stable since 1993 with only a marginal decline to present day. The 3-year average OP concentration between 2016 and 2019 is ~0.10mg/L meaning the River is failing its CSMG target.

Table 5 : CSMG Targets for the Rivers Nadder and Sem

Long term (near natural) CSMG targets	Agreed NE CSMG targets	WFD Good	WFD High
0.03	0.05	0.069	0.038

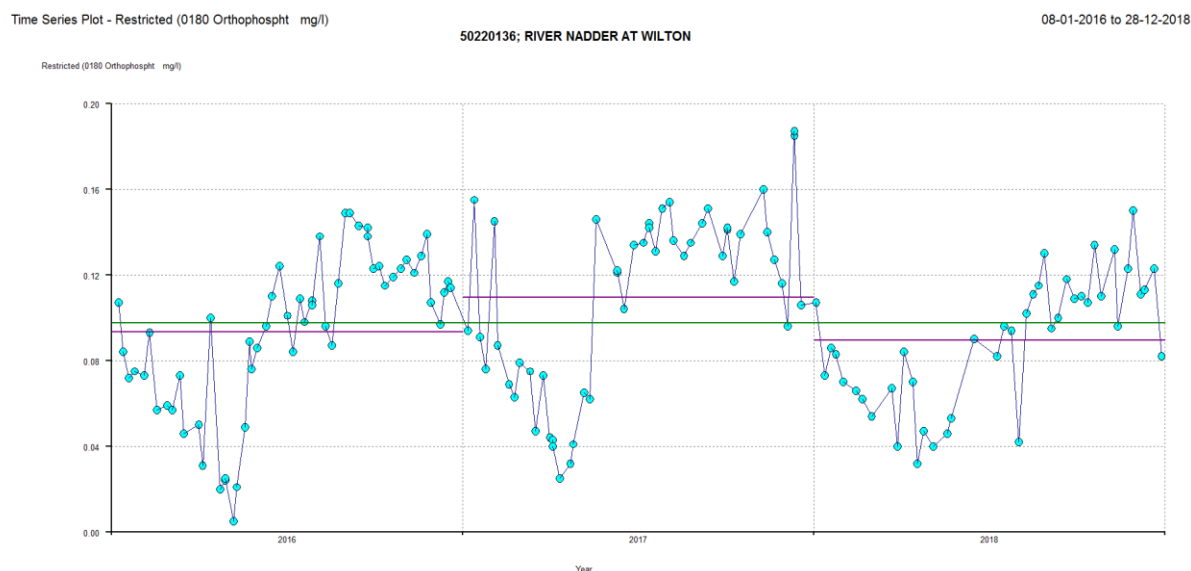


Figure 6 : Water quality data for the Rivers Nadder and Sem between 2016 and 2018

1.6 River Bourne

The bedrock is dominated by Chalk with some occurrences of upper Greensands and Gault at the very top of the catchment. The soils mainly consist of shallow silts over chalk. In the upper reaches there are some occurrences of well drained fine silts over clayey and argillaceous soil.

The SSSI designation covers the lower section of the river Bourne, stretching from the confluence with the Avon and the Village of Winterbourne Dauntsey. The river SSSI Units are classified as “Unfavourable - No change”.

Long term water quality trends are given in Appendix* and show substantial reductions in the OP concentration. During the 1980s average annual concentrations was ~0.225 mg/L.

Significant improvements in the OP concentration were observed between 2006 and 2010.

The average concentration in the three years up to 1/1/2019 was 0.047 mg/L. Recent WQ monitoring completed by the Environment Agency suggest that the agreed CSMG target is being met at the bottom of the catchment.

Table 6 : CSMG Targets for the River Bourne

Peak in concentration as a result of Tidworth Garrison

Long term (near natural) CSMG targets	Agreed NE CSMG targets	WFD Good	WFD High
0.03	0.05	0.081	0.044

Time Series Plot - Restricted (0180 Orthophosph mg/l)

50240116; RIVER BOURNE AT LAVERSTOCK

08-01-2016 to 28-12-2018

Plotting e

Restricted (0180 Orthophosph mg/l)

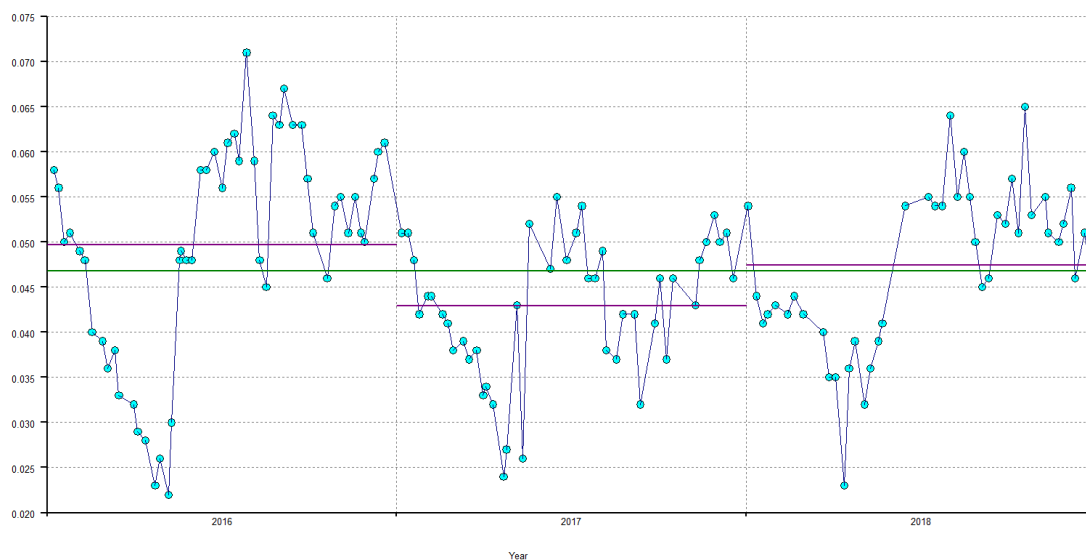


Figure 7 : Water quality data for the River Bourne between 2016 and 2018

1.7 Till

The bedrock of the River Till is dominated by the Chalk with superficial sand and gravel deposits. The soils are dominated by shallow silts.

The river SSSI unit covers the lower section of the waterbody and is classified as Unfavourable – Recovering. Long term river concentrations are given in Appendix* and show that concentrations in the river have been relatively stable at 0.04 – 0.06 mg/L) since 1987. In the three years since 2016 the average OP concentration of 0.025mg/L which shows that the Till is meeting the Agreed CSMG target.

Table 7 : CSMG Targets for the River Till

Long term (near natural) CSMG targets	Agreed NE CSMG targets	WFD Good	WFD High
0.02	0.03	0.078	0.042

Time Series Plot - Restricted (0180 Orthophosph mg/l)

50231010; RIVER TILL AT STAPLEFORD

08-01-2016 to 06-12-2018

Restricted (0180 Orthophosph mg/l)

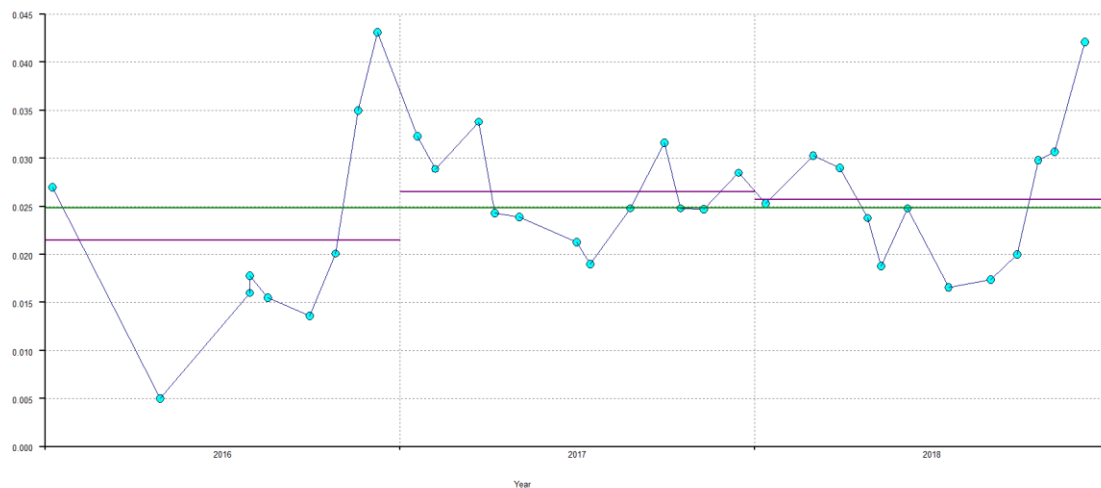


Figure 8 : Water quality data for the River Till between 2016 and 201

1.8 Dockens

The geology is dominated by interbedded sandstones and argillaceous rock. Soils in the catchment are dominated by seasonally wet loams and clays mainly over gravels.

The SSSI units cover most of the main river and is currently classified as Unfavourable – Recovering. Long-term water quality trends are given in appendix* and show that OP concentrations vary significantly between years, which is typical of a flashy catchment. The 3-year average OP concentration between 2016 and 2019 is ~0.15mg/L meaning Dockens water is meeting its CSMG target.

Table 8 : CSMG Targets for Dockens water

Long term (near natural) CSMG targets	Agreed NE CSMG targets	WFD Good	WFD High
0.015		0.090	0.050

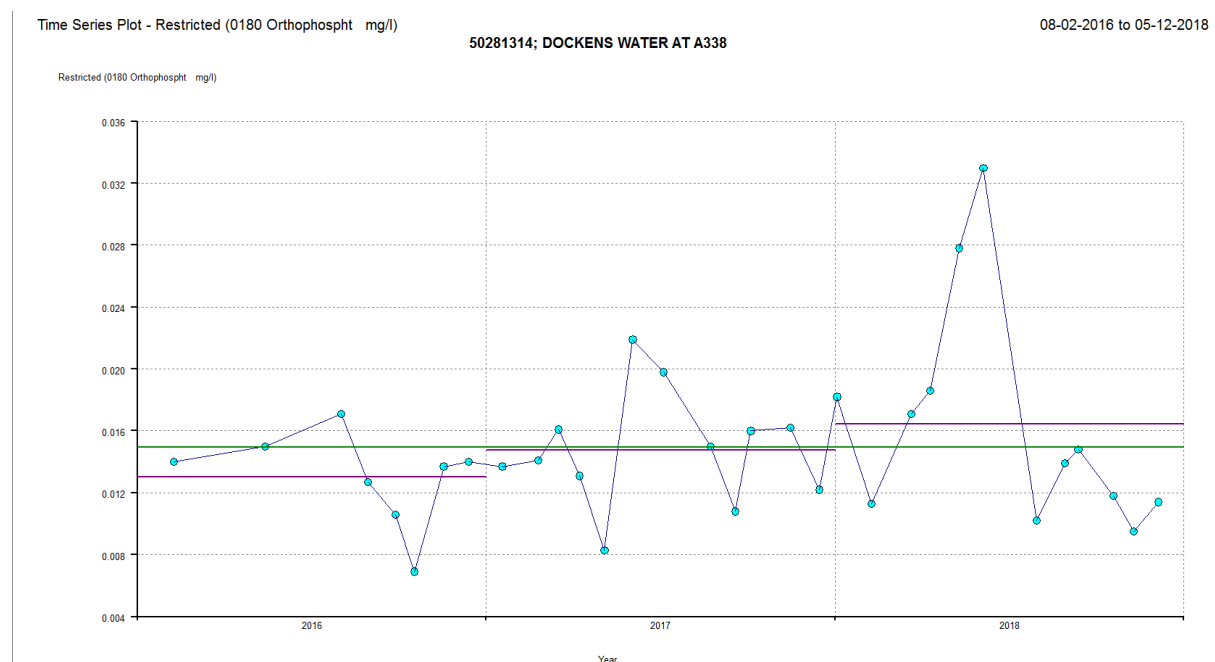


Figure 9 : Water quality data for Dockens water between 2016 and 2018.

2 Appendix 2 Farmscoper Modelling Prior Implementation Predictions

The objective of this report is to provide information on the diffuse pollution in the Hampshire Avon that results from agriculture. The work will also estimate the reduction that can be expected from bundles of different agricultural measures, aimed at reducing nutrient losses from a farming system.

2.1 Farmscoper Model v4 for the Hampshire Avon.

The FARMSCOPER tool (Goody et al., 2014), contains a library of over 100 mitigation methods, based around those in the Mitigation Method User Guide (Newell-Price et al., 2011) and certain Entry Level Scheme options. For this Hampshire Avon build, the model was applied at catchment scale.

The catchment-scale version of Farmscoper requires knowledge of the agricultural and land practices in the catchment and applies a number of assumptions to this data. The assumptions are based upon national survey data, such as the British Survey of Fertiliser Practice (BSFP) and Defra Farm Practice Surveys and are therefore representative of the average management across a catchment rather than the management on any one particular farm. For more detailed description of the FARMSCOPER model please see (REF) and on the EA catchment setup please see (Stuart Axe)

2.1.1 Previous Work EA Work –

The NMP for the River Avon SAC was produced in 2015 to help to reduce and manage phosphorus levels in the River, in accordance with international obligations, principally in the EU Habitats, Wild Birds and Water Framework Directives. It was intended to help to facilitate development and change in the catchment and mitigate phosphorous load in the river (Ref). As part of this work the Farmscoper was used, this predicted that a 14% reduction in phosphate could be achieved through Basic measures, 28% from New Environment Management Scheme (NELMS) measures and 44% from all measures. The modelling presented as part of this review used the updates V4 of the Farmscoper model.

2.1.2 Publications

Parts of the River Avon were used as a Demonstration Test Catchment and as a result received a significant amount of attention during the development of the Farmscoper model. As a result, a number of publications are available that cover diffuse pollution in the catchment. A brief review of the relevant findings are summarised below.

To assess the potential uptake measures and reduction in diffuse pollution, Collins et al (2016) shortlisted 29 low cost or cost-neutral on-farm measures contained in the Farmscoper model. This shortlist was selected via a farmer attitudinal survey. These were then modelled on a national scale assuming a 95% uptake to estimate the technically feasible impact on annual agricultural emissions to water and air, relative to business as usual. Simulated median

emission reductions, relative to current practise, for water management catchments across England and Wales, were estimated to be in the order sediment (20%) ammonia (16%) total phosphorus (15%) nitrate (11%) methane (11%) and nitrous oxide (7%).

For the Hampshire Avon, the predicted 15% reduction in phosphorous from the current levels is likely to be less. This is due to long history of farmer engagement in the Hampshire Avon catchment, driven by various national schemes and local initiatives, including the Countryside Stewardship Scheme (CSS; [Natural England, 1991](#)) and the current options as represented by the Entry and Higher Level schemes (ELS/HLS; [Natural England, 2005](#)). In addition, the area has benefitted from being designated as a priority catchment under the CSF scheme and the corresponding eligibility for capital grants for on-farm mitigation measures. The NVZ designation has also driven farm inspections for compliance, e.g. with manure storage requirements and spreading closed periods as components of the Nitrates Directive Action Programme.

On more localised level a paper was published which describes the application of FARMSCOOPER specifically in the Hampshire Avon DTC and assess the potential benefits of relevant and practical mitigation options (Zhang et al 2012). Spatial datasets and the Agricultural Census return for 2009 specific to the River Avon catchment were integrated to produce a collection of representative farm types which capture the characteristics of the local physical environment, land use patterns and farm management practices. The scenarios investigated comprised baseline losses with no mitigation measures implemented, current emissions using information on the present implementation of options under existing schemes and initiatives and, the maximum potential reduction possible on the basis of implementing all available and relevant options.

Modelling the current situation is difficult, as there is no information on the relative uptake of individual mitigation methods in the Hampshire Avon. To account for this, the study adopted rates of various mitigation methods from a national-scale assessment ([Anthony et al., 2009](#)). This was used to estimate the current improvement from a catchment baseline. Model outputs suggested that reductions in pollutant loads in response to the existing uptake of mitigation methods are small (e.g. 10% for phosphorus, 7% for sediment, 4% for nitrate and 5% for nitrous oxide). This is partially a result of the afore mentioned farm engagement.

The optimisation feature within FARMSCOOPER was the used to assess cost-effective suites of mitigation methods that lie on the Pareto front and would be more appropriate than the implementation of all mitigation methods possible under the ‘maximum reductions scenario’. FARMSCOOPER suggested that technically feasible pollutant reductions on the basis of the implementation of more mitigation options could be of the order of 47% for phosphorus, 66% for sediment, 22% for nitrate and 16% for nitrous oxide. More detailed information on the level of reduction and the number of mitigation methods are given in Table** below.

Table 8 – Effect of the minimum cost solutions that achieve minimum target pollutant reductions, for the mixed farm.

Target reduction (%)	Cost (£)	Reduction achieved (%)						Number of methods
		NO ₃ -N	P	SS	NH ₃	CH ₄	N ₂ O	
5	-15,712	8	7	13	6	3	14	9
10	-14,667	10	20	13	12	3	16	15
15	-13,054	16	24	20	16	3	15	18
20	-7407	20	31	26	21	4	16	29
25	-253	21	54	31	28	4	16	37
30	-85	21	44	39	33	4	17	38
35	1183	21	58	56	35	4	17	38
40	9388	21	47	51	36	4	17	43
45	10,034	21	51	58	36	4	17	44
50	10,433	21	62	61	36	4	17	46
55	10,708	21	59	57	36	4	17	42
60	12,509	21	60	61	36	4	17	46

The nine methods selected to achieve the minimum target % reduction (Table 8) are as follows:

1. do not apply P fertilisers to high P index soils
2. use clover in place of grass.
3. integrate fertiliser and manure nutrient supply.
4. use a fertiliser recommendation system.
5. use plants with improved nitrogen use efficiency.
6. make use of improved genetic resources in livestock.
7. improved feed characterisation.
8. replace urea fertiliser with another form (e.g. ammonium nitrate).
9. cultivate compacted tillage soils.

The first six of these mitigation options are predicted to make a net financial saving for the farm due to reduced inputs.

2.1.3 EA FARMSCOPER modelling 2019.

The latest version of Farmscoper (v4) includes catchment input data at a range of spatial scales, from River Basin Districts down to Water Framework Directive waterbodies, as well as the data for N2K catchments including the River Avon. These input data were derived from the 2015 Defra June Agricultural Survey (JAS), with the locations of farms found by joining the JAS data to farm boundary data. Farmscoper also requires the number of each farm type, found on the different climate zones and soil types, weather they are located within a NVZs. The model simplifies the data by separating the farms into 4 robust farm types based on the JAS data and the typical distribution of cropping and livestock between farm types.

The outputs for the Avon are shown in Table*** along with the climate and soil type. Livestock are allocated to farm types as shown in Table*** and land use data in Table***. Farmscoper calculates the effects of diffuse pollution control measures on this simplified population of composite farms.

2.1.3.1 Farmscoper data and assumption – Hampshire Avon catchment

		No of Farms	Total Area Km
Farm type	Arable	309	605
	Extensive	351	380
	Housed	31	61
	Intensive	121	261
Soil Type	Drained Ar	47	72
	Drained ArGR	130	200
	Free Drain	635	1035
Climate	700 - 900	551	890
	900 - 1200	261	417

Livestock Data	Number
Dairy Cows and Heifers	11709
Dairy Heifers in Calf (2 years +)	1841
Dairy Heifers in Calf (< 2 years)	3437
Bulls (2 years +)	382
Beef Cows and Heifers	8634
Beef Heifers in Calf (2 years +)	1776
Beef Heifers in Calf (< 2 years)	4268
Other Cattle (2 years +)	1529
Other Cattle (1 - 2 years)	5556
Other Cattle (< 1 year) & Calves	16917
Sheep	45229
Lambs (< 1 year)	42261
Sows in Pig & Other Sows	5925
Gilts in Pig & Barren Sows	1222
Gilts Not Yet in Pig	339

Boars	230
Other Pigs (> 110kg)	459
Other Pigs (80 - 110kg)	6544
Other Pigs (50 - 80kg)	10551
Other Pigs (20 - 50kg)	12936
Other Pigs (< 20kg)	12540
Layers (Caged)	119421
Layers (Uncaged)	50865
Pullet	50865
Broilers	240384
Turkeys	4755
Breeding Birds	40808
Other Poultry	49628

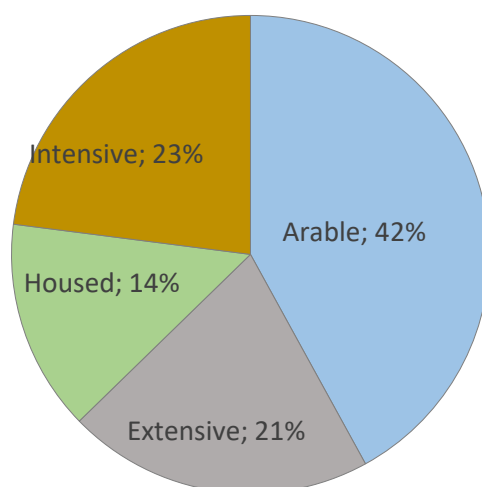
Land use Data	Km
Permanent Pasture	404
Rotational Grassland	88
Rough Grazing	129
Winter Wheat	218
Winter Barley	52
Spring Barley	148
Winter OSR	111
Maize	27
Potatoes	0.5
Sugar Beet	0.1
Peas	8.4
Beans	8.7
Fodder Crops	10
Other Crops	1.5
Vegetables (Brassica)	5.3
Vegetables (Other)	1.9
Orchards	0.1
Soft Fruit	0.1
Bare Fallow	26
Land for Outdoor Pigs	4.6
Set Aside	0.0
Woodland	55

From this information FARSCOPER predicts the baseline losses from the farms within the catchment. Note that the actual losses from farm will be lower, as these figures assume that there are no mitigating measures being practiced. A more realistic prediction is given by the “Prior” implementation output given later in the document.

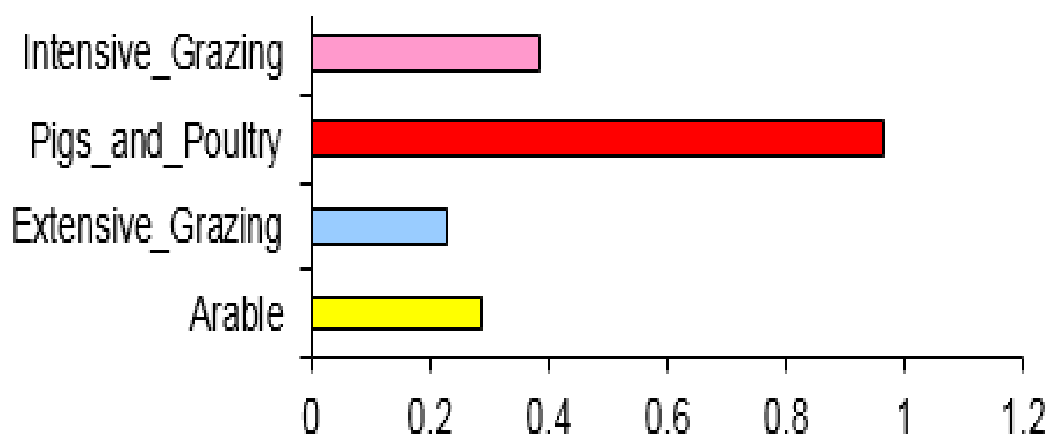
Table 4. FARMSCOPER baseline loss of phosphorus from farms within the River Avon catchment.

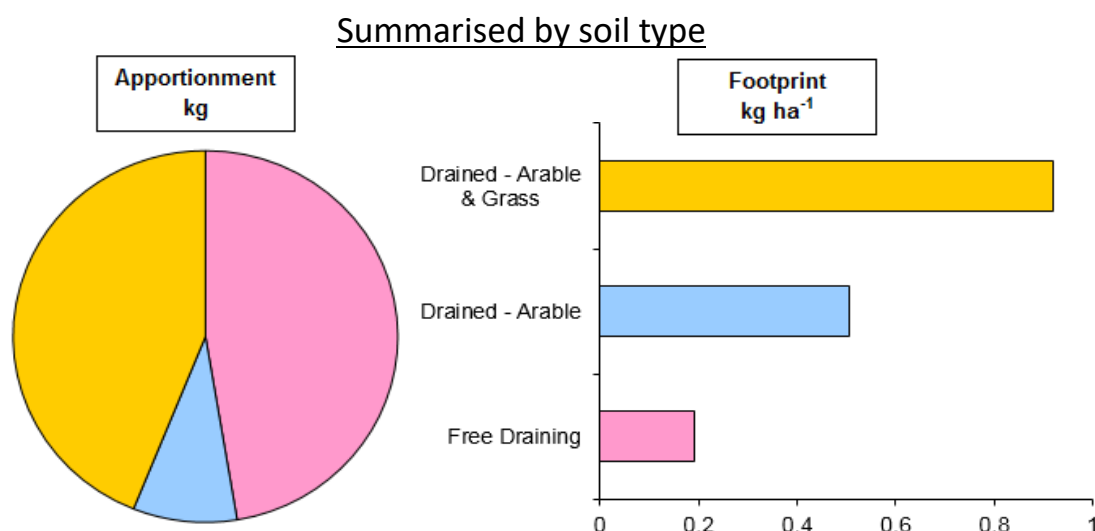
	Nitrate (kg)	Phosphorus (kg)	Sediment (kg)	Ammonia (kg)	Methane (kg)	Nitrous Oxide (kg)	Pesticides (Units)	FIOs (10 ⁹ cfu)
Baseline	3,611,095	41,929	21,130,705	1,768,139	4,158,474	872,769	7,398	3,713,063

Farmscoper (Prior) Total P for whole catchment



Footprint
kg ha⁻¹





2.2 Reduction Scenarios

The approach used to estimate the potential reduction in diffuse pollution was similar to that used in the neighbouring Poole Harbour, where 4 “bundles” of measures are modelled. Here each scenario is built onto the previous, where the nature of the measures becomes more onerous. This approach will allow more time for landowners to react to those measures that require capital investment and changes to the business. The measures listed in this report are a subset of a far larger list of measures (**ref**) and landowners should not restrict themselves to these measures alone. The measures can be implementing in a practical way and are not at always restrictive as the given description suggests, please refer to the detailed descriptions for more information. For the purpose of this modelling a compliance rate of 80% was used.

These are outlined below:

- Scenario HA 1 - reflecting methods in the ‘Farming Rules for Water’ implemented in 2018.
- Scenario HA 2 - focuses on “field and crop measures” relatively low-cost additional measures that can be implemented without significant capital investment.
- Scenario HA 3 - is a combination of relatively small scale land use change and allowing field drains to deteriorate.
- Scenario HA 4 - introduces reduction in nutrient input at source and investment in capital items, infrastructure or equipment.

Scenario 1

- Cultivate land for crops in spring rather than autumn.
- Use a fertiliser recommendation system.
- Avoid spreading manufactured fertiliser to fields at high-risk times.
- Do not apply P fertilisers to high P index soils.
- Move feeders at regular intervals.

- Manure Spreader Calibration.
- Do not apply manure to high-risk areas.
- Do not spread slurry or poultry manure at high-risk times.
- Do not spread FYM to fields at high-risk times.
- Fence off rivers and streams from livestock.

Scenario 2

- Establish cover crops in the autumn.
- Early harvesting and establishment of crops in the autumn.
- Cultivate compacted tillage soils.
- Manage over-winter tramlines.
- Loosen compacted soil layers in grassland fields.
- Re-site gateways away from high-risk areas.
- Farm track management.
- Uncropped cultivated margins.
- Unfertilised cereal headlands.
- Undersown spring cereals.

Scenario 3

- Establish in-field grass buffer strips.
- Establish riparian buffer strips.
- Allow grassland field drainage systems to deteriorate.
- Establish and maintain artificial wetlands - stading runoff.
- Management of arable field corners.
- Plant areas of farm with wild bird seed / nectar flower mixtures.
- Beetle banks.
- Management of grassland field corners.

Scenario 4

- Adopt reduced cultivation systems.
- Make use of improved genetic resources in livestock.
- Use manufactured fertiliser placement technologies.
- Reduce dietary N and P intakes: Dairy.
- 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.
- Use slurry injection application techniques.
- Use dry-cleaning techniques to remove solid waste from yards prior to cleaning.

Table 9: List of key agricultural measures key to reducing phosphorus in the Hampshire Avon River based on farm type and % percentage yielded from each phase (bottom row) – source Farmscoper. Note this approach is designed to be introduced gradually.

	Measure uptake from Paula	Full Legislation	Paula Baseline S1	Paula Baseline S2	Paula Baseline S3	Paula Baseline S4
Establish cover crops in the autumn	2	80	2	80	80	80
Early harvesting and establishment of crops in the autumn	50	80	50	80	80	80
Cultivate land for crops in spring rather than autumn	80	80	80	80	80	80
Adopt reduced cultivation systems	20	80	20	20	20	80
Cultivate compacted tillage soils	10	80	10	80	80	80
Cultivate and drill across the slope	25	80	25	25	25	25
Leave autumn seedbeds rough	10	80	10	10	10	10
Manage over-winter tramlines	10	80	10	80	80	80
Establish in-field grass buffer strips	2	2	2	2	80	80
Establish riparian buffer strips	10	10	10	10	80	80
Loosen compacted soil layers in grassland fields	10	80	10	80	80	80
Allow grassland field drainage systems to deteriorate	0	0	0	0	80	80
Make use of improved genetic resources in livestock	10	10	10	10	10	80
Use a fertiliser recommendation system	50	80	80	80	80	80
Integrate fertiliser and manure nutrient supply	80	80	80	80	80	80
Do not apply manufactured fertiliser to high-risk areas	80	80	80	80	80	80
Avoid spreading manufactured fertiliser to fields at high-risk times	2	80	80	80	80	80
Use manufactured fertiliser placement technologies	10	80	10	10	10	80
Do not apply P fertilisers to high P index soils	0	80	80	80	80	80
Reduce field stocking rates when soils are wet	50	80	50	50	50	50
Move feeders at regular intervals	50	80	80	80	80	80
Increase the capacity of farm slurry stores to improve timing of slurry applications	2	80	2	2	2	80
Site solid manure heaps away from watercourses/field drains	80	80	80	80	80	80
Store solid manure heaps on an impermeable base and collect effluent	10	10	10	10	10	80
Use liquid/solid manure separation techniques	10	2	10	10	10	80
Manure Spreader Calibration	25	80	80	80	80	80
Do not apply manure to high-risk areas	50	80	80	80	80	80
Do not spread slurry or poultry manure at high-risk times	20	80	80	80	80	80
Use slurry injection application techniques	2	2	2	2	2	80
Do not spread FYM to fields at high-risk times	2	80	80	80	80	80
Fence off rivers and streams from livestock	50	80	80	80	80	80
Construct bridges for livestock crossing rivers/streams	80	80	80	80	80	80
Re-site gateways away from high-risk areas	0	80	0	80	80	80
Farm track management	50	50	50	80	80	80
Establish and maintain artificial wetlands - steading runoff	2	0	2	2	80	80
Management of arable field corners	10	10	10	10	80	80

Plant areas of farm with wild bird seed / nectar flower mixtures	10	10	10	10	80	80
Beetle banks	2	2	2	2	80	80
Uncropped cultivated margins	2	2	2	80	80	80
Unfertilised cereal headlands	2	2	2	80	80	80
Undersown spring cereals	2	2	2	80	80	80
Management of grassland field corners	2	2	2	2	80	80
Leave over winter stubbles	80	80	80	80	80	80
Use correctly inflated low ground pressure tyres on machinery	25	80	25	25	25	25
Locate out-wintered stock away from watercourses	10	80	10	10	10	10
Use dry-cleaning techniques to remove solid waste from yards prior to cleaning	0	0	0	0	0	80
Capture of dirty water in a dirty water store	80	80	80	80	80	80
Monitor and amend soil pH status for grassland	0	80	0	0	0	0

Scenario Results (Cumulative)

	Capital Cost (£)	Operational Cost (£)	Total Cost (£)	Environ. Benefit (£)
Prior Implement	1,190,000	478,600	1,668,000	3,047,000
Full Legislation	2,415,289	4,963,826	5,300,001	2,415,289
S1	2,046,000	1,204,000	3,250,000	3,814,000
S2	2,074,000	4,797,000	6,870,000	5,162,000
S3	2,578,000	8,004,000	10,580,000	6,702,000
S4	3,652,000	7,650,000	11,300,000	7,351,000

	Nitrate (kg)	Phosphorus (kg)	Sediment (kg)	Ammonia (kg)	Methane (kg)	Nitrous Oxide (kg)	Pesticides (Units)	FIOs (10 ⁹ cfu)	Soil Carbon (t)
Prior Implement	3,308,000	37,820	19,190,000	1,638,000	4,082,000	817,100	5,718	3,042,000	16,830,000
Full Legislation	3,213,547	32,344	16,808,492	1,629,276	4,089,620	787,622	5,514	2,445,858	16,827,577
S1	3,272,000	34,910	18,940,000	1,620,000	4,079,000	802,500	5,684	2,526,000	16,830,000
S2	3,224,000	32,590	16,960,000	1,603,000	4,079,000	786,500	5,495	2,517,000	16,830,000
S3	3,168,000	29,670	14,350,000	1,588,000	4,079,000	778,200	5,252	2,485,000	16,540,000
S4	3,135,000	28,950	14,310,000	1,534,000	4,003,000	774,100	5,283	2,363,000	16,540,000

	Energy Use (kg)	Production (£)	Biodiversity (Score)	Water Use (Score)	Soil Quality (Score)
Prior Implement	130,800,000	150,200,000	2,670	286	5,041
Full Legislation	124,099,097	148,822,248	3,088	367	12,821
S1	127,900,000	148,800,000	3,048	367	4,853
S2	126,700,000	146,800,000	7,114	367	9,690
S3	124,400,000	144,200,000	17,400	367	11,720
S4	120,600,000	144,900,000	17,420	367	11,920

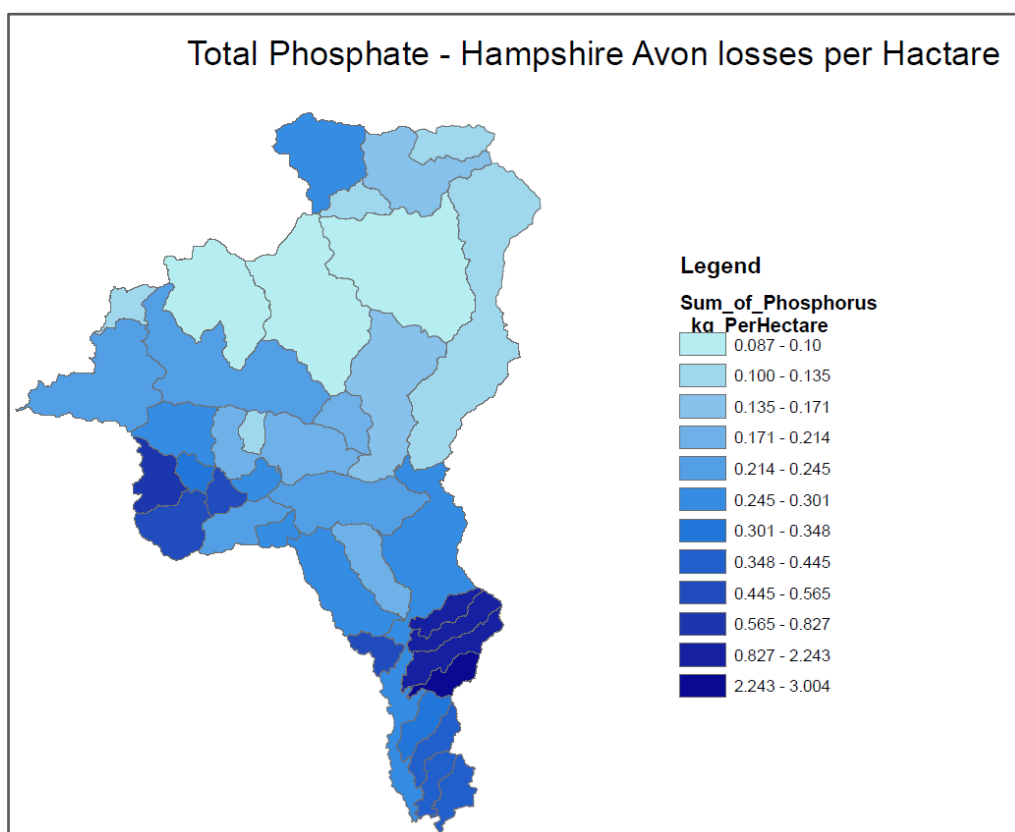
Reductions in phosphate from the baseline as predicted by Farmscopper. (Cumulative)

	Phosphorus (kg)	Phosphate (%) reduction from baseline
Prior Implement	37,820	
Full Legislation	32,344	14.5
S1	34,910	7.7
S2	32,590	13.8
S3	29,670	21.5
S4	28,950	23.5

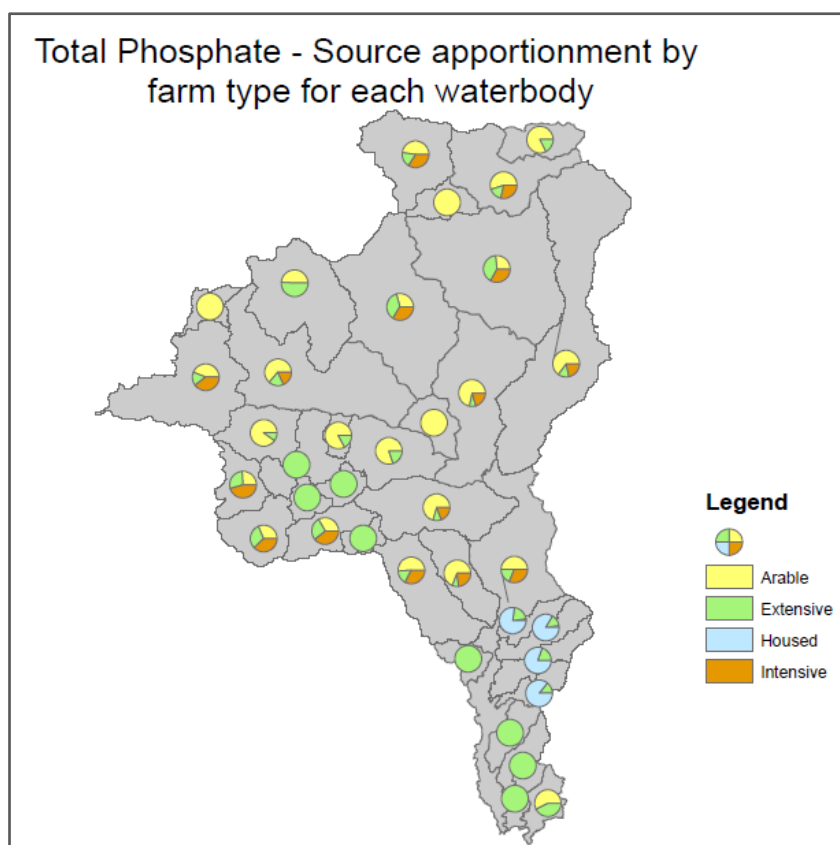
The predicted reductions from the Farmscopper model was then used to inform the scenarios for a SAGIS. The predicted reductions of 7.7%, 13.8% and 24% were used.

P Saving	Cost increase vs prior	Cost £ per KG P	Environmental Benefit per	Ratio of Cost vs environmental benefit £
5,476	3,632,001	663	2,415,289	0.67
2,910	1,582,000	544	3,814,000	2.41
5,230	5,202,000	995	5,162,000	0.99
8,150	8,912,000	1,093	6,702,000	0.75
8,870	9,632,000	1,086	7,351,000	0.76

In addition to the catchment scale run, a waterbody scale model run was completed which separates the catchment into WFD boundaries. This was used to show the contribution from each waterbody, in addition the contribution was calculated on a per km basis, this gives an indication of the most polluting waterbodies.



*Note that the new forest streams data is skewed as a result of an impact from housed units. See **Figure** below. The lowest impact is at the top of the catchment in the waterbodies of the Upper Avon, Till and Wylde, potentially a result of the low input land around the MOD facilities at the Salisbury plain. (See Copyright Statement 1)



For data protection reasons the agricultural census data was amalgamated across three waterbodies with similar typology. As a result, the data should be interpreted with caution. The dominant agriculture type in each of the waterbodies can be used in combination with risk mapping to target advice and planning. (See Copyright Statement 1)

2.3 Farmscoper v4 by CSMG Reach

In this section we have used the Farmscoper model to estimate the contribution from agriculture in each of the CSMG reaches

2.3.1 Upper Avon

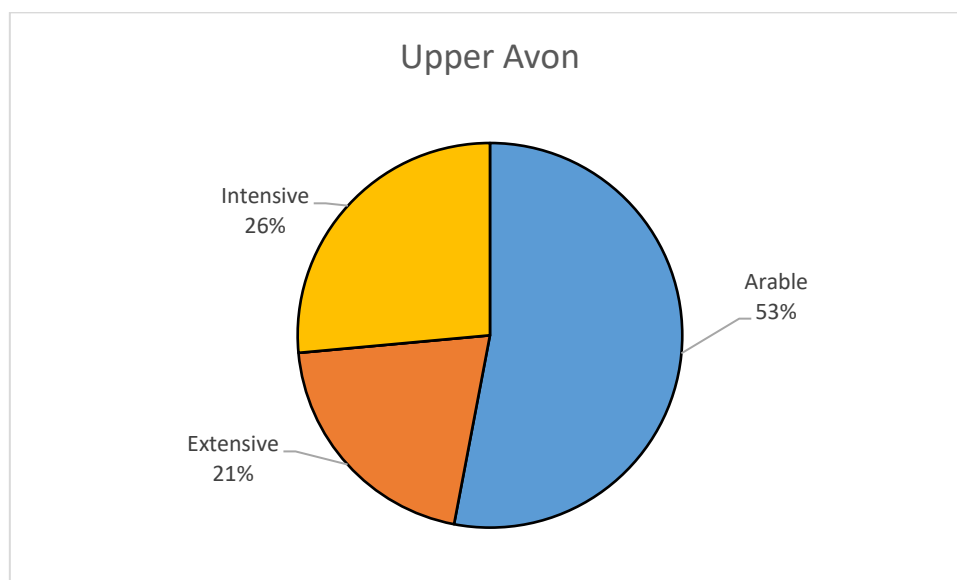


Figure 10 : Pie chart of the source apportionment of phosphorous from agriculture, modelled by Farmscoper for each of the DEFRA robust farm types in the Upper Avon CSMG catchment.

Table 10 : Shows the amount of phosphorous lost, predicted by the Farmscoper model for each of the DEFRA robust farm types and the area of land used by the model in the Upper Avon CSMG catchment.

	Arable (kg per annum)	Extensive (kg per annum)	Housed (kg per annum)	Intensive (kg per annum)
kg of P per annum	3745.8	1453	0	1869.871
Area (Ha)	23659.4	16288.2	0	11758.2

*For data protection reasons Farmscoper model uses average data for a number of farms, this may cross waterbody boundaries and potentially introduced inaccuracies when using the data on a small scale

2.3.2 Lower Avon

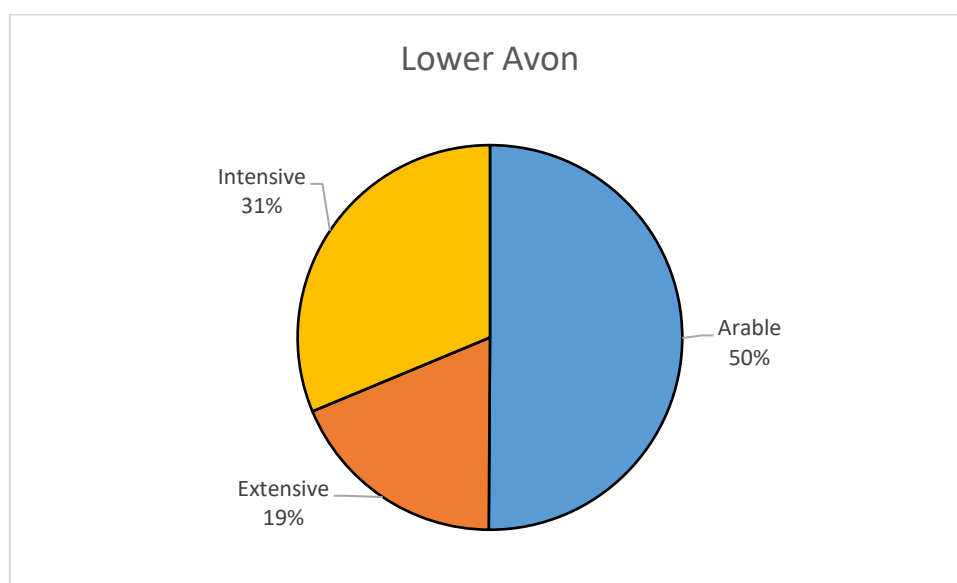


Figure 11 : Pie chart of the source apportionment of phosphorous from agriculture, modelled by Farmscoper for each of the DEFRA robust farm types in the Lower Avon CSMG catchment.

Table 11 : Shows the amount of phosphorous lost, predicted by the Farmscoper model for each of the DEFRA robust farm types and the area of land used by the model in the Lower Avon CSMG catchment.

	Arable	Extensive	Housed	Intensive
kg of P per annum	2112.8	785.4	<Null>	1318.8
Area (Ha)	6602.8	4296.6	<Null>	3107.2

*For data protection reasons Farmscoper model uses average data for a number of farms, this may cross waterbody boundaries and potentially introduced inaccuracies when using the data on a small scale

2.3.3 Wylfe Upper

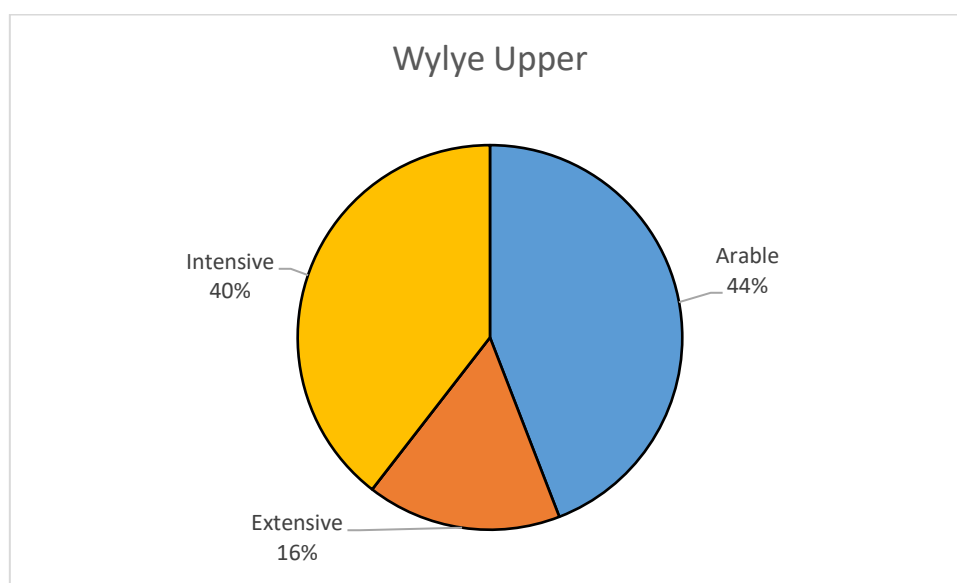


Figure 12 : Pie chart of the source apportionment of phosphorous from agriculture, modelled by Farmscoper for each of the DEFRA robust farm types in the Upper Wylfe CSMG catchment.

Table 12 : Shows the amount of phosphorous lost, predicted by the Farmscoper model for each of the DEFRA robust farm types and the area of land used by the model in the Upper Wylfe CSMG catchment.

	Arable (kg per annum)	Extensive (kg per annum)	Housed (kg per annum)	Intensive (kg per annum)
kg of P per annum	1742.5	646.5	<Null>	1559.8
Area (Ha)	7484.4	3301.2	<Null>	5306.4

*For data protection reasons Farmscoper model uses average data for a number of farms, this may cross waterbody boundaries and potentially introduced inaccuracies when using the data on a small scale

2.3.4 Wylfe Lower

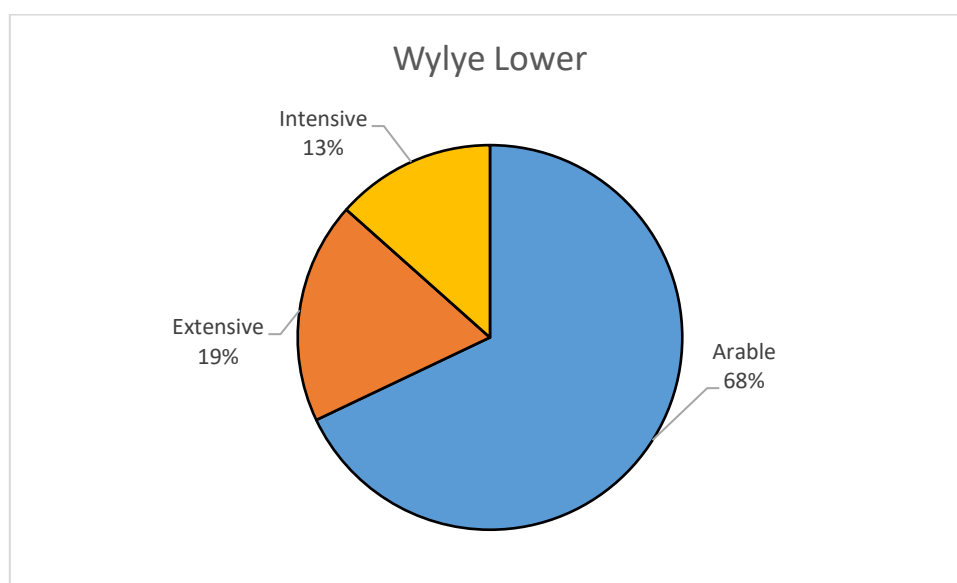


Figure 13 : Pie chart of the source apportionment of phosphorous from agriculture, modelled by Farmscoper for each of the DEFRA robust farm types in the Lower Wylfe CSMG catchment.

Table 13 : Shows the amount of phosphorous lost, predicted by the Farmscoper model for each of the DEFRA robust farm types and the area of land used by the model in the Lower Wylfe CSMG catchment.

	Arable (kg per annum)	Extensive (kg per annum)	Housed (kg per annum)	Intensive (kg per annum)
kg of P per annum	4243.9	1164.2	0	838.4275
Area (Ha)	20657.4	8012.7	0	2900.4

*For data protection reasons Farmscoper model uses average data for a number of farms, this may cross waterbody boundaries and potentially introduced inaccuracies when using the data on a small scale

2.3.5 Nadder and Sem

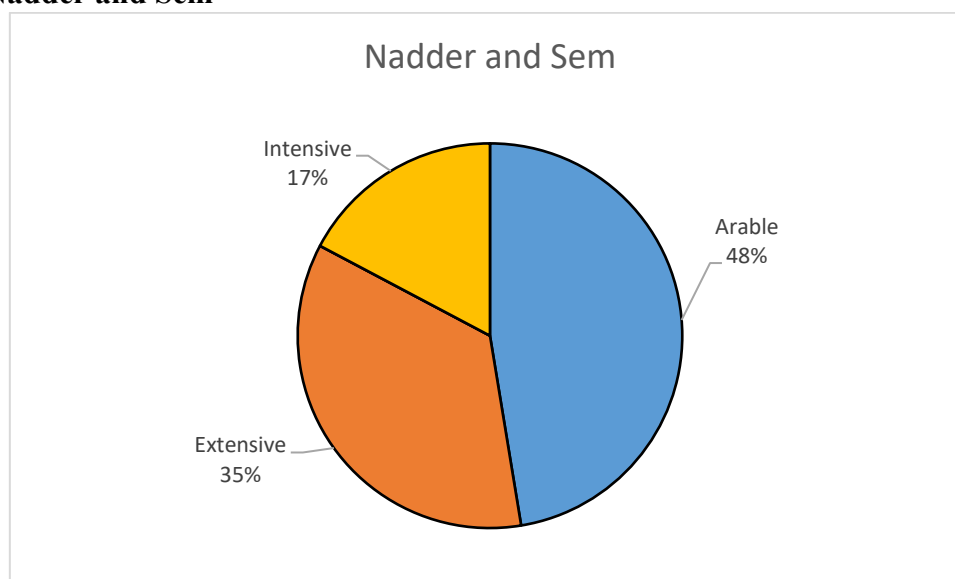


Figure 14 : Pie chart of the source apportionment of phosphorous from agriculture, modelled by Farmscoper for each of the DEFRA robust farm types in the Nadder and Sem CSMG catchment.

Table 14 : Shows the amount of phosphorous lost, predicted by the Farmscoper model for each of the DEFRA robust farm types and the area of land used by the model in the Nadder and Sem CSMG catchment

	Arable (kg per annum)	Extensive (kg per annum)	Housed (kg per annum)	Intensive (kg per annum)
kg of P per annum	3535.3	2635.5	0	1286.92
Area (Ha)	13350.2	8713.4	0	1353.6

*For data protection reasons Farmscoper model uses average data for a number of farms, this may cross waterbody boundaries and potentially introduced inaccuracies when using the data on a small scale

2.3.6 The Bourne

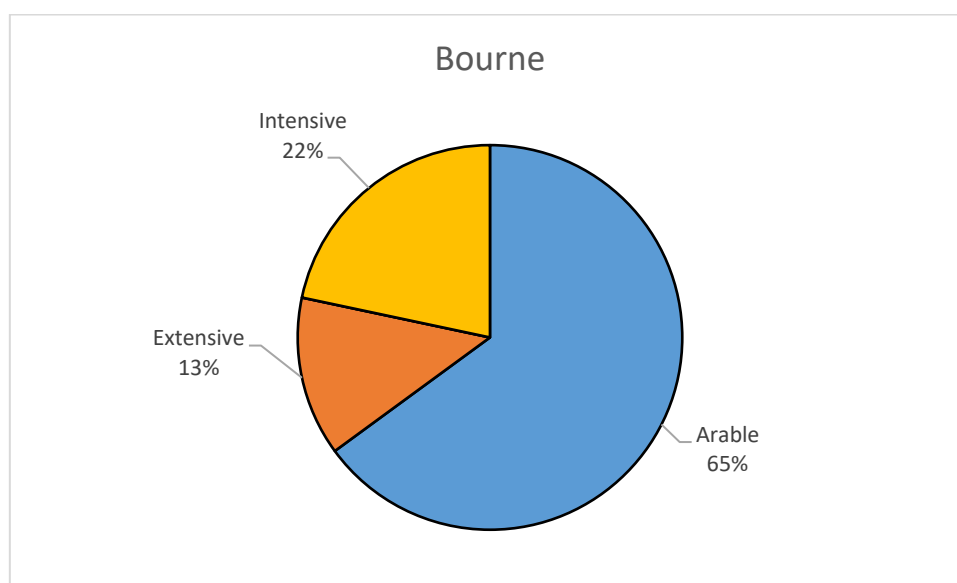


Figure 15 : Pie chart of the source apportionment of phosphorous from agriculture, modelled by Farmscopper for each of the DEFRA robust farm types in the Bourne CSMG catchment.

Table 15 : Shows the amount of phosphorous lost, predicted by the Farmscopper model for each of the DEFRA robust farm types and the area of land used by the model in the Bourne CSMG catchment.

	Arable	Extensive (kg per annum)	Housed (kg per annum)	Intensive (kg per annum)
kg of P per annum	2057	424	<Null>	686
Area (Ha)	18223.4	3765	<Null>	4552

*For data protection reasons Farmscopper model uses average data for a number of farms, this may cross waterbody boundaries and potentially introduced inaccuracies when using the data on a small scale

2.3.7 The Till

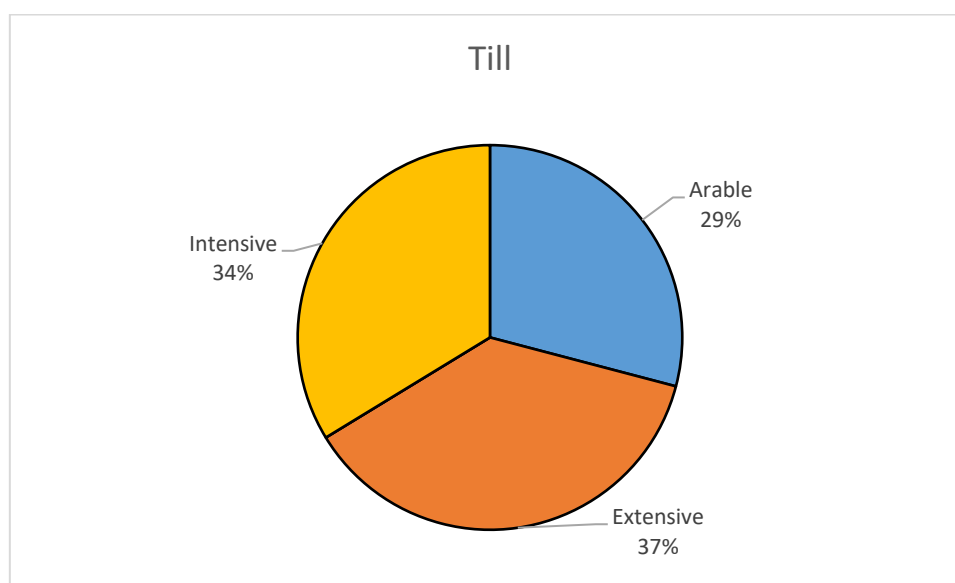


Figure 16 : Pie chart of the source apportionment of phosphorous from agriculture, modelled by Farmscoper for each of the DEFRA robust farm types in the Till CSMG catchment.

Table 16 : Shows the amount of phosphorous lost, predicted by the Farmscoper model for each of the DEFRA robust farm types and the area of land used by the model in the Till CSMG catchment.

	Arable (kg per annum)	Extensive (kg per annum)	Housed (kg per annum)	Intensive (kg per annum)
kg of P per annum	659.5	843.0	<Null>	764.2768
Area (Ha)	6305.4	10566	<Null>	5701

*For data protection reasons Farmscoper model uses average data for a number of farms, this may cross waterbody boundaries and potentially introduced inaccuracies when using the data on a small scale

2.3.8 Dockens Water

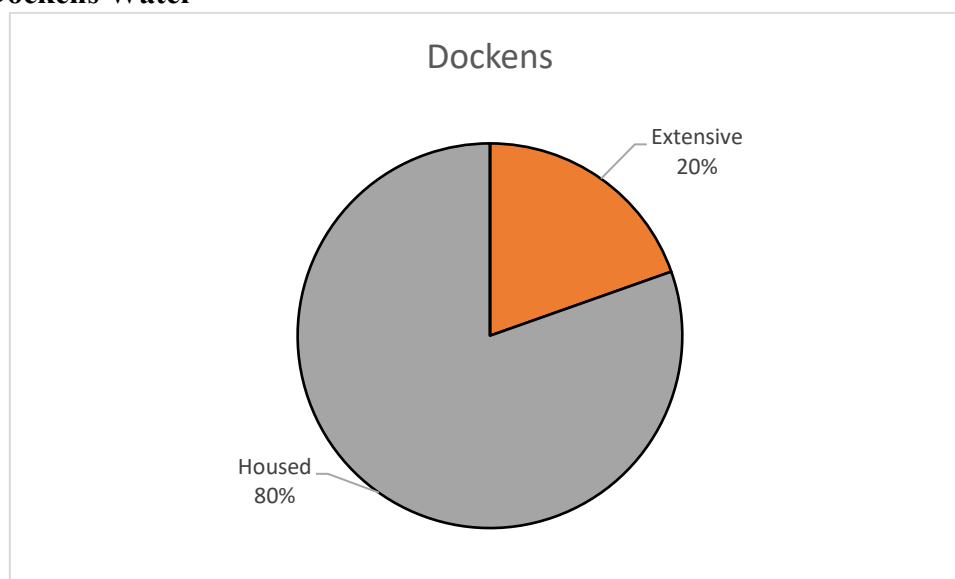


Figure 17 : Pie chart of the source apportionment of phosphorous from agriculture, modelled by Farmscoper for each of the DEFRA robust farm types in the Dockens water CSMG catchment.

Table 17 : Shows the amount of phosphorous lost, predicted by the Farmscoper model for each of the DEFRA robust farm types and the area of land used by the model in the Dockens Water CSMG catchment

	Arable (kg per annum)	Extensive (kg per annum)	Housed (kg per annum)	Intensive (kg per annum)
kg of P per annum	<Null>	356.7	1463.7	<Null>
Area (Ha)	<Null>	578.6	382	<Null>

*For data protection reasons Farmscoper model uses average data for a number of farms, this may cross waterbody boundaries

3 Appendix 3 SAGIS SIMCAT Scenario Modelling Results

3.1 Pont Source inputs

The tables below show the WwTW input loads used in the SAGIS-SIMCAT model for the monitored and permitted flows. The calculations for the WwTW with descriptive permits are also given.

CSO spill data is included in the model but not presented here. All flows through a WwTW should be captured in the SAGIS-SIMCAT model however increased concentrations of CSO effluent are not factored into the model.

Table showing the parameters used in the SAGIS model to estimate the contributions from permitted WWTW.

WWTW	Baseline model mean flow (2010-2012) ML/d	Baseline model quality (2010-2012) mg/L	Tonnes Per Annum	Permit mean flow ML/d*	Permit TP conc. mg/L	Tonnes per Annum
Salisbury WWTW	22.11	0.53	4.28	33.87	1.0	12.36
Warminster WWTW	4.46	0.26	0.42	8.60	1.0 (0.5 in 2021)	3.14
All Cannings WWTW	0.42	5.00	0.77	0.35	1.0	0.13
Hurdcott WWTW	2.60	0.29	0.28	2.40	1.0	0.88
Collingbourne Ducis WWTW	0.39	5.00	0.71	0.48	5.0	0.88
Pewsey WWTW	1.94	0.39	0.28	2.11	1.0	0.77
Downton WWTW	1.84	0.25	0.17	1.66	1.0	0.61
East Knoyle WWTW	0.17	5.00	0.31	0.35	1.0	0.13
Amesbury WWTW	1.37	0.31	0.16	2.05	1.0	0.75
Shrewton WWTW	1.28	0.23	0.11	2.59	1.0	0.94
Ratfyn WWTW	3.04	0.19	0.21	5.48	1.0	2.00
Great Wishford WWTW	1.13	0.19	0.08	0.92	1.0	0.34
Fovant WWTW	0.43	0.31	0.05	0.53	1.0	0.19
Marden WWTW	0.19	0.80	0.06	0.35	2.0	0.26
Upavon WWTW	0.47	0.35	0.06	0.59	1.0	0.22
Netheravon WWTW	0.46	0.19	0.03	2.13	1.0	0.78
Tisbury WWTW	1.07	0.22	0.09	1.32	1.0	0.48
Maiden Bradley WWTW Prior to soakaway	0.03	5.00	0.05	0.07	5.0	0.13
Barford St Martin WWTW	0.10	0.75	0.03	0.18	2.0	0.13
Fordingbridge WWTW	2.34	0.26	0.22	3.56	1.0	1.30
Ringwood WWTW	4.49	0.26	0.43	4.27	1.0	1.56
Warminster Garrison	0.25	4.10	0.37	0.25	4.1	0.37
Tidworth Garrison	2.55	5.00	4.65	2.20	5.0	4.02
Shipton Bellinger	0.24	5.00	0.44	0.63	5.0	1.14
Total			14.24			33.49

*(calc. Mean Flow =DWF*Ratio of measured flow (DWF/measured Q80 flow 2010-2012))

Parameters used in the SAGIS model to estimate the contributions from small WWTW with descriptive permits.

Descriptive permits	Baseline model mean flow MI/d (2010-2012)	Baseline model quality (2010-2012)	Tonnes Per Annum
Etchilhampton	0.04	5.00	0.07
Stanton St Bernard	0.05	5.00	0.09
Wedhampton	0.03	5.00	0.05
Semley	0.04	5.00	0.06
Hindon WWTW	0.09	5.00	0.16
Tilshead	0.01	5.00	0.03
Berwick St James	0.03	5.00	0.05
Maiden Bradley WWTW	0.03	5.00	0.05
Monkton Deverill	0.02	5.00	0.03
Crockerton	0.01	5.00	0.01
Bishopstone	0.04	5.00	0.07
Everleigh	0.04	5.00	0.07
Total			0.72

Fish and Cress Farms

The total 1.66 tonnes per annum

Table showing the parameters used in the SAGIS model to estimate the contributions from fish and cress farms.

Site Name	Sagis Flow Ml/d (all scenarios)	Baseline Model P conc. mg/l	Tonnes per Annum
MANNINGFORD TROUT FA	15.17	0.01	0.055
HAXTON STOCK PONDS	1.36	0.01	0.005
LUDWELL CRESS BEDS	2.08	0.01	0.008
MILLBROOK FISH FARM	7.58	0.01	0.028
DEVERILLS FISH FARM	11.38	0.01	0.042
HILL DEVERILL WATERC	1.99	0.01	0.007
HILL DEVERILL WATERC	2.86	0.01	0.010
HILL DEVERILL WATERC	6.54	0.01	0.024
BRITFORD TROUT FARM	34.17	0.01	0.125
CHALKE VALLEY TROUT	6.63	0.01	0.024
CHALKE VALLEY TROUT	9.08	0.01	0.033
BROADCHALKE WATERCRE	2.14	0.01	0.008
LONGFORD MILL FISH F	7.58	0.01	0.028
WATERWAYS HATCHERY	2.67	0.01	0.010



BARFORD FISH FARM	80.83	0.01	0.295
BARFORD FISH FARM	72.92	0.01	0.266
THE CRESS BEDS	1.29	0.01	0.005
DAMERHAM FISHERIES L	1.29	0.01	0.005
CRYSTAL SPRINGS TROU	3.75	0.01	0.014
ASHFORD WATER FISH F	7.03	0.01	0.026
ASHFORD WATER FISH F	7.03	0.01	0.026
BICKTON FISH FARM	94.58	0.01	0.345
BICKTON FISH FARM	75.83	0.01	0.277

3.2 SAGIS-SIMCAT Model for the Hampshire Avon

The following section aims to provide information on reduction scenarios modelled for the Hampshire Avon. The SAGIS-SIMCAT model can be used to represent phosphate concentrations through the watercourse and is the main tool used in water company planning. The model employs an annual average approach and was calibrated using monitoring data from 2010-2012. Point source inputs have been updated based on current flow, concentration and/or current permit. The WWTW and other point source inputs are then attributed to the river concentration and the remaining, unaccounted OP is then attributed to the diffuse sections and apportioned using a number of assumptions and catchment data.

The result of the model being calibrated using an annual average data means discharges during peak flow are not captured which can lead to a significant underestimation of the loads from diffuse sources when compared to a flow apportioned method. Conversely a flow apportionment method will overestimate the impact of diffuse sources on river receptors as the majority of phosphate, and indeed other contaminants will bypass receptors in the river during high flow event and be flushed through the system and into Christchurch harbour and beyond. Estimating this impact is difficult and will vary between catchments and flood events. It is clear that modelling catchments is very complex, it is therefore important to understand the assumptions and their impact of the data. Despite these complexities the SAGIS-SIMCAT model remains the most suitable model for catchment management.

Figure 18 shows the modelled output and the OP concentration across the Hampshire Avon Catchment. As a validation check Figure 20 provides a comparison between the modelled water quality across the catchment and recent monitoring data. For the purpose of this document and for data presentation, the phosphate loading, and concentration are commonly reported at the lower boundary of the CSMG reach as in Table 18 below.

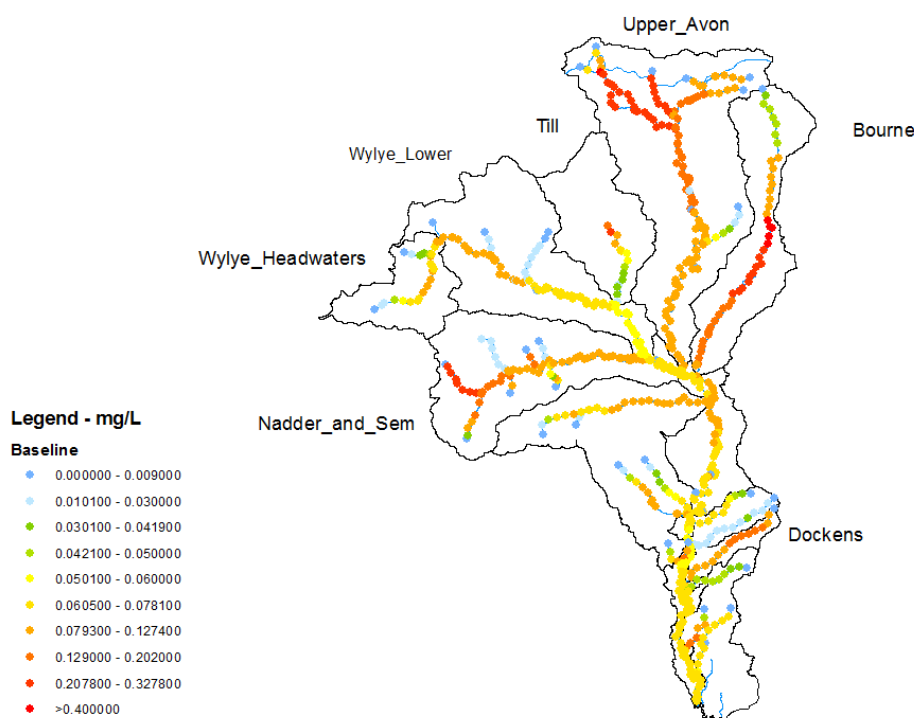


Figure 18 : Map showing the concentration of OP modelled by SAGIS-SIMCAT across the catchment. (See Copyright Statement 1)

Figure 18 above shows how the model is representing the elevated concentrations in the headwaters of the Nadder and Sem, Wylie and Upper Avon.

Table 18 : Table showing the water quality and phosphate loading at the lower boundaries of the CSMG reaches in the man rivers, calculated using the SAGIS-SIMCAT model.

Reach	Kg/annum	Mean SRP mg/L
Upper Avon	13127	0.091
Till	479	0.029
Wylie (Headwaters)	6401	0.087
Wylie Lower	14056	0.056
Lower Nadder	11455	0.064
The Bourne	6184	0.122
Dockens Water	939	0.112
Lower Avon	51445	0.063

The model is capable of calculating the concentration of SRP in the river from upstream and downstream of a discharge, this is based on Monte Carlo principals and assumes complete mixing of discharge and receiving water. The impact of the main discharges are given in Figure 19 below.

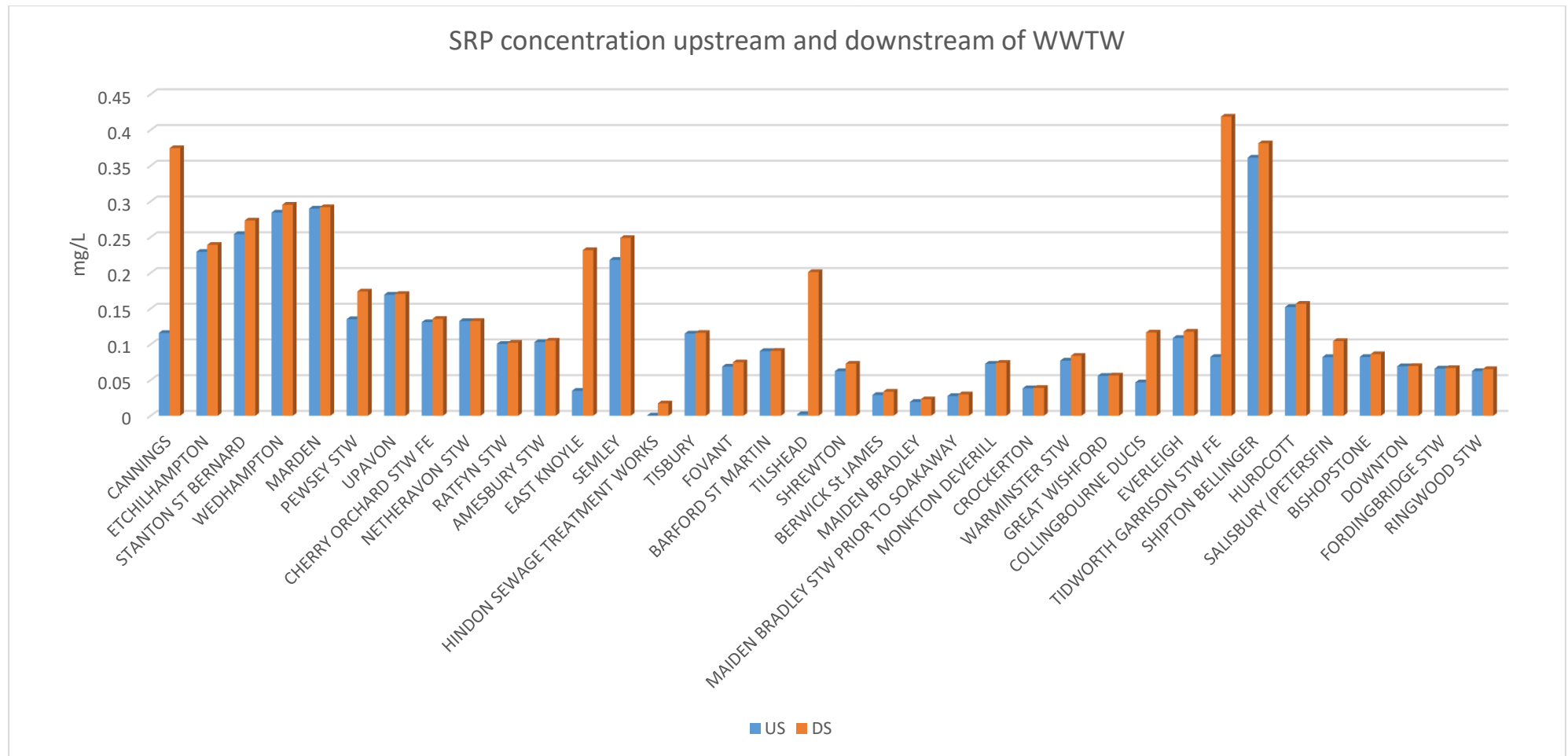


Figure 19 : Shows the SRP concertation in the main river, above and below the main WWTW after complete mixing of the discharge.

These data show how Cannings, Pewsey, East Knoyle, Semley, Hindon, Tilshead (discharge to ground), Collingbourne Ducis, Tidworth Garrison (Ground) Shipton Bellinger (ground) go to ground at all times or for long periods of the year. Salisbury WWTW have notable impacts on downstream concentrations.



In the following section the comparison between actual measured concentrations and modelled water quality are compared, this should provide some indication of the accuracy of the model across the catchment.

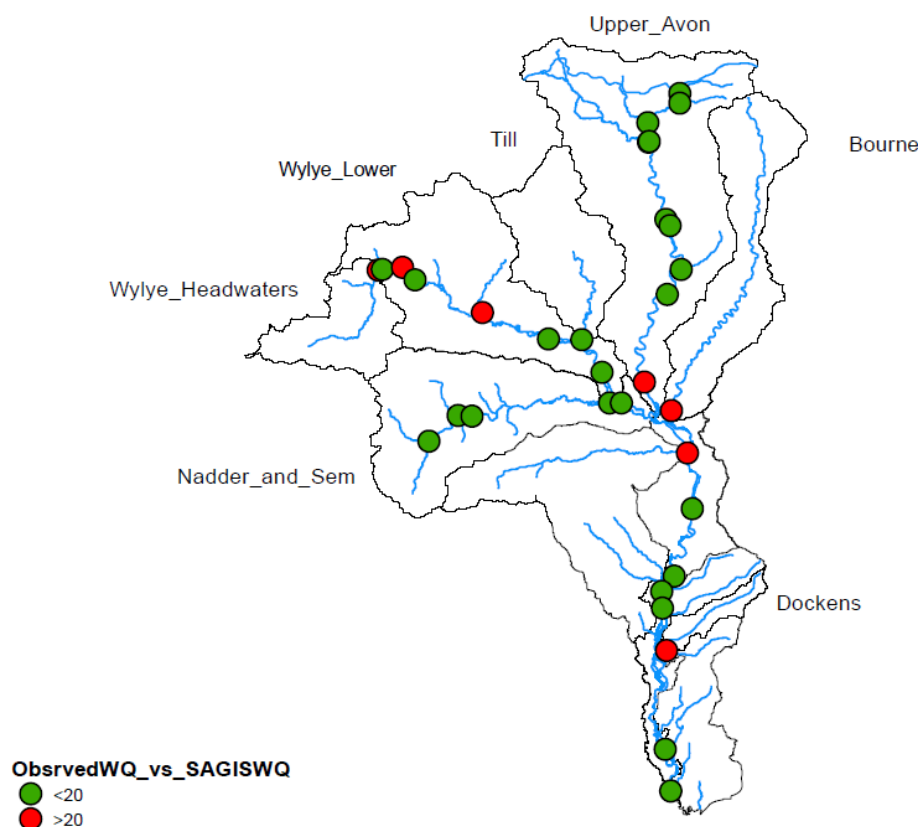


Figure 20 : Map shows the location of Water Quality Samples that coincide with SAGIS sample locations. The colour represents the deviation (%RSD) between the two data and indicate where we have greater confidence in the modelled data. (See Copyright Statement 1)

Validation of the model through a comparison of monitoring data and modelled output show a good agreement in across the main stem of the Lower Avon, the Upper Avon, Wylfe and the Nadder and Sem. A number of the small tributaries Bourne and Dockens water are outside a 20% deviation and shows a poor model fit. In these catchments SAGIS results are overestimates OP concentrations, further investigation showed that monitoring data from the calibration years (2010-2012) were significantly above long-term average concentrations as a result of high rainfall. This peak was not present in the larger river of the catchment and the calibration issue is not suspected here. Due to the poor fit of the model with current data results for these stretches should be treated with caution. Due to the winterbourne and/or low flows obtaining long term monitoring sites on the River Bourne, Till and Dockens Water are limited with a single calibration site near the confluence with the main rivers, as a result building a robust model is difficult. Modelled data on these reaches should therefore be treated with caution. A detailed description and the SAGIS profile of each of the reaches is given below.

3.2.1 Upper Avon

EA monitoring data is available for much of the Upper Avon. A close model fit is observed with recent monitoring data (Sample location 50210209). Water quality throughout the reach here exceeds the targets with an average concentration of 0.070mgL. Annual average concentrations in the river increase towards the headwaters with concentration in excess of 0.280mgL in the western arm and 0.150mgL in the eastern arm. Source Apportionment shows how the impact from WWTW on the main stem of the Avon is low with 11% at the bottom of the reach, SAGIS does indicate an increased influence in isolated areas such as in the river below Pewsey WWTW where 36% of the OP in the river is attributed to point sources. In the headwaters at Etchilhampton the impact from All Cannings STW is high with over 70% attributed to point sources. The SAGIS-SICAT profile shows how the high concentrations in the greensand influent headwater followed by a slow decline through the chalk geology.

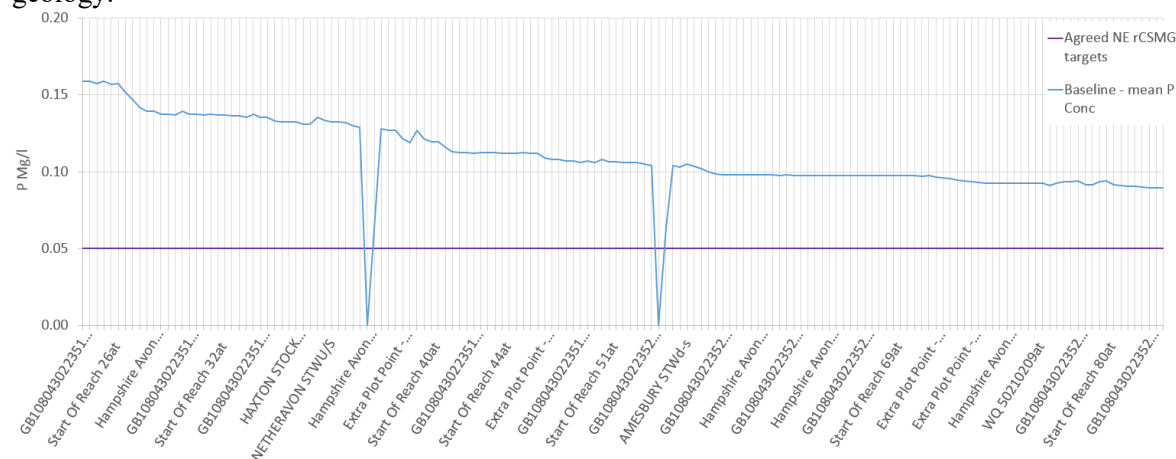


Figure 21 : Showing the SAGIS-SIMCAT modelled concentration through the Upper Avon

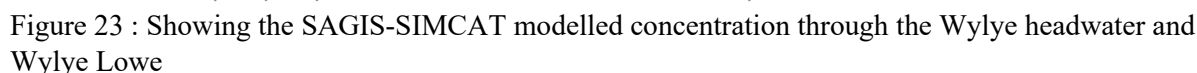
3.2.2 Lower Avon

Monitoring data in the catchment shows concentrations of OP in the upper reaches ~0.071mgL and remain consistent with a small decrease throughout the reach to 0.065mgL, the model suggest that the 0.05mgL CSMG targets is not being met anywhere in the reach. SAGIS modelled data in the main stem is in good agreement with the observed data. The model shows the steady decrease through the catchment with no notable concentration increases as result of point source inputs. Source apportionment shows that the lower Avon reach is significantly impact by WWTW with ~25% of the OP load at Downton, this shows a steady decrease with a 17% contribution in the lower catchment. Localised impacts from Petersfin WWTW are also high with downstream contributions modelled at 48%.



Monitoring data in the headwaters show that OP concentrations are ~0.105mg/L which is considerably above the 0.04mg/L CSMG targets. There is a small underestimation by the SAGIS model (0.085mg/L). The model suggests there is no notable impact in concentration from Maiden Bradley, Cockerton WWTW or Warminster WWTW. WWTW contribution at the bottom of the reach are low (<3%) with some impact from Warminster at 13% and Maiden Bradley at 20%.

Monitoring data in the lower Wylye shows that concentrations in the upper reaches are $\sim 0.133\text{mg/L}$ and decline to 0.058mg/L towards the bottom of the reach, again these are above the 0.050mg/L CSMG target. SAGIS model data shows a good fit with monitored data and suggests a decrease in OP through the reach with no notable influence on concentrations from point sources. Impacts from WWTW is low in the catchment with $\sim 7\%$ contributions in the lower reaches.



Monitoring data in the catchment shows that concentration in the upper reaches are elevated and decrease through the reach to 0.095mg/L which is still considerably above the 0.05mg/L target. SAGIS model data shows a good fit with observed data and also shows a consistent trend through the catchment. Maximum WWTW contributions in the Nadder are observed below Tisbury and Fovant WWTW with 10% contributions. The model does suggest significant impacts in the headwaters of the Sem and its

tributary the Fonthill stream where East Knoyle and Hindon WWTW account for 86 and 98% of the phosphate respectively.

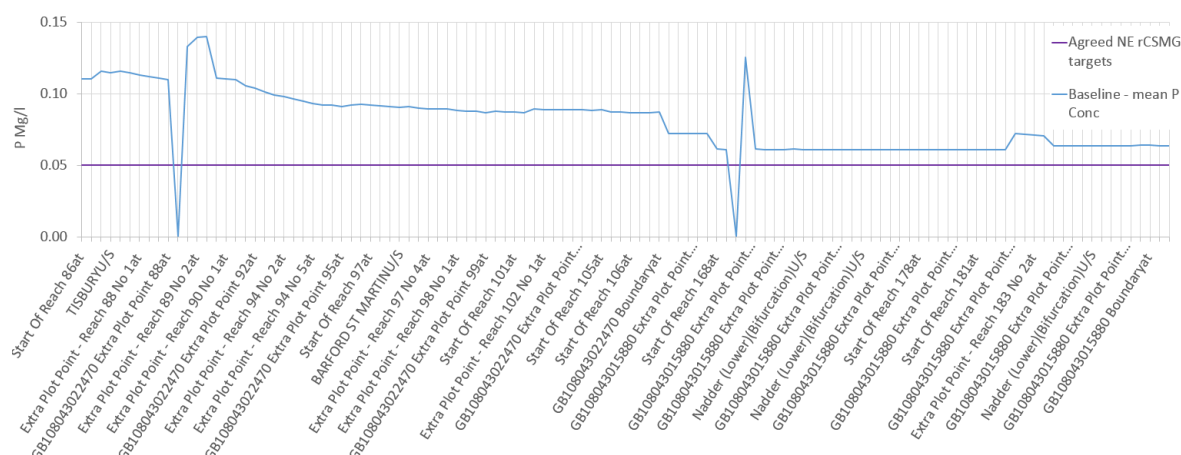


Figure 24 : Showing the SAGIS-SIMCAT modelled concentration through the Nadder and Sem

3.2.6 The Bourne

The only open monitoring site collecting phosphate data for the Bourne is at the lower water body boundary (50240116), average water quality between 2016 and 2019 is ~0.47mgL showing that the CSMG target is being met here. There is no recent Environment Agency data for the upper reach with the more stringent 0.040mgL target. The SAGIS model seems to be overestimating the river concentration here with modelled concentrations over double the observed data (0.122mgL). Modelling water quality in the catchment is difficult due to the winterbourne nature of the river flows, poor model fit has also been noted elsewhere (MU). Recent data collected by Wessex Water (MU) show that concentrations in the upper catchments are significantly elevated with concentrations below Collingbourne WWTW being 0.225mgL. Source apportionment from the model suggests the reach is significantly impact by WWTW with 71% of the phosphate originating from these sources at the bottom of the reach, localised impacts include Collingbourne (61%), Everleigh (61%), Tidworth Garrison (90%), Shipton Bellinger (89%) and Hurdcott (76%). The catchment is dominated by chalk geology and is not impacted by phosphate rich groundwater.

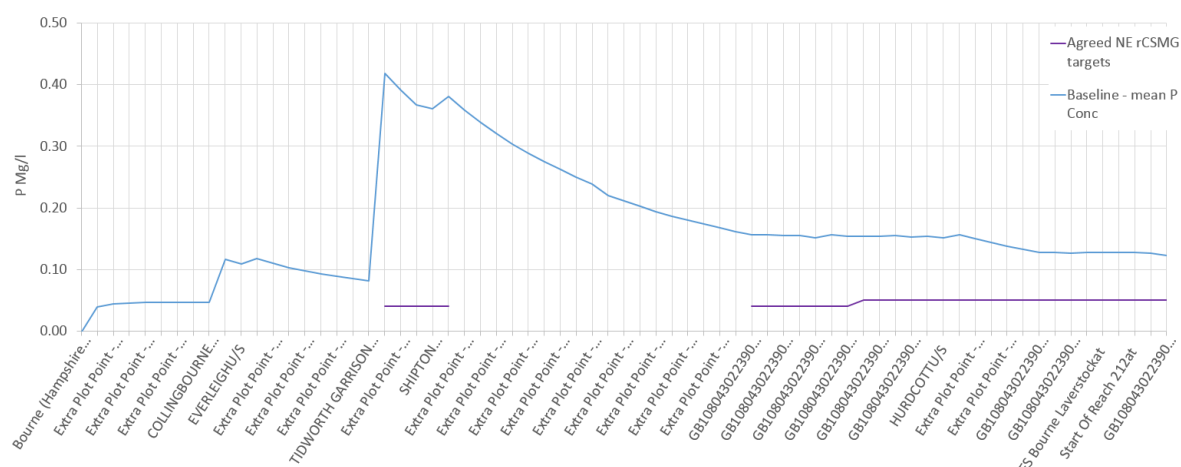


Figure 25 : Showing the SAGIS-SIMCAT modelled concentration through the Bourne.

3.2.7 The Till

EA monitoring in the Till catchment is only available at the bottom of the catchment and shows average concentrations of ~0.025mg/L which is below the CSMG target. When comparing this with the SAGIS model (0.029mg/L), they are in close agreement. A recent investigation (MU) suggested a poor model fit in this catchment, which was also observed in previous EA model calibration. The recent improvements in the model bring more confidence in the results here. Despite the improvements, the winterbourne nature of the catchment will introduce some uncertainty. SAGIS modelling does indicate nearly an order of magnitude increase with concentrations below Tillshead WWTW at 0.200mg/L, however this discharges directly to ground and is not well represented by the model which does not assume any attenuation of nutrients. Model result in the Bourne suggest the catchment is heavily impacted by Point Sources with 64% of the phosphate attributed to WWTW, discharges include Tillshead, Shrewton (85%) and Berwick St James (69%).

3.2.8 Dockens Water

Monitoring data for the catchment is available at the bottom of the waterbody and shows how the CSMG target of 0.015mg/L is being met. The SAGIS is significantly overestimating the WQ in the catchment with 0.113mg/L. The catchment is considered low risk with limited agriculture, no WWTW and low population density.

3.3 SAGIS-SIMCAT -Source Apportionment

Establishing accurate source apportionment figures is fundamental to developing an effective strategy for reducing pollution, this involves calculating the load from each of the key polluting sectors. This approach underpins the polluter pays principle, and the EA commonly uses the SAGIS-SIMCAT model for assessing contribution of phosphate to rivers. It is however recognised that in catchments significantly impacted by groundwater, then the diffuse sectors are difficult to apportion, this is further complicated by the phosphate rich groundwater characteristic of the upper catchment of the Hampshire Avon.

Table 19 : SAGIS source apportionment taken from the lower Avon at Knapp Mill. Autumn 2020 model run

			mg/L	kg/d	kg/annum	% Load
WWTW	Point	Point	0.0106	17.9	6532	12.7
Intermittent	Point	Point	0.0000	0.0	0	0.0
Industry	Point	Point	0.0021	3.0	1078	2.1
livestock	Diffuse	Diffuse	0.0267	58.8	21480	41.6
Arable	Diffuse	Diffuse	0.0055	11.8	4312	8.4
Highways	Diffuse	Diffuse	0.0000	0.0	0	0.0
Urban	Diffuse	Diffuse	0.0147	44.7	16307	31.6
OsWWTW	Diffuse	Diffuse	0.0033	5.2	1911	3.7
Total Point				20.9	7610	14.7
Total Diffuse				120.5	44010	85.3
Total			0.011	141.4	51620	100

*Note that the total discharged from WWTW point sources is estimated to be 8150kg/annum however attenuation reduces the contributions.

The SAGIS-SICAT source apportionment shown in Table 19 above suggests that livestock and urban are the most significant sources of OP across the catchment. Previous work and work conducted for

this review provides a contradiction to this, these are discussed in the main document. The model is also unable to represent groundwater inputs and for these reasons this review will reapportion the diffuse sectors.

3.4 SAGIS-SIMCAT Reduction scenarios

The approach taken for this review was for the working group to agree a number of model scenarios which could represent a number of different approaches for reducing phosphate concentration across the catchment. The scenarios included and:

- Estimate the current water quality.
- Estimate the realistic improvement under existing strategies.
- Estimate the improvements using mechanisms currently at the disposal to regulators.
- Estimate improvements using the maximum diffuse reductions predicted from the Farmscoper model while maintaining current land use practices, in combination with beyond Fairshare point source measures.
- Estimate improvements using an estimated maximum diffuse reduction.
- Estimate the reduction needed to meet the target in all areas of the catchment.

Details of each model scenario are given in Table 20 below. The results from the model run are described in detailed in the following chapter. Groundwater influences are not represented and have been apportioned to the diffuse sectors.

Table 20 : Showing the details of the model scenarios applied to the SAGIS model.

Option	Diffuse reduction applied	WWTW Quality and Flow parameters	Point Source Flow	Point Source Quality	Required outputs
Baseline	None	Current WWTW flow and quality performance based on 2010-12 time series	Measured	Measured	Final concentration and load Source Apportionment – point and diffuse total only
Current estimate - 2025 Growth & 8% Diffuse	8% reduction in diffuse	Predicted flow and permit quality	Predicted Flow (Wessex Water September 2018 calculations)	Permit quality	Impact of growth on spatial WQ (and so offsetting required) Gap between WQ target and predicted WQ under scenario
Option 1 - WWTW adjusted for growth with maximum (non WPZ) diffuse reduction (2eFFCF)	16% reduction in diffuse	2036 growth Wessex Water (WxW) predicted flows and quality (based on most recent performance WxW 2018 update)	Predicted Flow (Wessex Water September 2018 calculations)	Historic Average Quality (2013 – 2017)	Final concentration and load Source Apportionment - point and diffuse total only
Option 1a – WWTW adjusted for growth with maximum (with WPZ) diffuse reduction – (3e)	24% reduction in diffuse	2036 growth WxW predicted flows and quality (based on most recent performance WxW 2018 update)	Predicted Flow (Wessex Water September 2018 calculations)	Historic Average Quality (2013 – 2017)	Final concentration and load Source Apportionment - point and diffuse total only
Option 2 – Largest WWTW limits set at TAL (permitted flow) with maximum diffuse reduction scenario – (3d)	24% reduction in diffuse	+ 21 largest WWTW operating at TAL (Permitted flow) Smaller WWTWs at fairshare or 2mg/l	Permit Flow	TAL (0.25 mg/L) at 21 of the main works MOD sites at permit (Fairshare) flow & quality	Final concentration and load Source Apportionment - point and diffuse total only

Option 2a - Largest WWTW limits set at TAL (current flow) does not include growth but with maximum diffuse reduction scenario	24% reduction in diffuse	+ 21 largest WWTW operating at TAL (Current flow) Smaller WWTWs at fairshare or 2mg/l	Current Flow (Wessex Water September 2018 calculations)	TAL at 21 of the main works MOD sites at permit (Fairshare) flow & quality	Final concentration and load Source Apportionment - point and diffuse total only
Option 3 – Point source adjusted for growth and applying beyond TAL limits at WWTW with maximum diffuse reduction (Scenario 4 and 3c)	24% reduction in diffuse	+ 21 of the largest works either set at TAL or beyond 0.1.	Permit Flow	Beyond TAL at main works	Final concentration and load Source Apportionment – point and diffuse total only
Part 1 ‘Fairshare’ Scenario – CSMG targets met in all water-bodies	All sectors reduced to meet fair share contribution	Proportional reduction from Fairshare baseline date to meet CSMG based on permit flow at all WWTWs	Fairshare requirements	Fairshare requirements.	Final concentration and load Source Apportionment – point and diffuse total only
Part 2 ‘Fairshare’ Scenario – maximum diffuse	40%	Proportional reduction from Fairshare baseline	Fairshare requirements	Fairshare requirements.	Final concentration and load Source Apportionment – point and diffuse total only
Option 4	40%	Current WWTW flow and quality performance based on 2010-12 time series	Measured	Measured	
Option 4a	40%	+ 21 largest WWTW operating at TAL (Permitted flow) Smaller WWTWs at fairshare or 2mg/l	Current Flow (Wessex Water September 2018 calculations)	TAL at 21 of the main works MOD sites at permit (Fairshare) flow & quality	

3.4.1 Option 1 - Predicted best case improvement using current mechanisms The Bourne

This scenario was built to represent what could be potentially achievable under the current mechanisms. This includes increased in point source discharges from predicted population growth to 2036 and a 16% diffuse reduction. The diffuse reduction of 16% will include progress since the baseline years of 2010-2012. The table below shows the predicted water quality at the lower boundary of each of the CSMG reaches.

Table 21 : Reductions in P modelled by SAGIS in each of the main CSMG catchments.

Reach	Mean SRP mg/L	SRP change from baseline kg/annum
Upper Avon	0.094	-377
Till	0.063	+619
Wylfe (Headwaters)	0.075	-3449
Wylfe Lower	0.043	-6406
Lower Nadder	0.050	-4226
The Bourne	0.125	+1372
Dockens Water	0.049	-666
Lower Avon	0.051	-14201

***Nadder and Sem only meet compliance following mixing with the river Wylfe**

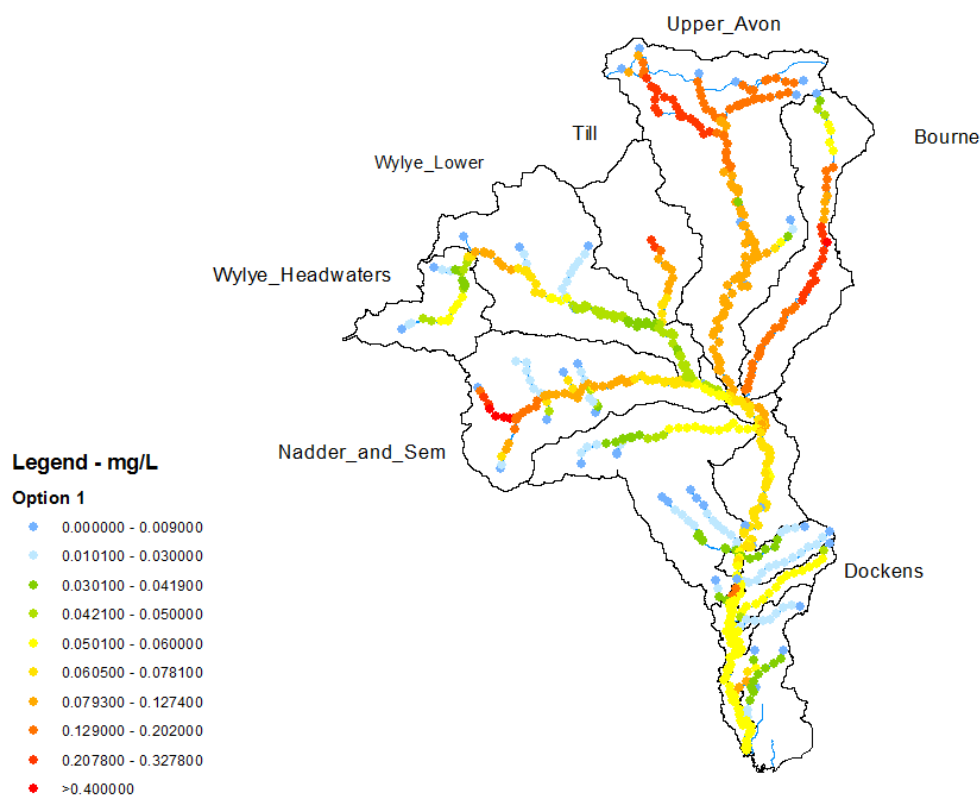


Figure 26 : Shows the modelled concentration for Scenario 2eFFCF which used the Wessex Water predicted WWTW discharges and a 16% reduction in diffuse pollution. (See Copyright Statement 1)

**Blue symbols represent the <0.03 target and Green represent the <0.05 target*

The table above show how only the Wylfe Lower and the lower Nadder (following mixing with the Wylfe) are meeting the CSMG target at the bottom of the reaches with the Lower Avon close to meeting the targets at the bottom of the catchment. Despite these improvements at the lower boundary and a predicted reduction of 14 tonnes of phosphate being delivered across the catchment, the majority of the catchment is still predicted to fail CSMG targets across the catchment (Figure 9). Some localised class improvements within the Wylfe Lower and Nadder and Sem (following mixing with the Wylfe) areas are expected. The Till and the Bourne are both predicted to increase phosphate concentrations due to population growth and increase in discharge from WWTW. This predicted increase is within the current permit headroom and in-line with the existing Fairshare principles; however recent developments through a memorandum of understanding with the local authorities and implications of nutrient neutrality mean that this increase is unlikely to be observed.

Meeting the 16% reduction from diffuse sources will require additional resources and support in the catchment and is considered to be the upper limit of what is achievable with the current mechanisms. Even if the reductions are achieved the CSMG targets will not be achieved. The following section looks at further reductions which will require additional mechanisms.

3.4.2 Option 1a -

This scenario was built to represent what could be achieved through diffuse reductions of 24% considered to be the technically achievable under the current farming structure. This includes the predicted growth to 2036. This build on Scenario 1 with a further 8% diffuse reduction.

Table 22 : Reductions in P modelled by SAGIS in each of the main CSMG catchments.

Reach	Mean SRP mg/L	SRP Reduction from baseline kg/annum
Upper Avon	0.091	-769
Till	0.060	+563
Wylfe (Headwaters)	0.072	-3559
Wylfe Lower	0.041	-6744
Lower Nadder	0.048	-4615
The Bourne	0.124	+1295
Dockens Water	0.044	-690
Lower Avon	0.050	-15528

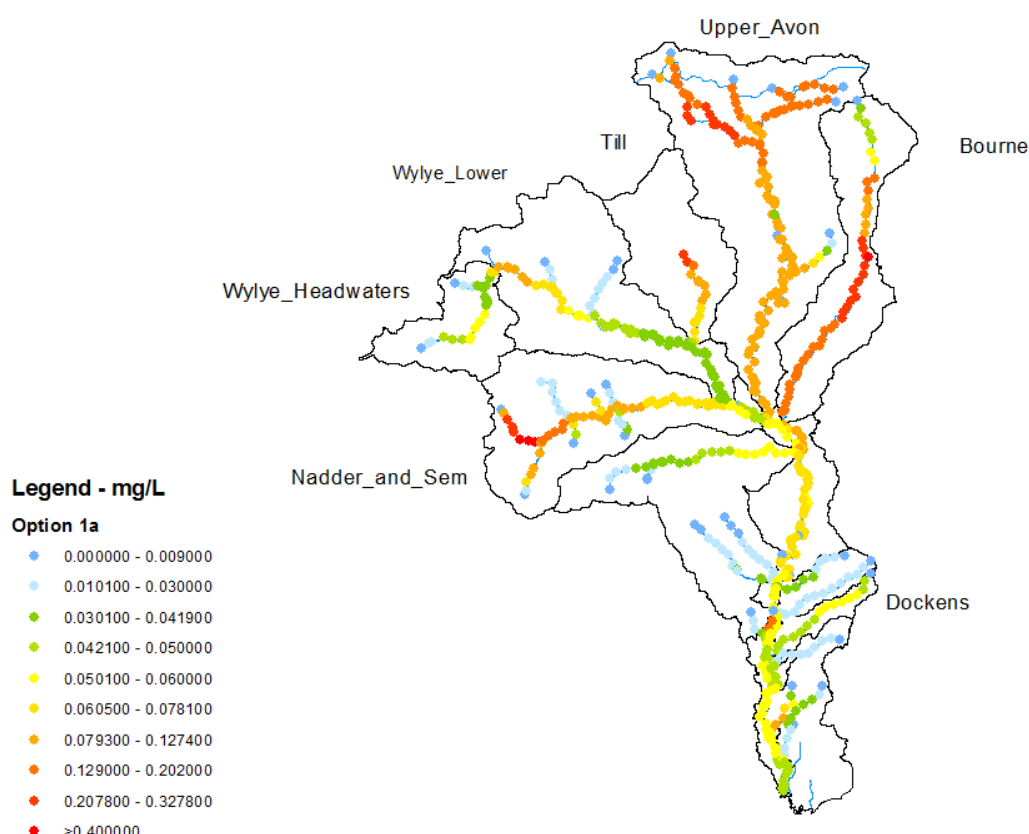


Figure 27 : Shows the modelled concentration for Option 1a which maintains WWTW loads at current level and a 24% reduction in diffuse pollution. (See Copyright Statement 1)

*Blue symbols represent the <0.03 target and Green represent the <0.05 target

These data show substantial reductions in concentration, however only the Wylze, Nadder and Sem (Following mixing with the Wylze) and Lower Avon are achieving the targets at the bottom of the catchment. Notable improvements in water quality are observed in the Wylze and Lower Avon. Despite the scenario delivering a substantial reduction with 15.5 tonne reduction at the bottom of the Avon the majority of the catchment is still failing CSMG. When comparing this option to the previous, only minimal water quality improvement are recognised with a localised improvements in status within the Wylze Lower, Nadder and Sem and Lower Avon.

3.4.3 Option 2

This scenario built upon the previous one and represents what additional restriction on WWTW can achieve. Here the technically achievable limit for phosphate is modelled on the 21 of the largest works and a 24% reduction across all diffuse sectors.

Reach	Mean SRP mg/L	SRP Reduction from baseline kg/annum
Upper Avon	0.085	-1199
Till	0.051	+467
Wylfe (Headwaters)	0.058	-3914
Wylfe Lower	0.037	-7195
Lower Nadder	0.045	-4890
The Bourne	0.051	-2305
Dockens Water	0.044	-690
Lower Avon	0.040	-20091

The table shows a significant reduction in phosphate concentration.

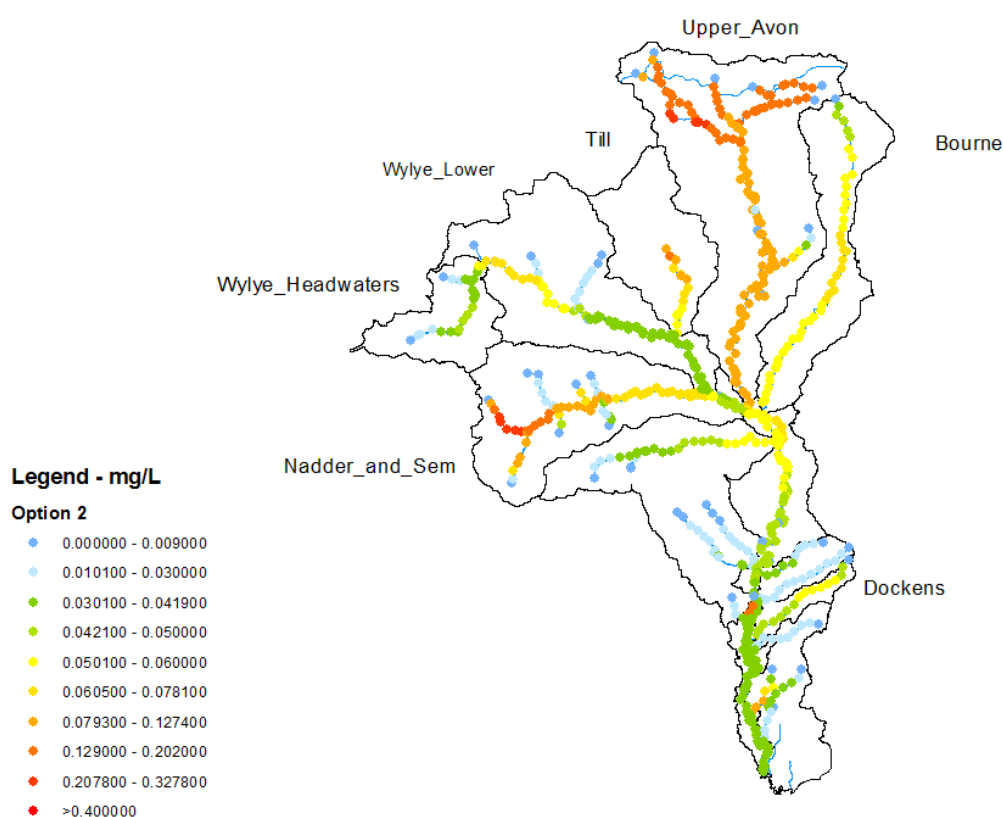


Figure 28 : Shows the modelled concentration for Option 2 which limits WWTW discharges to TAL and a 24% reduction in diffuse pollution. (See Copyright Statement 1)

*Blue symbols represent the <0.03 target and Green represent the <0.05 target

For point source contributions the impact of tightening the permit conditions beyond their current fairshare was modelled, this included using TAL (0.25 mg/L) on 21 of the largest. The large reduction in permit concentration at the large WWTW in combination with a 24% reduction in diffuse has delivered water quality reductions with large areas of the Wylfe Lower and Avon Lower now meeting CSMG targets. The scenario has delivered a large reduction in phosphate loading with a 20 tonne reduction at the bottom of the Avon. Considering load reductions alone is however difficult due to permitted flow being used for the WWTW discharges in this scenario.

3.4.4 Option 2a

This scenario built upon Option 2, which took the permitted flow and applied a TAL limit on 21 of the largest discharges, in Option 2a, the flow was held at current discharge volumes. This was modelled in combination with a 24% reduction across all diffuse sectors.

Reach	Mean SRP mg/L	SRP Reduction from baseline kg/annum
Upper Avon	0.082	-1487
Till	0.049	+398
Wylfe (Headwaters)	0.052	-4213
Wylfe Lower	0.036	+7425
Lower Nadder	0.044	-5000
The Bourne	0.052	-2233
Dockens Water	0.044	-690
Lower Avon	0.039	-20894

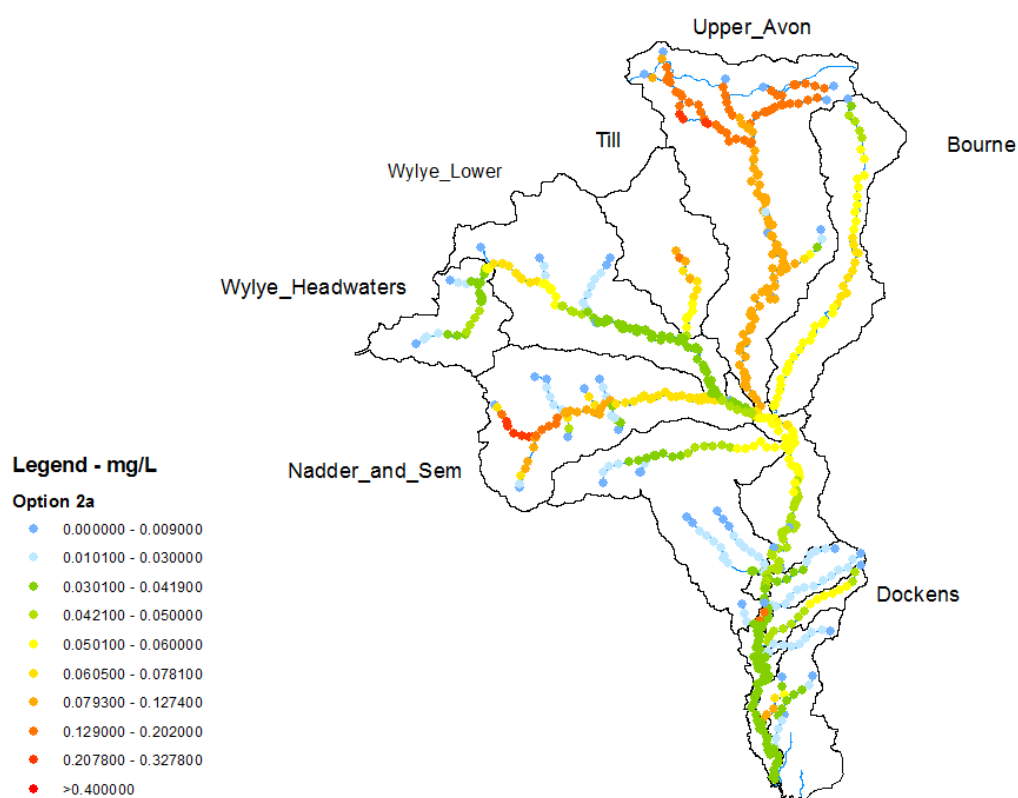


Figure 29 : Shows the modelled concentration for Option 2a which limits WWTW discharges to TAL at current flows and a 24% reduction in diffuse pollution. (See Copyright Statement 1)

*Blue symbols represent the <0.03 target and Green represent the <0.05 target

This scenario has delivered has not delivered any notable change when compared to Option 2, this is a result of decrease in flow from the WWTW at a very low concentration of 0.25 mg/L. In the

groundwater impacted catchment this is lower than the river concentration, so dilution effects are causing small differences. As a result, there are only small changes in total loading.

3.4.5 Option 3

This scenario looked at the predicted water quality when beyond TAL limits of 0.1 in addition to a 24% reduction in diffuse pollution.

Reach	Mean SRP mg/L	SRP Reduction from baseline kg/annum
Upper Avon	0.081	-1543
Till	0.051	+467
Wylfe (Headwaters)	0.046	-4337
Wylfe Lower	0.035	-7432
Lower Nadder	0.043	-5021
The Bourne	0.075	-1083
Dockens Water	0.044	-690
Lower Avon	0.038	-21049

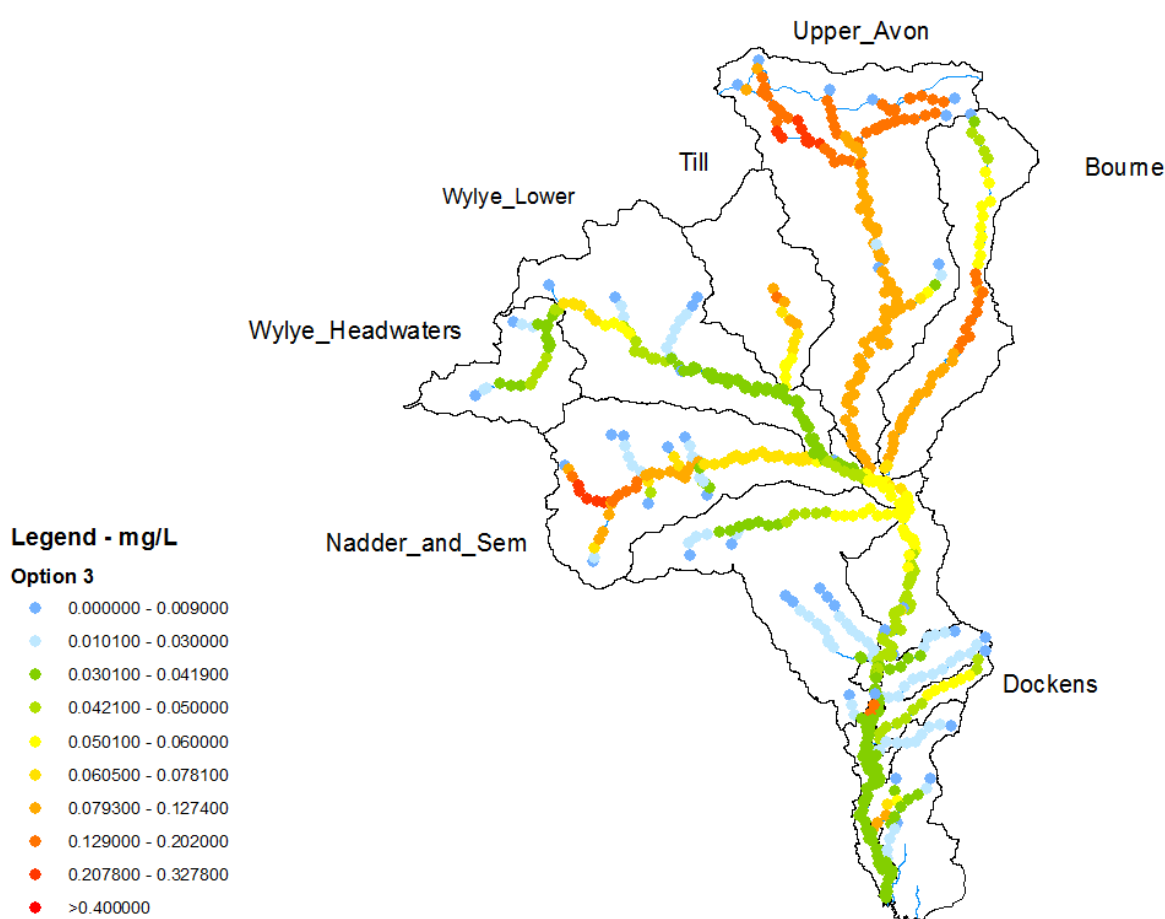


Figure 30 : Shows the modelled concentration for Option 3 which limits WWTW discharges to 0.1ug/L and a 24% reduction in diffuse pollution. (See Copyright Statement 1)

*Blue symbols represent the <0.03 target and Green represent the <0.05 target

The scenario had delivered significant improvements in water quality improvements with much of the Wylfe and the lower Avon meeting the target and significant reductions in the across the catchment. Despite a 21-tonne reduction in phosphate much of the Upper Avon and the Nadder still failing CSMG targets. When compared to options 2 and 2a only the Bourne is predicted to yield a meaningful change.

3.4.6 Option Fairshare at 40%

This employs a 40% reduction in diffuse pollution and current WWTW permits in line with the Fairshare.

Reach	Mean SRP mg/L	SRP Reduction from baseline kg/annum
Upper Avon	0.068	-4136
Till	0.029	-10
Wylfe (Headwaters)	0.073	-1102
Wylfe Lower	0.040	-4547
Lower Nadder	0.044	-3955
The Bourne	0.047	-3554
Dockens Water	0.128	-408
Lower Avon	0.047	-16439

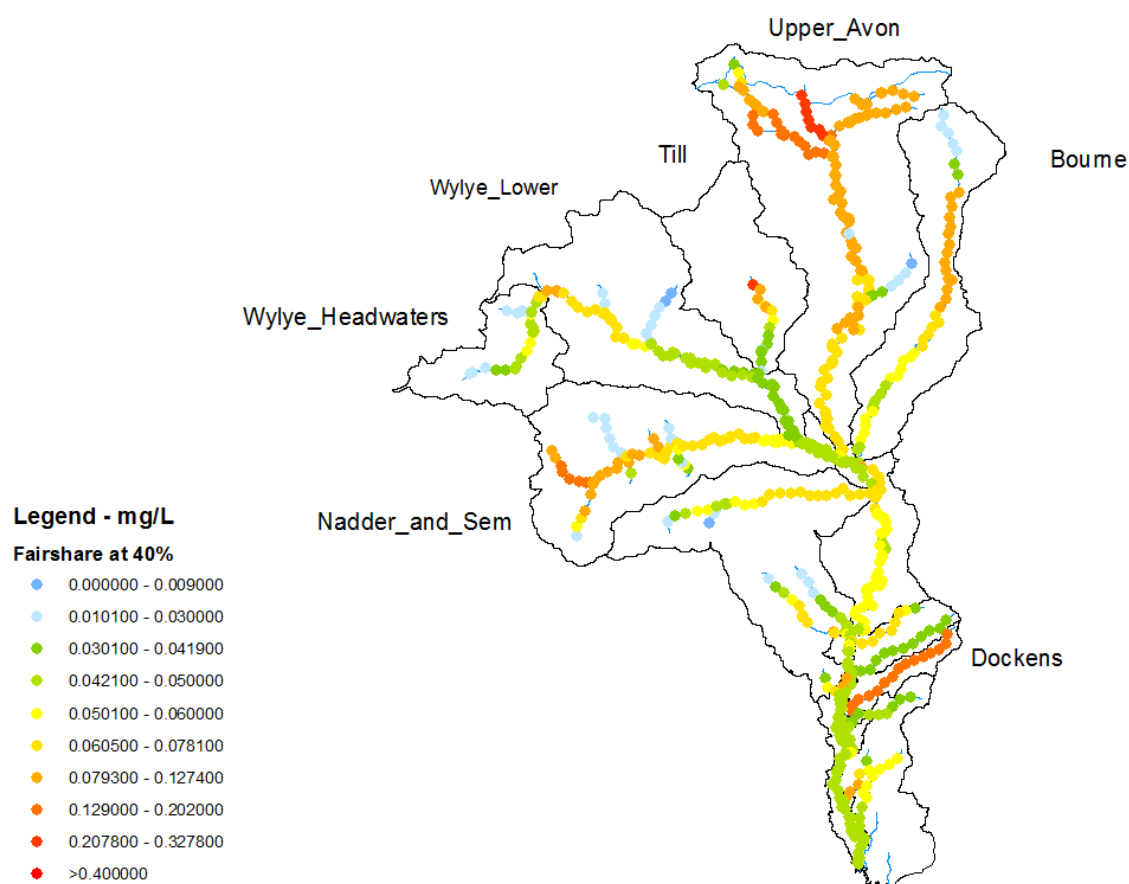


Figure 31 : Shows the modelled concentration when WWTW discharges are limited to current permit concentrations and a 40% reduction in diffuse pollution. (See Copyright Statement 1)

*Blue symbols represent the <0.03 target and Green represent the <0.05 target

The scenario has delivered significant improvements in water quality improvements with large sections of the Wylfe and Lower Avon now meeting the CSMG target. Significant water quality improvements have also been delivered in the Nadder and Sem, Upper Avon and Bourne. Despite the 16.4 tonne reduction in phosphate across the catchment all of the reaches still fail the CSMG target in some areas.

3.4.7 Option Fairshare - Fairshare reduction to meet target

This scenario takes the current WWTW permits in line with current Fairshare and further reduces the diffuse concentration until the targets are met across the catchment. Assumptions – permit flow at WWTW

Reach	Mean SRP mg/L	SRP Reduction from baseline kg/annum	Percentage Reduction from baseline
Upper Avon	0.030	-9845	-75
Till	0.029	-7	-1
Wylfe (Headwaters)	0.060	-4284	-67
Wylfe Lower	0.018	-11303	-80
Lower Nadder	0.020	-8956	-78
The Bourne	0.030	-4465	-72
Dockens Water	0.010	-838	-89
Lower Avon	0.047	-24125	-47

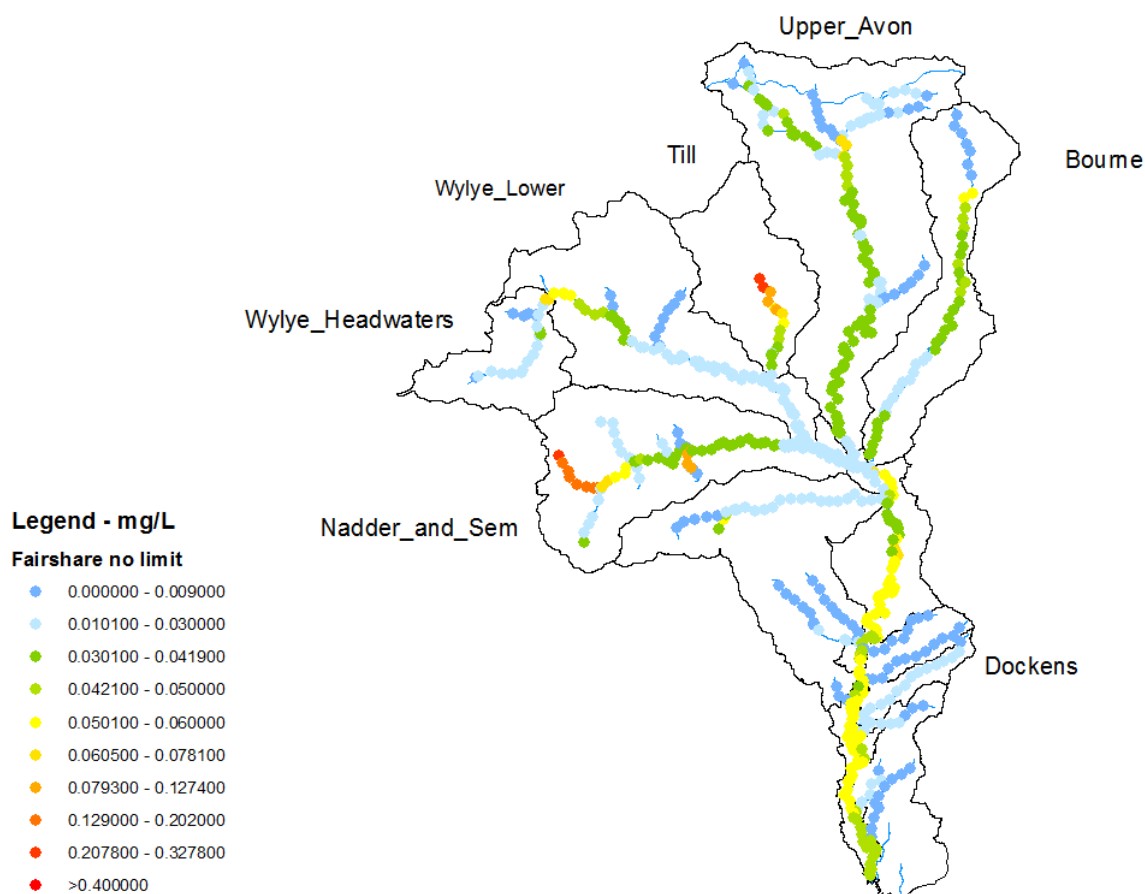


Figure 32 : Shows the modelled concentration required to meet the target in all reaches of the Hampshire Avon with WWTW discharges at current agreed levels. (See Copyright Statement 1)

*Blue symbols represent the <0.03 target and Green represent the <0.05 target

The scenario has delivered significant improvements in water quality improvements most of the catchment now meeting CSMG target. The majority of the Upper Avon, Wylve, Nadder and Bourne are now meeting the CSMG target. Despite a 24.2 tonne reduction in OP across the catchment, some areas of the lower Avon are exceeding the CSMG target, however this is only by a small majority.

3.4.8 Option 4 - 40% diffuse reduction and Baseline STW

Additional Hybrid Scenarios. The approach taken with the SAGIS model allows Sector Contribution to be combines, in the following section point source scenarios and diffuse scenarios have been combined model water quality.

Reach	Mean SRP mg/L	SRP Reduction from baseline kg/annum
Upper Avon	0.060	-4856
Till	0.024	-80
Wylve (Headwaters)	0.056	-2220
Wylve Lower	0.036	-5287
Lower Nadder	0.041	-4316
The Bourne	0.109	-941
Dockens Water	0.128	-407

Lower Avon	0.045	-17634
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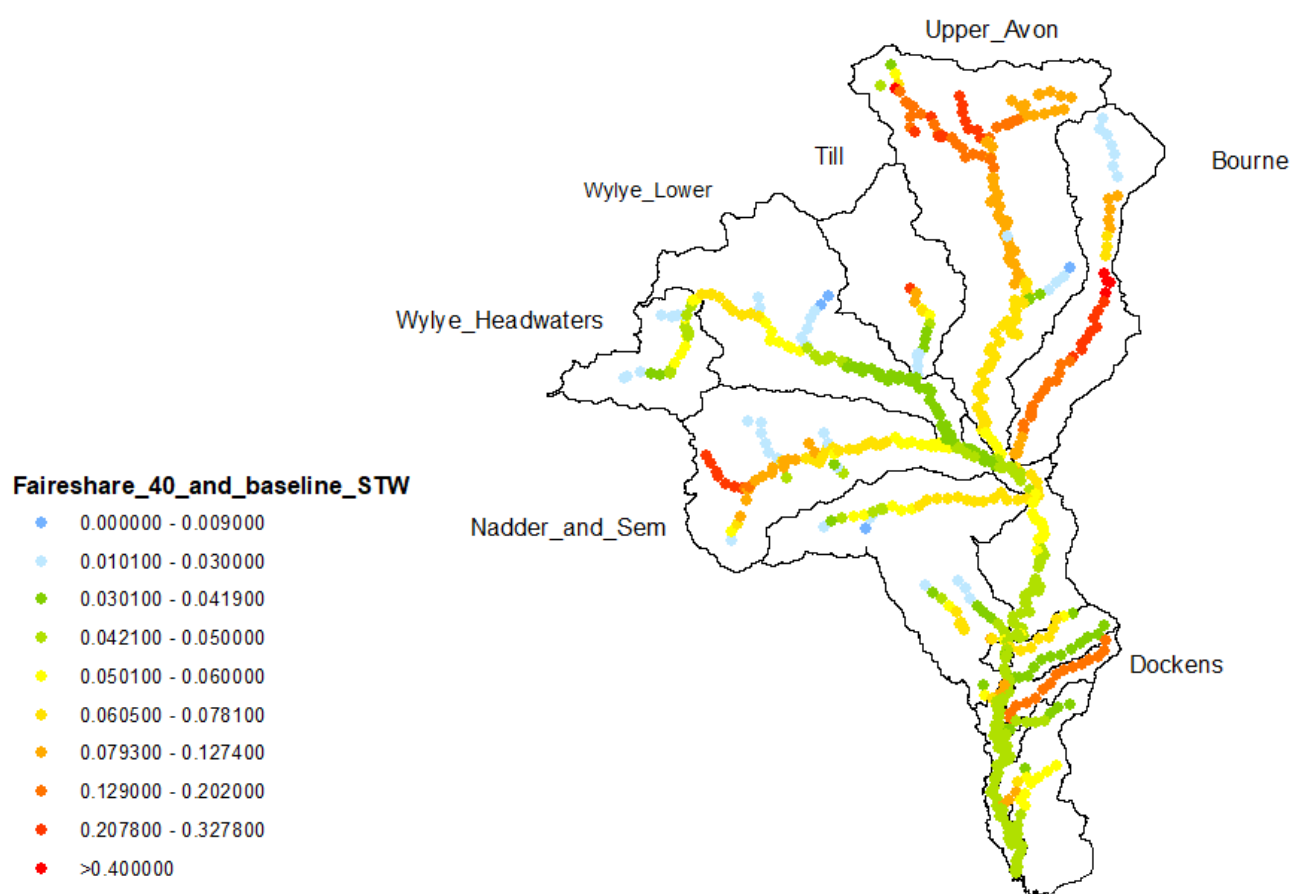


Figure 33 : Shows the modelled concentration when WWTW discharges are limited to current concentrations and a 40% reduction in diffuse pollution. (See Copyright Statement 1)

*Blue symbols represent the <0.03 target and Green represent the <0.05 target

The scenario has delivered significant improvements in water with large areas on the Lower Avon and Wylve now delivering concentration of <50ug/L. The Upper Avon and Nadder and Sem are still failing targets. The scenario delivers a 17.6 tonne reduction in OP across the catchment, some areas of the lower Avon are exceeding the CSMG target, however this is only by a small majority.

3.4.1 Option 4a - 40% diffuse reduction and STW at TAL

Additional Hybrid Scenarios. The approach taken models a 40% reduction in diffuse sources and the improvements from limiting major WWTW to TAL.

Reach	Mean SRP mg/L	SRP Reduction from baseline kg/annum
Upper Avon	0.057	-5140
Till	0.019	-169
Wylve (Headwaters)	0.060	-2256
Wylve Lower	0.036	-5559
Lower Nadder	0.040	-4547
The Bourne	0.033	-4022
Dockens Water	0.128	-407

Lower Avon	0.039	-21180
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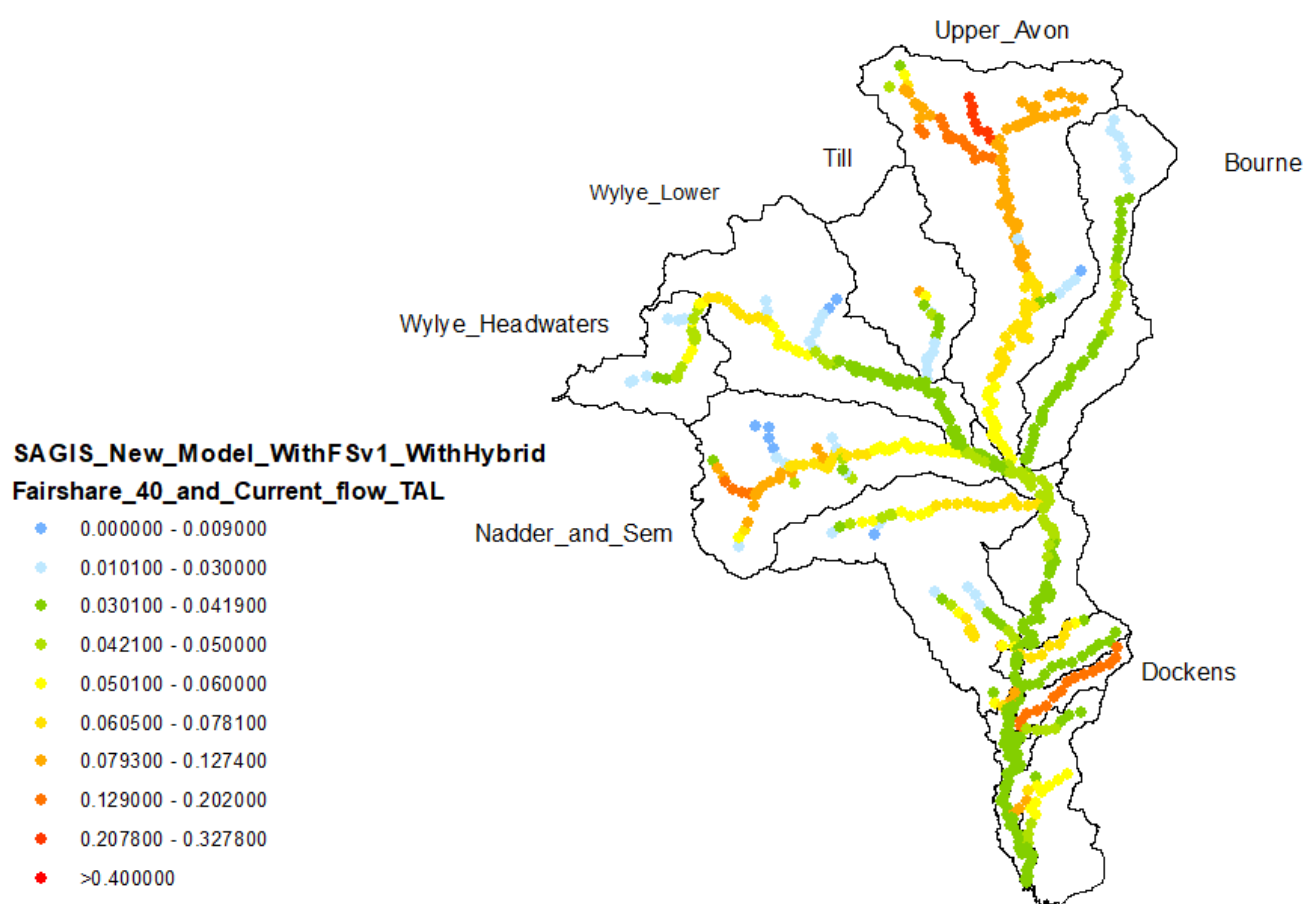


Figure 34 : Shows the modelled concentration when WWTW discharges are limited to TAL and a 40% reduction in diffuse pollution. (See Copyright Statement 1)

The scenario has delivered significant improvements in water with large areas on the Lower Avon, Wylve and Bourne (poor model fit) now delivering concentration of <50ug/L. The Upper Avon and Nadder and Sem are still failing targets. The scenario delivers a 21.1 tonne reduction in OP across the catchment.

3.5 Evaluation of the reduction scenarios

The change in concentration is shown in **Error! Reference source not found.** below and shows how option 1, 1a and both the Fairshare options lead to an increase in phosphate from WWTW, this is a result of either headroom in the permits for the Fairshare runs or predicted increases from growth. I am not able to explain the increases in diffuse contributions in the Bourne and Till and is possibly a result of the SAGIS-SIMCAT making its own decisions.

These data show how the reduction from diffuse sources is significant and with both the Fairshare runs illustrating the large reduction required. These options also require all diffuse sectors to reduce their phosphate discharges, given that groundwater concentrations are not expected to reduce, other sectors will have to reduce phosphate further. In Figure 35 below illustrates the magnitude of reduction required in many of the reaches where the “FS option” can be used as a guide for the water quality targets.

Table 23 and Table 24 below show the instream concentration at each of the lower boundaries of the CSMG reaches and are colour coded to indicate if the target is being met. Given that the requirement of the N2K designation is that the all units must meet the target, the criteria represented in Table 24 is considered first, however the only viable requires a 80% reduction in many of the catchment. These data illustrate the difficulty of meeting the target in the headwaters of the catchments. The results show that in the groundwaters impacted headwaters of the Hampshire Avon, Wylfe and the Nadder and Sem meeting the target is not technically achievable.

When considering WWTW impacts, Options 2a and 3 are the lead to a reduction in phosphate loading from WWTW. This can however be misleading as in many of the scenario’s permitted flow is used, when a high flow from a WWTW is combined with a low permit limit then the impact on the river concentration is low, due to discharge quality being similar to instream river quality. As a result the concentrations are also given in **Error! Reference source not found., Error! Reference source not found., Error! Reference source not found.** These data show how option 1a, 2, 2a, 3 and both the Fairshare options deliver a reduction in instream phosphate and localised improvements in water quality.

Table 23 Table shows the SAGIS-SIMCAT predicted concentration at the bottom of each of the CSMG reaches for each of the modelled scenarios, the colour represent if the target is being reached using the bottom of the reach as a compliance point

	CSMG Target	Baseline	Option 1	Option 1a	Option 2	Option 2a	Option 3	Option Fairshare at 40%	Option Fairshare to target	Option 4	Option 4a
Hampshire Avon (Upper)	0.05	0.091	0.094	0.091	0.085	0.083	0.081	0.068	0.030	0.060	0.057
Till (Hampshire)	0.03	0.029	0.064	0.060	0.051	0.049	0.051	0.029	0.029	0.024	0.019
Wylfe (Headwater)	0.05	0.087	0.075	0.072	0.058	0.052	0.046	0.073	0.060	0.056	0.060
Wylfe (Lower)	0.05	0.056	0.043	0.041	0.037	0.036	0.035	0.040	0.018	0.036	0.036
Nadder (Lower)	0.05	0.064	0.051	0.048	0.045	0.044	0.044	0.044	0.020	0.041	0.040
Bourne	0.05	0.123	0.125	0.124	0.051	0.052	0.075	0.047	0.030	0.109	0.033
Dockens Water	0.015	0.113	0.049	0.044	0.044	0.044	0.044	0.129	0.010	0.128	0.128
Hampshire Avon (Lower)	0.05	0.063	0.051	0.050	0.040	0.039	0.038	0.047	0.047	0.045	0.039
Failing CSMG											
Narrow Fail of CSMG											
Meeting CSMG											

Table 24 Table shows the SAGIS-SIMCAT predicted concentration at the bottom of each of the CSMG reaches for each of the modelled scenarios, the colour represent if the target is being reached across the whole of the reach

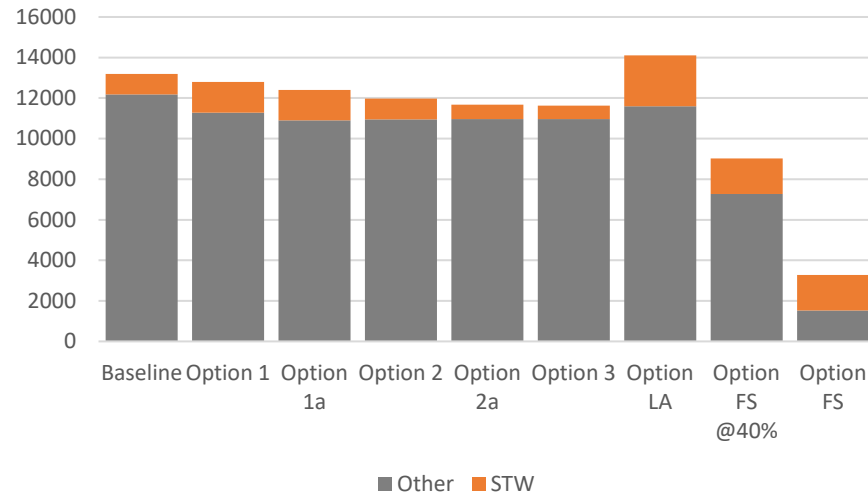
[illegible]

Table 25 Table shows the SAGIS-SIMCAT predicted loads at the bottom of each of the CSMG reaches for each of the modelled scenarios, the colour represent if the target is being reached across the whole of the reach

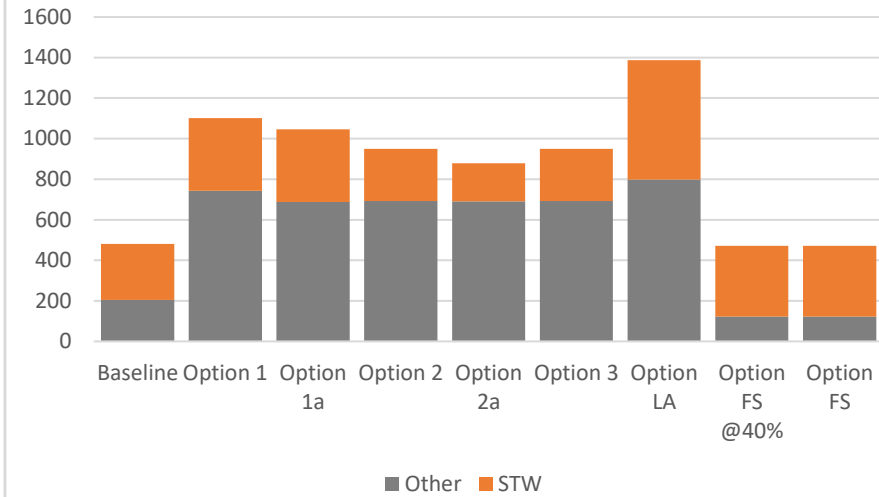
[illegible]



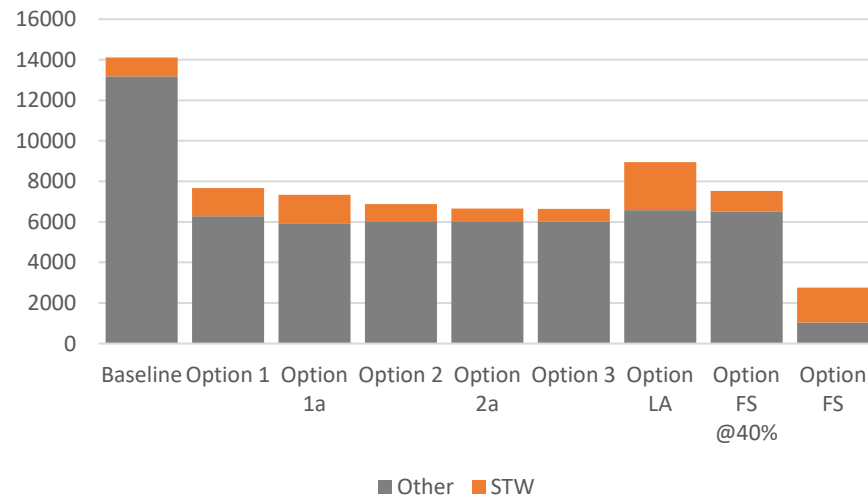
Upper Avon



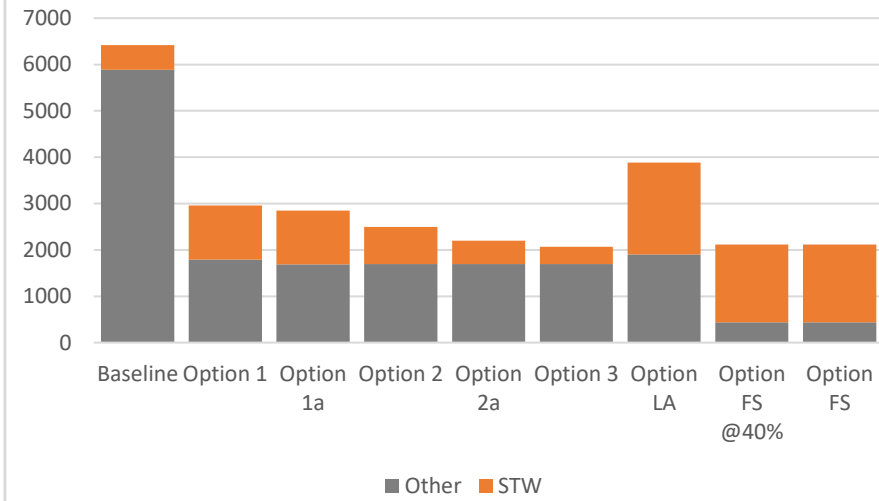
Till



Wylfe Lower



Wylfe Headwaters



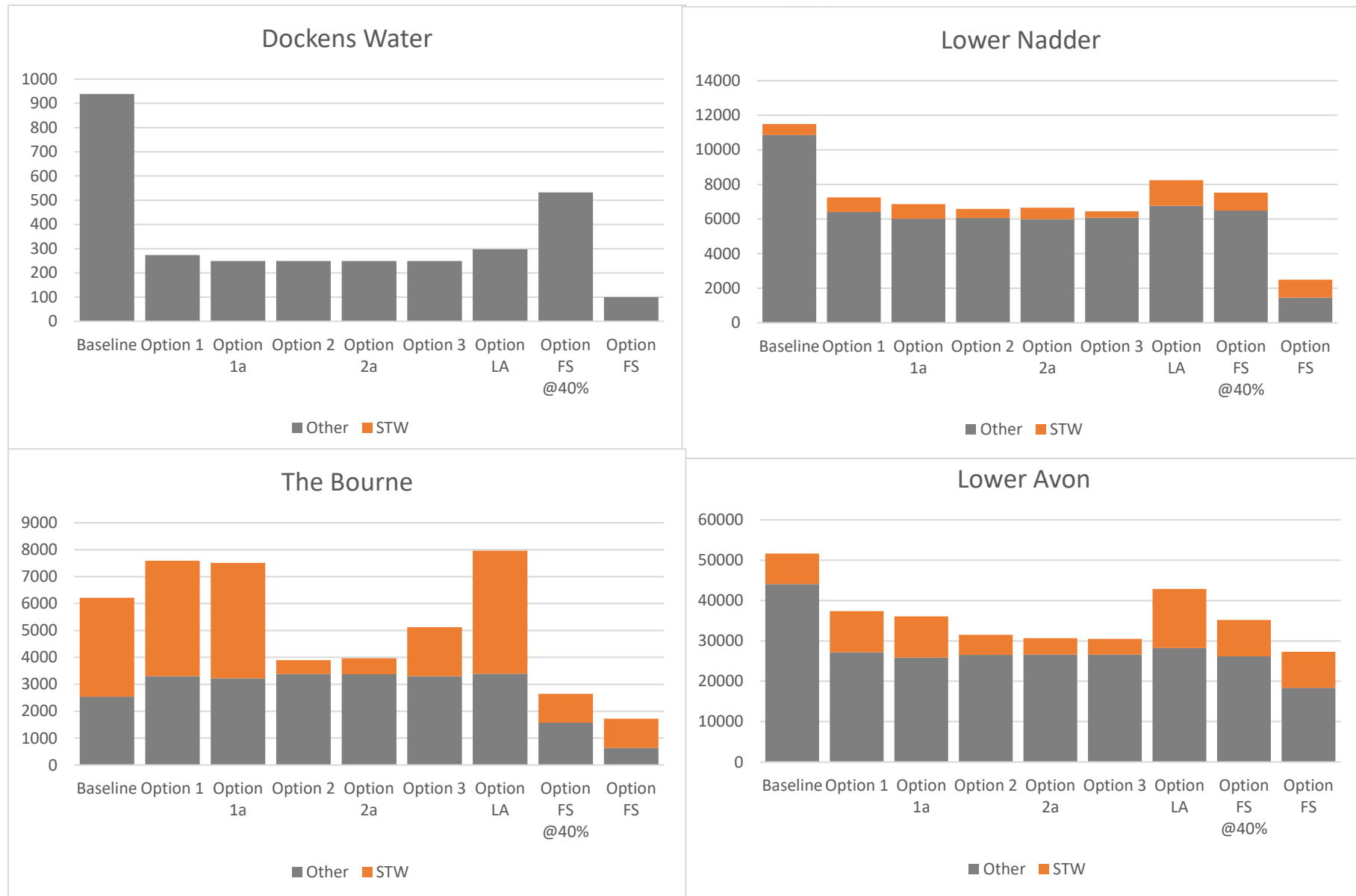


Figure 35 : Figure showing the impact from WWTW (STW) and other sources on each of the reaches, where the Option FS represents the required reduction to meet the target across the catchment

4 Appendix 4 Farmscoper Option Appraisal

Feasibility of delivering the targets following traditional approaches in Farmscoper and more widely are detailed below. These are presented for illustrative purposes and it will be for each sector to identify how they will deliver their fair share.

4.1 A potential reduction strategy.

The previous section has already estimated the magnitude of change required to meet the targets. The following section will focus on the technical, practical and overall feasibility of meeting the target.

4.1.1 Diffuse Pollution reductions

Two diffuse reduction scenarios are proposed with a 24% reduction and a 40% reduction. The load reductions are given in **Error! Reference source not found.** above.

4.1.2 Agricultural reductions

Reductions in phosphorus from agricultural sources can broadly be defines into mitigation measures, where the current farming structure is maintained, with changes in practice and infrastructure improvements are used to deliver more sustainable losses of nutrients, known as mitigation measures.

4.1.2.1 Agricultural mitigation measures

Achieving a reduction of 24% from agriculture was modelled using Farmscoper, this translates to a reduction in total phosphorous loads from 37820kg to 28950kg (8870kg reduction). The measures given in Table 26 are those suggested by the Farmscoper model however, reductions from agricultural land can be delivered through any measure or approach deemed suitable by the landowner.

Table 26 : Table showing the measures suggested by Farmscoper required to achieve a 24% reduction in TP.

Mitigation Measure	Assumed Baseline uptake 2020	Level of uptake required
Use a fertiliser recommendation system	50	80
Avoid spreading manufactured fertiliser to fields at high-risk times	2	80
Do not apply P fertilisers to high P index soils	0	80
Move feeders at regular intervals	50	80
Manure Spreader Calibration	25	80
Do not apply manure to high-risk areas	50	80
Do not spread slurry or poultry manure at high-risk times	20	80
Do not spread FYM to fields at high-risk times	2	80
Fence off rivers and streams from livestock	50	80
Early harvesting and establishment of crops in the autumn	50	80
Farm track management	50	80
Adopt reduced cultivation systems	20	80
Cultivate compacted tillage soils	10	80
Manage over-winter tramlines	10	80
Loosen compacted soil layers in grassland fields	10	80
Establish riparian buffer strips	10	80

Make use of improved genetic resources in livestock	10	80
Store solid manure heaps on an impermeable base and collect effluent	10	80
Use liquid/solid manure separation techniques	10	80
Management of arable field corners	10	80
Plant areas of farm with wild bird seed / nectar flower mixtures	10	80
Establish cover crops in the autumn	2	80
Uncropped cultivated margins	2	80
Unfertilised cereal headlands	2	80
Undersown spring cereals	2	80
Establish in-field grass buffer strips	2	80
Increase the capacity of farm slurry stores to improve timing of slurry applications	2	80
Use slurry injection application techniques	2	80
Establish and maintain artificial wetlands - steading runoff	2	80
Beetle banks	2	80
Management of grassland field corners	2	80
Re-site gateways away from high-risk areas	0	80
Allow grassland field drainage systems to deteriorate	0	80
Use dry-cleaning techniques to remove solid waste from yards prior to cleaning	0	80

The strategy outlines the potential needs for further reduction to 40% in addition to groundwater mitigation and a reduction of 18606kg/yr is required. The addition 9736 kg/yr reduction would require measures which go beyond the previous suggestion of mitigating measures.

4.1.2.2 Agricultural land use change.

Taking land out of agricultural use involves the reversion of land from high input land uses to low input lands uses. This reduces the application of organic and inorganic fertilisers and also protects soil from erosion and compaction. Export figures for reverted land, assume legacy P from agriculture has been depleted, the duration for this is depended on a number of factors but can be as high as 11 years (Gatiboni, L, Schmitt, D Et al 2021). Comparison of estimated baseline scenario pollutant loadings (kg/ha/yr) for the farm types across the Hampshire Avon using the Farmscoper v4 model are given below. Data presented in **Error! Reference source not found..**

Table 27 : Reduction in phosphorus from reverting land to woodland, calculated using Farmscoper V4

Farm Type	Losses kg/Ha/Yr*	Reverted to Woodland – reduction kg/Ha/yr	Area of Land Type reverted to woodland to reduce 9736kg of Phosphorous (Ha)
Intensive	0.385*	0.355	27425
Housed	0.968*	0.938	10380
Extensive	0.228*	0.198	49172
Arable	0.287*	0.257	37883
Woodland	0.03 ^s		

*Calculated using Farmscoper v4 for 700-900mm rainfall on Free Draining Soil

^sassumed phosphorous losses from woodland calculated using Farmscoper for the given climate and soil type.

With arable land-use being the most dominant agricultural type in the catchment, the biggest opportunity for reversion in this sector. Implementation of the strategy would look to target the least productive, marginal land which intercepts runoff into the rivers and tributaries, this approach would be expected to additional savings. Farmscoper suggest that 62400 Ha of land are principally occupied by Arable land and the 37883 Ha of land would require around 60% of arable lend to be converted to woodland.

4.1.2.3 Agricultural Wetlands

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 removal rate of total phosphorus (TP) is highly dependent on the loading rate, for the purpose of this study median removal rates of TP 1. 2 g/m²/year (Land 2016) which would require the creation of 8110000m² or 811 Ha of wetland for the removal of 9736kg of P. This equates to approximately 0.65% of agricultural land (assuming 1244km² of agricultural land **Error! Reference source not found.**). Alternatively, to deliver the entire agricultural obligation of 18606 then approximately 155Ha of wetland are required. Through the strategic creation of the wetlands to target land with high phosphate losses, this area of wetland needed could be reduced significantly.

4.1.2.4 Agricultural stocking density reduction

livestock number in the catchment are given in APPEDIX** and using the Farmscoper tool the impact of reducing the stocking density by 30% was modelled. The reductions from key pollutants are shown in Table 4 below.

Table 28 : Reduction in major agricultural pollutants as a result if reducing stocking densities by 30%.

	Nitrate (%)	Phosphorus (%)	Sediment (%)	Ammonia (%)	Methane (%)	Nitrous Oxide (%)
Stocking 30% reduction (Prior)	6.7	7.4	2.5	15.5	29.5	6.3

The low reduction in phosphorus from stocking destiny is a product of the catchment being mainly dominated by arable type agriculture and the phosphorus emissions from livestock being low.

4.1.3 Groundwater phosphorus mitigation

Reduction required from groundwater sources are given in **Error! Reference source not found.**. In-situ treatment of groundwater is not feasible and as a result the load would need to be offset from other sectors or through catchment-based solutions such as wetlands and river restoration. For the purpose of this strategy the groundwater OP load has been accounted for by other sectors.

4.1.4 Urban phosphorus mitigation

Urban sources are also significant in the catchment with 7005 kg of TP, a reduction of 3447kg would therefore be required through the improvement in infrastructure (do misconnections count?) and the retrospective installation of SUDS. Catchment based solution should looks to reduce the transport of phosphorus from the landscape to hardstanding and drainage networks. Sustainable Urban Drainage (SuDS) are typically used to manage urban pollution with TP removal rates of 1.2 g/m²/yr, creating the need for 287 Ha of SuDS across the catchment to address urban sources, Local Authority and Water Companies should collaborate and assess the multiple benefits delivered by sustainable urban drainage solutions.

4.1.5 Onsite-WWTW

Unsewered contributions in the catchment are low with 943kg attributed across the catchment, however this assumes attenuation by host rock, and that systems are well maintained. A strategy to

ensure that misconnections and on-site wastewater treatment plants are properly maintained is advised.

4.2 Point source reductions

Direct discharges from permitted activities contribute an around 15% of the phosphorus across the catchment, these can impact stretches of the river and provide an opportunity to treat discharges at source.

4.2.1 Fish and Cress farming

Previous work has suggested that fish farms pose can contribute to nutrients. Reductions from this sector can be achieved through site management and a requirement for problematic sites to install wastewater treatment systems and be subject to permit reviews. Most of the facilities have differential permits, however the suitability of these for protecting water courses should be reviewed by the EA to better manage risk.

4.2.2 WWTW

Under the baseline scenario, WWTW are required to maintain the current discharge level and maintain a standstill approach. This standstill approach is also required following EU Dutch nitrogen case preventing any increase in discharge. Due to the revision if CSMG targets, WWTW permits will need to go through a Review of Consents to secure any additional treatment required. The groundwater mitigation required in **Error! Reference source not found.** will also be required.

Wessex Water has exceeded its obligation in terms of the existing ROC for the Upper and Lower Avon, Nadder and Sem and the Wylfe, with some reductions are required in the Till (WXW CSMG study). Any reductions beyond Fairshare would need to be agreed with the water company. Achieving TAL at large WWTW across the catchment will require current permits of 1mg/L and smaller works are assumed to discharge at 5 mg/L to be reduced to 0.25mg/L and 2 mg/L respectively.

4.2.3 Point source reductions

Point source reductions focus on permitted activities in the catchment, a number of reduction scenarios have been modelled and are provided in APPENDIX X.

Table 29 : Table showing point source loads reduction required under different scenarios and the total load discharged.

		Baseline – This Study (Input Loads) P (kg)	Groundwater mitigation required 24% P (kg)	Groundwater mitigation required 40% P (kg)	TAL Permitted Flow* Total load in kg/TP/yr	Beyond TAL Permitted Flow* Total load in kg/TP/yr
WWTW	Point	14952	480	801	6093 - groundwater mitigating	
Fish and Cress	Point	1666	79	132		

*Taken from WWTW input loads - 0.25mg/L limit on large WWTW; 2 mg/L on smaller WWTW; 0.01 mg/L Fish and Cress

5 Appendix 5 Ecosystem Services Assessment & Semi Quantitative Cost Benefit

5.1 Ecosystem services assessment of options

The following section undertakes a qualitative assessment of the potential benefits and disbenefits of different the options considered in each of the scenarios given in Section 4.6.

Table 30 : Ecosystem Services Assessment of options available to deliver diffuse and point source inputs.

[illegible]

[illegible]

[illegible]

Category	Agr i Tier 1	Agr i Tier 2	Agr i Tier 3	Agr i Tier 4	Agr i Fairshar e	Reductio n in Stocking	Land use Chang e	Agricultura l Wetland Creation	Urban Wetland s and SUDS	Groundwater r mitigation	Fish and Cres s	Unsewere d Diffuse	WWTW Standstil l	WWT W @ TAL	WWT W updated ROC
Existence Values	o	o	o	o	o	o	^^	^^	^^	^^	o	o	o	o	o
Social relations (e.g. fishing, grazing or cropping communities)	o	o	^^	^^	v	v	v	^	^	^	o	o	o	o	o
Supporting services															
Soil formation	^	^^	^^	^^	^^	^	^^	o	o	o		o	o	o	o
Primary production (in river)	o	^^	^^	^^	^^	^	^^	^^	^^	^^	^^	o	o	o	o
Nutrient cycling	^	^^	^^	^^	^^	^	^^	^^	^^	^^	^^	^	^	^^	^^
Water recycling	o	^	^	^	^	o	^	^^	^^	^^	^^	o	o	o	o
Photosynthesis (production of atmospheric oxygen)	o	^	^	^	^	o	^^	^^	^^	^^	o	o	o	o	o
Provision of habitat	o	^	^	^^	^^	^	^^	^^	^^	^^	o	o	o	o	o
significant noticeable no net change noticeable significant	^^	Benefit													
	^														
	o														
	v														
	vv														

5.1.1.1 Recommendations

Agriculture reduction – a total reduction of 8870kg/yr could be achieved through the uptake of Tier 4 mitigation modelled by FARMSOPER; the additional 9736kg/yr could come from the addition of 811 Ha of wetland creation if assuming a 1.2g/Ha/yr removal rate.

Urban Reduction – a total reduction of 3447kg through infrastructure improvements and sustainable drainage methods. This could consist of 287Ha of SUDS.

WWTW – Despite the WWTW meeting its fair share, an updated ROC will be needed in light of the revised CSMG targets. An additional 801 kg/annum should also be delivered for the mitigation of groundwater.

Fish and Cress – In line with the WWTW an updated ROC should be completed, and reductions secured through permit variations.

5.2 Costs and associated outcomes of each of the options

This section will outline cost estimates associated with the options outlined above. This will include the cost of implementing measures (e.g. cost to farmers) and costs of implementing measures and mechanism (including EA costs of advice and enforcement). The benefits and outcome of the measures will also be costed.

5.2.1 Agricultural mitigation measures

The FARMSOPER v4 tool provides cost estimate associated with each of the scenarios modelled, this can be used to estimate the capital, operation costs and the environmental benefits. Due to the variability in costs, this assessment is a guide only.

Table 31 : Summary of the costs and potential benefits of the different agricultural scenarios modelled by FARMSOPER.

	P Savi ng	Capital Cost	Operatio nal Cost	Total Cost	Cost increas e vs prior	Cos t £ per kg P	Environme ntal Benefit £	Ratio of Cost vs environme ntal benefit £
Prior		1,190,000	478,600	1,668,000	0		3,047,000	0.13
Full Legislation	5,476	2,415,289	4,963,826	5,300,001	3,632,001	663	2,415,289	0.67
Scenario 1	2,910	2,046,000	1,204,000	3,250,000	1,582,000	544	3,814,000	2.41
Scenario 2	5,230	2,074,000	4,797,000	6,870,000	5,202,000	995	5,162,000	0.99
Scenario 3	8,150	2,578,000	8,004,000	10,580,000	8,912,000	1,093	6,702,000	0.75
Scenario 4	8,870	3,652,000	7,650,000	11,300,000	9,632,000	1,086	7,351,000	0.76

The table above shows how the per kg of phosphorus costs increase as more measures are introduced and illustrates the level of investment needed. The environmental benefit cost ratio of Scenario 1 illustrates the large potential environmental benefit of these measures.

5.2.2 WWTW

High level estimates of costs have been provided by Wessex Water in August 2022. Here the potential costs of upgrading WwTW across the Avon have been calculated along with the associated CO₂.

	0.25mg/l			
Treatment Works	Capex (£k)	Opex (£k/yr)	Embodied Carbon (TCO₂e)	Operational Carbon (TCO₂e/yr)
All Cannings	2,000	20	70	5
Amesbury	3,500	35	100	10
Barford St Martin	1,500	15	60	5
Collingbourne Ducis	5,500	140	230	45
Downton	2,750	30	90	10
East Knoyle	1,750	15	70	5
Fordingbridge	3,250	35	100	10
Fovant	2,000	20	70	5
Hindon	4,500	115	200	40
Hurdcott	2,500	25	80	10
Maiden Bradley	4,250	105	180	35
Marden	1,750	20	70	5
Netheravon	2,250	20	80	10
Pewsey	3,000	30	90	10
Ratfyn	3,500	35	100	10
Ringwood	3,750	40	100	10
Salisbury	5,250	50	120	10
Shrewton	2,250	20	80	10
Tilshead	5,000	125	210	45
Tisbury	2,750	25	90	10
Upavon	2,000	20	70	5
Warminster	4,000	40	110	10
Wishford	2,250	20	80	10
	71,250	1,000	2,450	325

	0.1mg/l
--	----------------

Treatment Works	Capex (£k)	Opex (£k/yr)	Embodied Carbon (TCO₂e)	Operational Carbon (TCO₂e/yr)
All Cannings	2,500	30	90	10
Amesbury	4,250	45	120	15
Barford St Martin	2,000	25	90	10
Collingbourne Ducis	7,250	200	290	65
Downton	3,750	40	110	10
East Knoyle	2,500	30	90	10
Fordingbridge	4,000	45	110	10
Fovant	2,750	30	90	10
Hindon	6,500	185	280	65
Hurdcott	3,250	35	100	10
Maiden Bradley	6,250	175	260	60
Marden	2,500	30	100	10
Netheravon	2,750	30	100	10
Pewsey	3,750	40	110	10
Ratfyn	4,250	45	120	15
Ringwood	4,750	50	120	15
Salisbury	6,500	70	150	15
Shrewton	3,000	30	100	10
Tilshead	7,000	195	290	65
Tisbury	3,750	40	110	10
Upavon	2,500	30	90	10
Warminster	5,250	55	130	15
Wishford	3,000	30	100	10
	94,000	1,485	3,150	470

5.2.3 Wetlands creation

The potential for wetlands to reduce phosphorous losses has been highlighted by this work and several other studies. The table below describes the potential costs associated with wetland creation in combination with the different scenarios.

Table 32 Shows the reduction needed and the estimated costs associated with wetland creation.

	Total P reduction needed for wetlands kg	Wetland removal rate	Wetland area needed ha	Cost of wetland per annum*	Total Cost of wetlands £ per annum	Cost benefit of wetland
Constructed Wetland – Farms – No change	18606	12 kg/ha	1551	£820 per ha	1,271,410	£837-1291 /ha/year * ¹ Figures from 2011 for England
Constructed Wetland – Farms – Full legislation	13130		1094		897,217	
Constructed Wetland - Farms Scenario 1	15696		1308		1,072,560	
Constructed Wetland – Farms Scenario 2	13376		1115		914,027	
Constructed Wetland Scenario 3 - Farms	10456		871		714,493	
Constructed Wetland – Scenario 4	9736		811		665,293	
SuDS - Urban	3447		287		235,340	

*Costs considered land rental, installation, monitoring and maintenance cost over an 80 year period taken from Somerset Levels and Moors Phosphate Mitigation Solutions 2022, *1 [Microsoft Word - nea morris freshwater working paper draft final may 2011 revised 5 pm_2_.docx](#)

The table shows the potential costs associated with the different number of wetlands constructed in the catchment, when compared to the costs of mitigation measures, wetlands are an attractive solution. The table also outlines the cost needed for mitigation of Urban sources.

Assigning monetary values for the benefit of wetlands is a difficult and dependent on several local, regional and national factors. Enhanced services include flood control, surface and groundwater supply, water quality improvements, amenity and aesthetics, recreation and biodiversity.

6 Appendix 6 Qualitative Option Appraisal

6.1 Options Appraisal

The purpose of this report is to identify if current interventions or measures will deliver favourable condition across the Hampshire Avon.

- 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

Table 33 : Showing the options appraisal structure and description of the criteria.

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 impacts 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 in place	Yes - No	Is a regulatory instrument in place to deliver this and is it within existing guidance? Yes or No
Additional regulation needed	WPZ Policy	WPZ – Water protection zone Policy – changes in policy such as fairshare
Delivery timescales	Baseline year of 2019 for delivery by 2033	Years, aligning RBPM3

The options available to achieve this are broken down to diffuse, alternative and point source measures respectively. Each option is evaluated in line with the technical and practical feasibility, socioeconomic impact, proportionality and cost benefit. This section also considers if existing policy or regulatory powers are in place to deliver the measures.

6.1.1 Diffuse and Alternative option evaluation.

The following section focuses on the evaluation of the different options considered in the review and is intended to provide information on the deliverability, impact, benefits and practicality of each aspect of the options considered in the review.

Table 34 : Shows the evaluation of the main options considered in the Consent Order review.

	P % Reduction	kg P reduction	Compliance with Fairshare for CSMG target	Technically Feasibly	Practically Feasibly	Socio economic impact	Cost Benefit	Regulatory instrument in place	Additional regulation required	Delivery Timescale (based on 2019 baseline and 2033 delivery target)
Agri Full Legislation	14.5	5476	Below	Yes	Low	Medium	No	Yes	No	4 years
Agri Scenario 1	7.7	2910	Below	Yes	High	Low	Yes	Yes	No	2 years
Agri Scenario 2	13.8	5230	Below	Yes	Medium	Medium	Yes	Partial	No	4 years
Agri Scenario 3	21.5	8150	Below	Yes	Low	High	No	No	WPZ	7 years
Agri Scenario 4	23.5	8870	Below	Yes	Low	High	No	No	WPZ	7 years
Agri Fairshare	40	18606*	Yes	Yes	Low	High	No	No	WPZ	14 years
Urban	24	1681*	Below	Yes	Medium	Low		No	WPZ	8 Years
Urban	40	2802*	Yes	Yes	Low	Low		No	WPZ	14 years
Unsewered	24	226*	Below	Yes	Medium	Low		No	WPZ	7 Years
Unsewered	40	377*	Yes	Yes	Low	Low		No	WPZ	14 years
Point Source Standstill + ROC			Yes	Yes	Yes	Low		Yes	Dutch legal?	7 years
Point source @ TAL			Beyond	Yes	Low	High		No	Policy	AMP 8 (2030)

*Groundwater mitigation included

For those measures outlined above which do not meet the requirements (Section **Error! Reference source not found.**) there is a need to implement alternative measures such as wetland creation and land use change, the options have been evaluated in the table below.

Table 35 : Shows the evaluation of the alternative options considered in the Consent Order review.

	P % Reduction	kg P reduction	Compliance with Fairshare for CSMG	Technically Feasibly	Practically Feasibly	Socio economic impact	Cost Benefit	Regulatory instrument in place	Additional regulation required
Reduction in Stocking			-	Yes	Medium	Low		No	WPZ
Land use Change			-	Yes	Medium	Low		No	WPZ
Wetland Creation			-	Yes	Medium	Low		No	WPZ
Urban SUDS			-	Yes	Medium	Low		No	WPZ

7 SAGIS SIMCAT 2024 Scenario descriptions: From N&NR Modelling Summary Methodology Appendix 2.

Approach:

The modelling follows a standard set of scenarios for each site, to be reviewed with Area to ensure applicable. These are based on a standard set of assumptions and National Farmscoper modelling (see links below to the outputs) to largely reflect current and planned regulatory measures.

- [Nutrients and Nature Recovery Farmscoper modelling - Nov 2023.pdf](#)
- [Annex 1 Outputs pollutant loads reductions.xlsx](#)

Benefits of this work:

- Analysis will follow the revised polluter pays principle.
- Using the updated PR24 models to test scenarios (outputs will be commensurate with current water company planning)
- Using more recent figures from Farmscoper v5 (based on the 2019 Agriculture Census)

Scenario	Description	Tools & Method	Point Source Representation	Diffuse Representation
1. Current Quality.	To represent all delivered measures from the 2010 baseline. This will reflect compliance comparable with current in-river monitoring.	• PR24 calibration models.	Current flows and quality based on monitoring data.	Current inputs based on monitored in river data and model calibration of inputs from NEAP-N and Psychic.
Scenario	Description	Tools & Method	Point Source Representation	Diffuse Representation
2. Current Regulation 2025	To represent all delivered and planned regulatory measures from the 2010 baseline up to 2025.	• PR24 At Permit models with % reduction in diffuse input <u>loads</u> based on Farmscoper outputs.	Fully permitted AMP7 schemes. And any relevant Green Growth Schemes.	Diffuse input loads % reduction based on full (100%) compliance with required regulatory measures, 25% for Farming Rules for Water 'reasonable' measures (based

		• Farmscoper V5 representing full regulatory compliance.		on National Farmscoper Scenario 4 outputs). This represents pollutant load reductions from a full compliance rate for regulatory measures.
3. Current Planned 2030 Same as scenario 2 but using certain AMP8 schemes for STWs.	To represent all delivered and planned regulatory measures from the 2010 baseline up to 2030.	• PR24 At Permit models with % reduction in diffuse input <u>loads</u> based on Farmscoper outputs. • Farmscoper V5 representing full regulatory compliance.	Certain AMP8 schemes (all statutory drivers – NN TAL, HD IMP, UWW etc). And any relevant Green Growth Schemes.	As Scenario 2.
4. Optional – will not apply everywhere - Future Planned 2035	Includes scenario 3. To represent AMP9 and meeting the planned targets of the Environment Act.	• PR24 at permit models • Farmscoper V5 • Environment Act Long Term Targets New legally binding environment targets set out - GOV.UK (www.gov.uk) •	AMP9 schemes. (essentially the 80% reduction at STWs constrained by TAL). Do we need the catchment specific reductions from Neil?	As Scenario 2. – should this be the 75% uptake rate instead?
5. Theoretical Maximum	Includes scenario 3. To represent AMP9 and meeting the planned targets of the	• PR24 at permit models • Farmscoper V5 • Environment Act Long Term Targets	As Scenario 4. AMP9 schemes. (essentially the 80% reduction at STWs constrained by TAL).	Diffuse input loads % reduction based on full 100% compliance across all measures (based on National Farmscoper

	Environment Act.	New legally binding environment targets set out - GOV.UK (www.gov.uk)		Scenario 10 outputs).
6. Fair share reductions applied	Forward run to assess whether there are any non-compliant stretches, to help provide reassurance of validity of approach.	• PR24 At Permit models. • Diffuse catchment average <u>concentrations</u> applied.	As Scenario 4.	Catchment average diffuse sector share concentration (diffuse target) applied to the headwater and reach concentrations (NB. Headwater concentration may need to be constrained – headwater concentration should not exceed calibrated concentration or CSMG).

Catchment Specific Modelling Scenarios – to progressed following consultation with Areas/ NE on the above and the full suite of National Farmscoper Scenarios.

Scenario	Description	Tools & Method	Point Source Representation (examples only – need to be realistic for catchment)	Diffuse Representation (examples only – need to be realistic for catchment)
7. What If Scenarios (examples for illustration here, scenarios to be agreed with Areas/ NE)	Assess combinations of point and diffuse measures and implications for achieving CSMG compliance.	• PR24 at permit models • Farmscoper V5 outputs • Land Use Choices Tool outputs potentially (not expected until 2025)	e.g. Gap Filling – exploring opportunities for the water company to go further beyond TAL	e.g. % reductions based on reductions in stocking densities.
	Number and combination of measures will need to be constrained to ensure this		e.g. reduce headroom in flow permit.	e.g. % reductions based on land use change as represented by Farmscoper.
			e.g. pump STWs out of catchment.	e.g. % reduction based on figures from Land Use Choices Tool –

	does not become undeliverable. Some catchments will need more combinations of measures tested than others.			data not expected until 2025
Catchment Specific Sensitivity Testing				
8. Sensitivity Testing	Test results (if there are concerns about the accuracy or influence of a particular sector).	PR24 at permit models	e.g. test less pessimistic assessment of phosphorus concentrations post phosphorus removal (e.g. 70% TAL)	

8 Appendix Orthophosphate and Total Phosphorus concentration and loads across the Hampshire Avon catchments, 2000 to 2025.

1. Background

This report presents an assessment of long-term trends in orthophosphate (OP) and total phosphorus (TP) concentrations and loads across the Hampshire Avon catchment. The work supports ongoing evaluation of nutrient pressures in the catchment and provides updated evidence to inform nutrient management, regulatory decision-making and future catchment interventions. Two approaches to load estimation have been applied:

- **Step-interpolation**, consistent with the methodology previously used to support the Hampshire Avon Nutrient Management Plan¹
- **Weighted Regressions on Time, Discharge and Season (WRTDS)**, a statistical modelling framework developed by the United States Geological Survey².

The assessment focuses primarily on the period 2010 to 2025, reflecting the period following major reductions in point-source phosphorus inputs associated with widespread sewage treatment works (STW) phosphate stripping. Earlier data (from 2000 onwards) are included at selected locations to provide methodological comparison and longer-term context.

2. Methods

Monitoring Data

Orthophosphate (Det 0180) and total phosphorus (Det 0348) data for the period 2000–2025 were extracted from the Environment Agency Water Information Management System (WIMS). Data were available at a series of strategically selected sites representing major sub-catchments of the Hampshire Avon (see table 1).

Sampling frequency varies between sites, with:

- Weekly monitoring at Catchment Sensitive Farming (CSF) programme sites since 2007/08 (or 2009)
- Monthly sampling at upstream Avon sites and at Knapp Mill throughout the record

Associated daily mean river flow data were obtained from the Environment Agency Hydrology Data Explorer. Where short gaps were present, linear interpolation was applied. At Stratford-sub-Castle, where no gauged flow is available, a simulated daily flow series provided by the EA Hydrology Team was used.

Load estimation approaches

Step-interpolation

The step-interpolation method assumes that each measured concentration is representative of the period until the next sample. Concentrations are combined with daily river flow to estimate daily loads, which are aggregated to annual totals.

This method is simple, transparent, and consistent with legacy assessments; however, it is sensitive to sampling frequency and may misrepresent loads during short-duration high-flow events that occur between samples.

WRTDS modelling

WRTDS modelling was undertaken using the EGRET package in R. The method decomposes observed concentration time series into components related to Discharge, Seasonality and Long-term temporal trends.

The approach is suited to irregularly spaced environmental datasets and allows for changes in the concentration–discharge relationship through time. A key output is flow-normalised concentration and load, which removes the effect of interannual flow variability and provides a clearer indication of changes in contaminant inputs and catchment processes.

Default model settings were used throughout, including application of WRTDSKalman smoothing. All analyses were undertaken on a calendar-year basis.

Further information on WRTDS can be found in Appendix A.

Table1: WQ sampling sites, sample frequency and associated flow gauging stations

Sampling Point	Site Name	Sample Freq	Gauging Station
50210705	Western Avon At Upavon	Monthly	Upavon West
50211405	Eastern Avon At Upavon	Monthly	Upavon East
50210316	Hampshire Avon At Amesbury	Monthly	Amesbury
50210209	Hampshire Avon At Str Sub Castle [#]	Weekly	Stratford [*]
50220136	River Nadder At Wilton [#]	Weekly	Wilton
50230145	River Wylfe At South Newton [#]	Weekly	South Newton
50240116	River Bourne At Laverstock [#]	Weekly	Laverstock
50250102	River Ebbles D/S Longford Fish Farm [#]	Weekly	Nunton
50280585	Hampshire Avon At Fordingbridge [#]	Weekly	East Mills
50280271	Hampshire Avon At Knapp Mill	Monthly	Knapp Mill

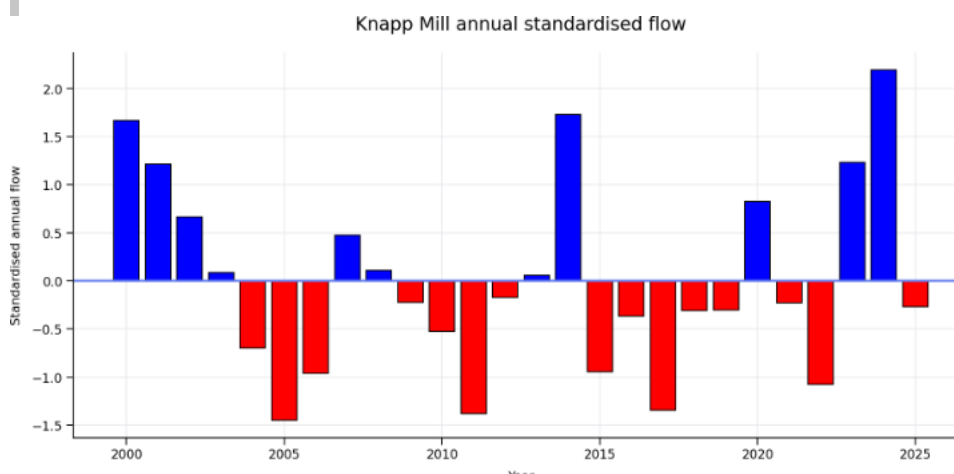
^{*}Modelled flow [#]Weekly since 2007/8 or 2009

3. Results

3.1 Hydrological context

To ensure that changes in load are evaluated relative to underlying hydrological conditions, annual mean flows were assessed against the long-term mean flow. The resulting comparison is presented in Figure 2. Annual mean flows show substantial interannual variability across the assessment period, with several notably wet years particularly toward the beginning and end of the study period.

Figure 1: Standardised Annual Flow against 2000-2025 Mean flow at Knapp Mill. (Blue bars are above mean, red bars, below mean)

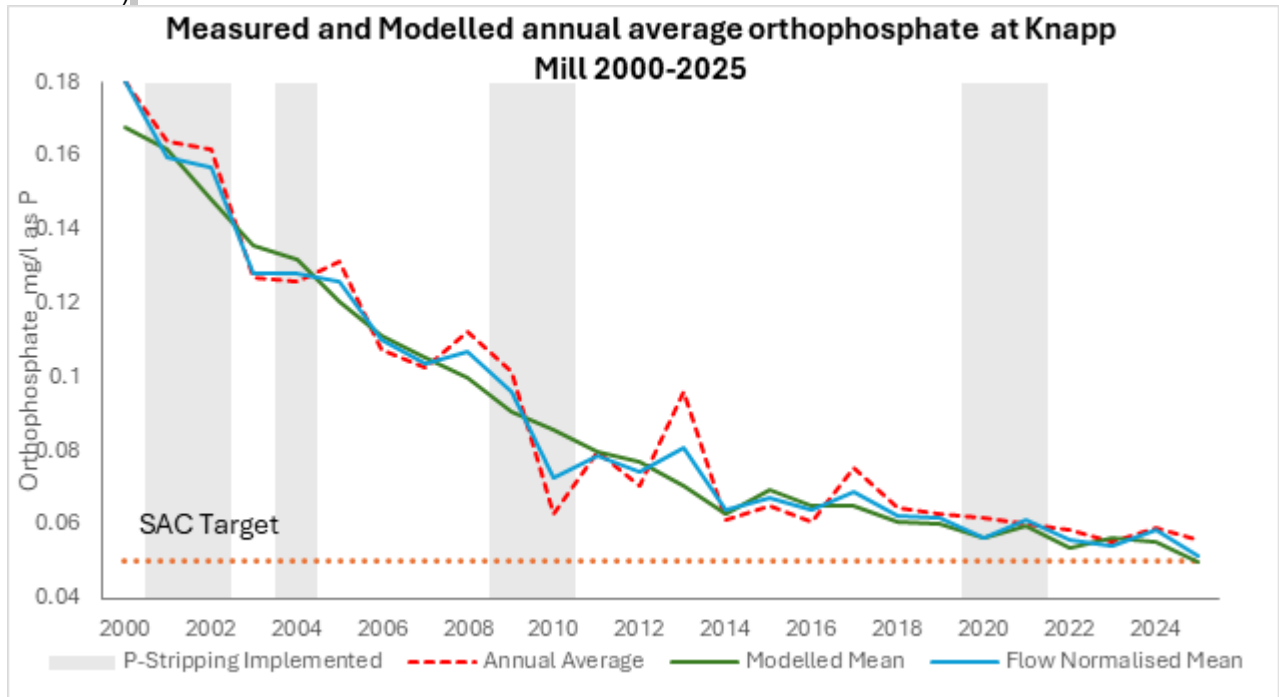


3.2 Concentration trends

At Knapp Mill, WRTDS-modelled annual mean orthophosphate concentrations show good agreement with sample-derived annual means (Figure 2), indicating acceptable model performance despite lower sampling frequency at this site.

Across the catchment, annual mean concentrations have declined substantially since the early 2000s, with the most pronounced reductions occurring prior to 2010. Post-2010, changes are more gradual, with concentrations broadly stabilising or declining slowly at most sites.

Figure 2: Annual mean orthophosphate concentration at Knapp Mill (Samples and Modelled estimates)



3.3 Load estimates and method comparison

Annual loads derived using step-interpolation and WRTDS show broadly similar temporal patterns at most sites and in most years. There is no consistent directional bias between methods across the catchment.

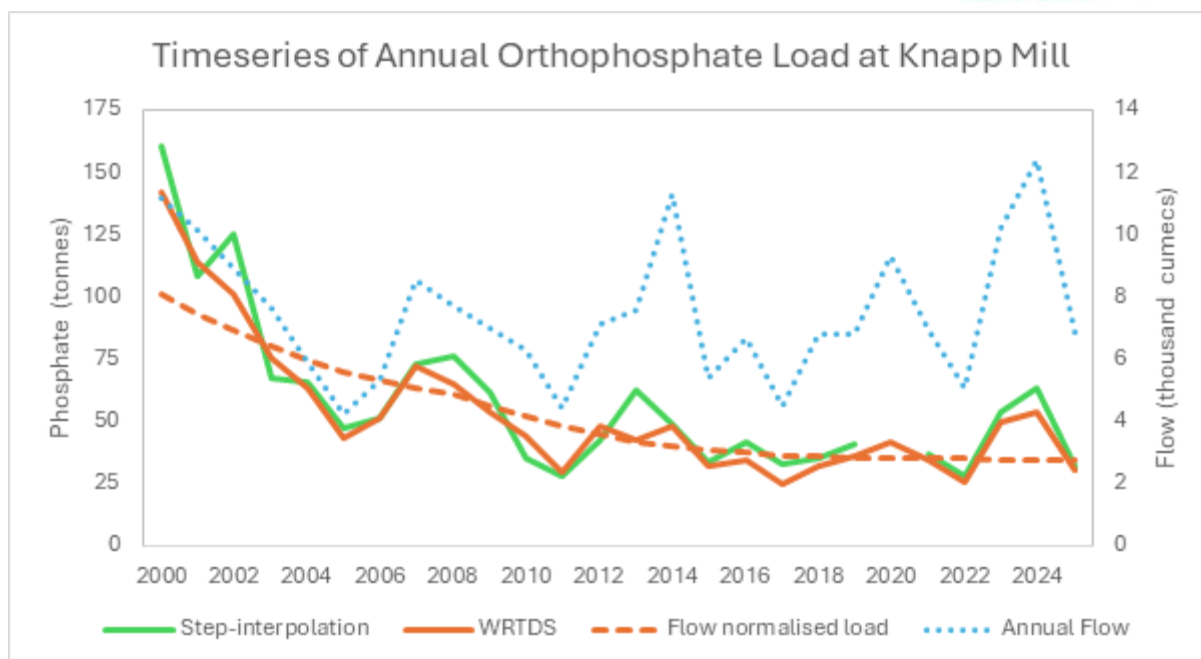
However:

- At sites with weekly sampling, differences between methods are generally small and stable
- At Knapp Mill, which has monthly (and occasionally sparse) sampling, step-interpolation estimates show greater interannual variability, particularly in high-flow years (Figure 3)

This reflects the increased sensitivity of step-interpolation to individual samples under conditions of low sampling density and variable flow.

Loads are subject to large interannual fluctuation, mirroring flow fluctuations.

Figure 3: Temporal change in load 2000-2025 for Knapp Mill



The full load calculations from both models are shown in Appendix B.

3.4 Flow-normalised trends

WRTDS flow-normalised load estimates for OP and TP (Appendix B4 & B8) indicate:

- An overall reduction in orthophosphate loads of between 4–9% (1-2 tonnes) since 2010 at several sub-catchment sites (notably Amesbury, Wilton and Laverstock)
- Little change or a slight increase in OP at Stratford-sub-Castle
- A reduction in Total Phosphorus loads across sites of between 4-18% (0.5 – 11.2 tonnes) since 2010

These results exclude Knapp Mill. While overall phosphorus pressures have reduced since the implementation of phosphate stripping, further reductions since 2010 have been very modest and spatially variable across the catchment.

The magnitude of change is small relative to the expected uncertainty in annual load estimates and should be interpreted as indicative rather than conclusive evidence of further load reduction. The results are consistent with a plateauing of improvements following major point-source controls rather than a strong continuing downward trend.

4. Discussion

4.1 Influence of flow and monitoring limitations

River flow remains the dominant control on annual phosphorus loads. Consequently, uncertainty in flow measurement directly affects confidence in load estimates.

At Knapp Mill, ongoing gauge bypassing results in significant uncertainty in both low-flow and high-flow estimates, reducing confidence in calculated loads at this point. Similarly, East Mills (Fordingbridge) is known to be affected by bypassing at higher flows, with work underway to improve the flow-stage rating.

4.2 Methodological considerations

Step-interpolation remains useful for transparency and continuity with historic assessments, but its limitations become pronounced where the sampling frequency is low, the Concentration–discharge relationships are non-linear or where high-flow events dominate annual loads (flashy catchments).

WRTDS addresses many of these limitations by explicitly modelling flow dependence and seasonality and by providing flow-normalised outputs that are better suited to assessing changes in catchment pressures.

As a statistical model, WRTDS relies on the quality and representativeness of underlying data. Confidence in outputs is therefore highest where sampling frequency and flow records are robust.

4.3 Nutrient concentration/load changes

Flow-normalised WRTDS outputs indicate modest reductions in orthophosphate load (of order 4–9%) at some sub-catchment sites since 2010. However, the analysis does not provide conclusive evidence of a statistically significant catchment-wide reduction in phosphorus losses over the 2010-2025 assessment period.

The presence of consistent year-on-year reductions in flow-normalised load at several sub-catchment sites strengthens confidence that phosphorus pressures have not increased and may be gradually reducing in some areas. However, the magnitude of change is small relative to uncertainty, and evidence is insufficient to demonstrate a statistically robust catchment-wide reduction.

Recommendations

Knapp Mill should not be used as a primary site for phosphorus load assessment due to flow measurement uncertainty. It remains suitable for long-term concentration trend analysis only.

Step-interpolation remains useful for transparency and continuity with historic assessments but its use should be limited to higher frequency monitoring sites only.

WRTDS flow-normalised outputs should be the preferred metric for long-term trend assessment, particularly when evaluating policy effectiveness.

Appendix A: WRTDS Approach to estimating loads

The Logic Behind Using Flow Normalisation

Flow varies a lot from year to year — wet years, dry years, flashy years.

Because $\text{load} = \text{concentration} \times \text{flow}$, any change in annual river flow can appear as a change in water quality.

Example:

A wet year → high loads even if pollution inputs have not changed.

A dry year → low loads even if pollution inputs are worsening.

Flow normalisation fixes this problem by removing hydrologic randomness

Flow-Normalised Concentration (FN-C)

“If long-term flow conditions had been ‘average’ every year, what concentration would we have expected in that year?”

Instead of using the actual discharge on each day of year, the method uses a representative long-term distribution of flows (typically the whole period’s distribution). FN-C is then the expected concentration under *this standardised flow regime*.

FN-C shows the true directional change in water quality after removing flow variability.

Flow-Normalised Load (FN-L)

“Given the average long-term flow distribution, how much P would the river have exported in that year, based only on changes in the concentration–flow–time relationship?”

WRTDS models a predicted concentration for every possible flow across the representative flow distribution. It multiplies $\text{concentration} \times \text{flow}$ across that distribution and combines this to produce the annual FN-L.

This removes “wet-year artificial load spikes” and “dry-year artificial load dips”. FN-L is therefore the best indicator of changes in catchment inputs (agricultural, point-source, land-use changes).

Appendix B: Load and Concentration summary tables

Table B1. Annual load estimate for orthophosphate in the Hampshire Avon 2000 to 2025 using step-interpolation method

Year	Upavon West	Upavon East	Amesbury	Stratford	Wilton	South Newton	Laverstock	Nunton	East Mills	Knapp Mill
2000	10.5	12.9	40.2	47.1	27.4	18.7	5.7		170.4	160.6
2001	8.1	10.0	28.9	34.7	19.1	14.1	7.5		104.5	108.0
2002	7.2	6.8	25.6	34.1	12.4	16.8	4.4		96.1	124.7
2003	4.4	5.9	14.7	20.9	9.4	12.1	5.9	1.4	54.8	67.5
2004	4.1	4.5	9.8	10.5	8.1	10.0	2.3	1.5	52.0	65.9
2005	2.7	3.2	8.3	8.5	5.1	7.2	2.0	0.8	44.4	47.2
2006	3.8	3.5	9.1	11.7	6.8	8.3	2.1	1.2	45.5	50.7
2007	5.5	5.8	15.5	17.8	10.6	10.4	3.1	2.2	62.3	72.7
2008	5.6	5.5	18.6	20.5	11.6	10.5	2.5	2.0	67.7	75.8
2009	4.0	4.4	12.0	12.0	8.9	10.4	2.1	2.0	54.1	61.3
2010	3.2	3.7	8.2	7.6	5.8	5.8	1.2	1.0	29.9	34.8
2011	2.4	2.8	5.5	5.5	3.5	4.7	0.6	0.9	23.1	28.1
2012	5.5	3.9	15.8	12.7	10.6	9.5	1.1	2.6	48.5	42.0
2013	4.9	5.6	14.8	13.5	9.1	8.2	3.7	2.0	49.4	62.0
2014	8.2	8.1	18.2	19.4	13.8	12.9	5.2	3.4	62.7	48.5
2015	3.2	3.6	7.8	7.6	5.6	6.6	0.9	1.2	28.5	33.4
2016	4.3	4.1	10.3	10.3	6.4	6.9	1.0	1.7	35.3	41.4
2017	2.9	2.8	7.2	6.5	4.1	6.3	0.6	0.9	24.9	32.5
2018	3.9	3.6	8.4	9.4	7.0	7.0	0.9	1.6	33.3	35.2
2019	4.6	3.9	10.9	10.3	7.7	8.4	0.8	2.0	38.8	40.3
2021	4.7	5.6	11.3	10.3	8.7	7.7	1.3	1.5	34.4	36.4
2022	2.4	3.2	6.0	6.4	4.9	6.4	0.7	1.1	26.5	28.1 ^{\$}
2023	5.6	6.1	14.3	17.1	13.2	12.4	1.7	3.0	60.8	53.6 [#]
2024	8.5	10.0	20.4	26.8	14.1	14.7	4.9	3.4	78.5	63.3
2025	!	!	12.1	10.5	7.9	9.4	2.3	1.6	38.9	31.5 [#]

! Insufficient data due to sampling access issues

\$ Following outlier analysis, a single erroneous sample result was removed from the Knapp Mill dataset for 2022.

[#] There was a reduced dataset due to capacity issues at the national laboratory Starcross

Table B2. Annual load estimate for Total Phosphorus in the Hampshire Avon 2000 to 2025 using **step-interpolation method**

Year	Stratford	Wilton	South Newton	Laverstock	Nunton	East Mills	Knapp Mill
2000							208.8
2001							147.3
2002							170.9
2003							83.8
2004							91.7
2005					1.0		64.2
2006		9.7			2.2		59.4
2007		15.8			3.5		80.8
2008		19.2			3.4		96.2
2009	15.6	14.2	11.6	2.6	3.1	71.9	86.8
2010	10.4	7.9	7.5	1.6	1.6	42.0	52.0
2011	7.9	6.2	4.8	0.8	1.4	32.5	39.3
2012	16.5	13.4	12.9	1.3	3.7	66.6	61.5
2013	17.9	16.8	12.6	4.4	3.5	73.5	87.2
2014	25.9	24.8	21.7	6.4	5.2	99.3	81.9
2015	10.5	10.9	7.7	1.2	2.0	44.2	52.4
2016	14.2	10.9	8.9	1.4	2.4	54.0	61.7
2017	9.4	9.2	5.7	0.9	1.5	36.9	45.9
2018	13.8	10.7	10.3	1.3	2.7	53.9	57.3
2019	14.7	12.2	10.5	1.3	2.8	58.3	60.5
2021	14.0	10.6	10.6	1.8	2.1	46.1	30.5
2022	8.8	9.0	6.6	1.0	1.6	39.1	30.6 ^{\$}
2023	22.1	19.0	16.9	2.4	4.1	83.1	75.9 [#]
2024	31.4	19.8	18.1	5.9	4.8	103.3	81.6
2025	14.9	13.5	10.5	2.9	2.4	54.6	40.1 [#]

^{\$} Following outlier analysis, a single erroneous sample result was removed from the Knapp Mill dataset for 2022.

[#] There was a reduced dataset due to capacity issues at the national laboratory Starcross

Table B3. WRTDS modelled annual load estimates (tonnes per year) for orthophosphate

Year	Upavon West	Upavon East	Amesbury	Stratford	Wilton	South Newton	Laverstock	Nunton	East Mills	Knapp Mill
2010	3.36	3.93	9.08	8.87	6.14	6.35	1.35	1.21	33.50	38.20
2011	2.34	2.81	5.58	4.91	4.42	3.50	0.65	0.86	22.80	27.60
2012	6.31	4.53	12.88	13.02	11.25	9.46	1.49	2.44	46.10	44.40
2013	5.21	5.73	12.79	13.69	9.06	8.67	3.13	1.96	46.20	41.10
2014	8.36	8.98	18.94	20.79	14.53	13.09	5.78	3.37	63.90	47.60
2015	3.10	3.83	7.55	7.67	6.53	5.48	0.94	1.23	29.40	31.60
2016	4.43	4.58	9.48	10.06	7.69	7.10	1.11	1.67	35.30	34.50
2017	2.80	2.88	5.84	5.85	5.36	3.85	0.67	0.82	22.60	24.80
2018	3.98	3.67	8.52	9.08	7.85	6.61	1.00	1.68	33.20	32.20
2019	5.00	4.05	10.77	11.29	9.85	7.80	1.04	2.27	41.90	36.10
2021	4.43	5.17	10.62	11.56	8.57	8.06	1.36	1.89	38.90	34.50
2022	2.74	3.24	5.96	6.35	6.62	5.14	0.75	1.22	27.10	25.40\$
2023	7.09	7.40	17.17	18.83	14.65	13.05	2.24	3.27	63.60	49.50#
2024	9.51	11.65	21.17	24.20	17.17	14.24	4.85	3.42	74.70	53.10
2025	!	!	9.49	11.08	8.81	7.41	2.13	1.52	38.00	30.20#

! Insufficient data due to sampling access issues

\$ Following outlier analysis, a single erroneous sample result was removed from the Knapp Mill dataset for 2022.

There was a reduced dataset due to capacity issues at the national laboratory Starcross

Table B4. WRTDS flow normalised load estimates (tonnes per year) for orthophosphate

Year	Upavon West	Upavon East	Amesbury	Stratford	Wilton	South Newton	Laverstock	Nunton	East Mills	Knapp Mill
2010	5.27	5.34	11.4	11.50	9.69	8.28	2.08	1.94	42.5	42.4
2011	5.23	5.3	11.4	11.60	9.68	8.28	2.08	1.95	42.4	41.6
2012	5.21	5.28	11.4	11.80	9.68	8.3	2.08	1.96	42.4	40.8
2013	5.17	5.25	11.4	11.80	9.66	8.29	2.06	1.97	42.2	39.9
2014	5.14	5.23	11.4	11.90	9.65	8.3	2.05	1.98	42.1	39
2015	5.11	5.23	11.5	12.00	9.66	8.3	2.03	1.98	42	38.1
2016	5.09	5.25	11.5	12.10	9.71	8.28	1.99	1.99	41.8	37
2017	5.05	5.28	11.5	12.10	9.74	8.22	1.91	1.98	41.5	35.8
2018	5.01	5.31	11.5	12.20	9.75	8.19	1.87	1.98	41.7	35
2019	4.92	5.32	11.4	12.40	9.67	8.19	1.86	1.99	42.2	34.7
2021	4.71	5.34	11.2	12.40	9.34	8.13	1.86	1.98	42	34.5
2022	4.6	5.34	11	12.30	9.23	8.09	1.87	1.97	41.7	34.1
2023	4.49	5.34	10.8	12.20	9.14	8.05	1.88	1.96	41.3	33.8#
2024	4.39	5.34	10.7	12.20	9.06	8.01	1.9	1.95	41.1	33.4
2025	!	!	10.5	12.00	8.96	7.95	1.9	1.94	40.7	33.1#

! Insufficient data due to sampling access issues

There was a reduced dataset due to capacity issues at the national laboratory starcross

Table B5. WRTDS modelled annual average concentration for orthophosphate 2010 to 2025.

Year	Upavon West	Upavon East	Amesbury	Stratford	Wilton	South Newton	Laverstock	Ebble	East Mills	Knapp Mill
2010	0.254	0.163	0.0946	0.067	0.0960	0.0612	0.0554	0.0412	0.0767	0.0729
2011	0.262	0.149	0.0929	0.060	0.0977	0.0595	0.0563	0.0400	0.0758	0.0727
2012	0.234	0.163	0.0993	0.075	0.0961	0.0646	0.0501	0.0434	0.0777	0.0718
2013	0.240	0.175	0.0942	0.073	0.0989	0.0610	0.0619	0.0417	0.0755	0.0670
2014	0.238	0.193	0.0977	0.079	0.1025	0.0615	0.0663	0.0432	0.0746	0.0621
2015	0.235	0.158	0.0906	0.068	0.0964	0.0604	0.0511	0.0410	0.0746	0.0686
2016	0.227	0.164	0.0910	0.072	0.0987	0.0605	0.0507	0.0404	0.0740	0.0650
2017	0.224	0.144	0.0854	0.065	0.0954	0.0589	0.0467	0.0388	0.0715	0.0653
2018	0.221	0.152	0.0867	0.068	0.0995	0.0596	0.0470	0.0397	0.0719	0.0609
2019	0.216	0.155	0.0929	0.072	0.0995	0.0603	0.0462	0.0411	0.0735	0.0603
2021	0.192	0.170	0.0924	0.075	0.0980	0.0611	0.0476	0.0421	0.0730	0.0596
2022	0.196	0.146	0.0807	0.063	0.0957	0.0589	0.0428	0.0385	0.0674	0.0538
2023	0.191	0.189	0.1005	0.083	0.1028	0.0621	0.0528	0.0434	0.0766	0.0565*
2024	0.192	0.219	0.1047	0.088	0.1046	0.0622	0.0617	0.0437	0.0772	0.0553
2025	!	!	0.0839	0.070	0.0977	0.0593	0.0492	0.0356	0.0673	0.0501*

! Insufficient data due to sampling access issues

*There was a reduced dataset due to capacity issues at the national laboratory starcross

Table B6. WRTDS modelled flow normalised concentration for orthophosphate.

Year	Upavon West	Upavon East	Amesbury	Stratford	Wilton	South Newton	Laverstock	Ebble	East Mills	Knapp Mill
2010	0.250	0.173	0.0953	0.069	0.0984	0.0620	0.0577	0.0420	0.0768	0.0714
2011	0.247	0.171	0.0949	0.070	0.0986	0.0619	0.0573	0.0419	0.0765	0.0703
2012	0.244	0.170	0.0946	0.071	0.0989	0.0617	0.0569	0.0418	0.0761	0.0692
2013	0.241	0.169	0.0942	0.071	0.0992	0.0615	0.0563	0.0418	0.0757	0.0681
2014	0.238	0.168	0.0939	0.072	0.0995	0.0613	0.0558	0.0417	0.0753	0.0669
2015	0.235	0.168	0.0937	0.072	0.0998	0.0611	0.0551	0.0415	0.0749	0.0657
2016	0.232	0.167	0.0935	0.072	0.1003	0.0607	0.0539	0.0411	0.0743	0.0642
2017	0.228	0.167	0.0933	0.073	0.1006	0.0602	0.0522	0.0407	0.0737	0.0623
2018	0.222	0.167	0.0930	0.073	0.1008	0.0598	0.0508	0.0404	0.0733	0.0606
2019	0.214	0.167	0.0924	0.073	0.1004	0.0596	0.0497	0.0404	0.0730	0.0593
2021	0.199	0.166	0.0907	0.073	0.0988	0.0600	0.0489	0.0402	0.0719	0.0572
2022	0.192	0.166	0.0898	0.073	0.0985	0.0601	0.0486	0.0401	0.0712	0.0561
2023	0.186	0.166	0.0889	0.073	0.0982	0.0602	0.0482	0.0400	0.0705	0.0550*
2024	0.179	0.166	0.0878	0.073	0.0979	0.0603	0.0480	0.0399	0.0698	0.0539
2025	!	!	0.0868	0.073	0.0978	0.0605	0.0477	0.0398	0.0691	0.0529*

! Insufficient data due to sampling access issues

*There was a reduced dataset due to capacity issues at the national laboratory starcross

Table B7. WRTDS modelled load estimates for Total Phosphorus (tonnes per year)

Year	Stratford	Wilton	South Newton	Laverstock	Nunton	East Mills	Knapp Mill
2010	12.43	8.69	8.35	2.10	1.82	52.00	60.20
2011	6.86	6.09	4.74	0.95	1.32	33.50	40.70
2012	17.59	16.74	12.28	2.00	3.61	68.10	69.10
2013	18.79	12.91	11.54	3.91	2.98	67.60	63.80
2014	26.83	21.38	17.10	6.66	4.82	89.30	71.70
2015	10.65	9.26	7.48	1.28	1.89	43.10	48.00
2016	14.09	11.29	9.73	1.52	2.53	52.80	53.50
2017	8.27	7.55	5.31	0.92	1.25	33.20	37.90
2018	12.85	11.66	9.15	1.40	2.52	49.90	50.20
2019	15.02	14.61	10.19	1.42	3.15	58.20	53.60
2021	15.54	12.17	10.59	1.83	2.64	54.90	50.10 [#]
2022	8.63	9.04	6.75	1.02	1.73	38.40	37.40 [#]
2023	24.26	20.81	16.48	2.92	4.44	83.60	64.50 [#]
2024	30.74	24.39	18.01	5.81	4.71	98.90	67.70 [#]
2025	14.50	11.63	9.50	2.66	2.10	51.30	41.10 [#]

[#]There was a reduced dataset due to capacity issues at the national laboratory starcross

Table B8. WRTDS modelled load estimates for flow normalised load of Total Phosphorus (tonnes per year)

Year	Stratford	Wilton	South Newton	Laverstock	Nunton	East Mills	Knapp Mill
2010	16.50	14.00	11.05	2.85	2.89	65.10	68.30
2011	16.60	14.10	11.13	2.77	2.94	64.10	66.40
2012	16.60	14.20	11.19	2.71	2.98	63.00	64.50
2013	16.60	14.20	11.17	2.63	2.99	61.60	62.20
2014	16.60	14.30	11.16	2.58	2.98	60.80	60.20
2015	16.70	14.50	11.16	2.55	2.95	60.20	58.60
2016	16.80	14.70	11.13	2.51	2.92	59.70	57.30
2017	16.80	14.70	11.01	2.47	2.87	59.10	55.40
2018	16.90	14.60	10.95	2.43	2.84	58.90	54.00
2019	17.10	14.40	10.93	2.41	2.83	59.10	53.20
2021	17.00	13.40	10.71	2.38	2.78	57.90	50.80 [#]
2022	16.70	13.00	10.58	2.37	2.75	56.80	49.20 [#]
2023	16.40	12.70	10.45	2.36	2.72	55.80	47.70 [#]
2024	16.20	12.30	10.34	2.35	2.70	54.90	46.20 [#]
2025	15.90	12.00	10.20	2.34	2.68	53.90	44.70 [#]

[#]There was a reduced dataset due to capacity issues at the national laboratory starcross

Table B9. WRTDS modelled annual average concentration for Total Phosphorus (mg/l).

Year	Stratford	Wilton	South Newton	Laverstock	Nunton	East Mills	Knapp Mill
2010	0.093	0.131	0.080	0.085	0.060	0.115	0.111
2011	0.083	0.129	0.079	0.077	0.060	0.108	0.105
2012	0.103	0.142	0.086	0.072	0.065	0.116	0.110
2013	0.100	0.134	0.081	0.081	0.063	0.108	0.099
2014	0.104	0.144	0.081	0.083	0.064	0.106	0.092
2015	0.093	0.130	0.081	0.068	0.062	0.105	0.100
2016	0.097	0.132	0.080	0.068	0.059	0.105	0.094
2017	0.088	0.126	0.078	0.064	0.056	0.100	0.096
2018	0.093	0.133	0.078	0.064	0.057	0.101	0.089
2019	0.098	0.137	0.079	0.063	0.059	0.103	0.088
2021	0.098	0.130	0.079	0.064	0.059	0.100	0.084 [#]
2022	0.085	0.121	0.075	0.058	0.054	0.093	0.081 [#]
2023	0.106	0.139	0.079	0.069	0.060	0.101	0.074 [#]
2024	0.111	0.142	0.078	0.077	0.060	0.101	0.070 [#]
2025	0.089	0.121	0.073	0.063	0.048	0.089	0.072 [#]

[#]There was a reduced dataset due to capacity issues at the national laboratory starcross

Table B10. WRTDS modelled flow normalised concentration for Total Phosphorus (mg/l).

Year	Stratford	Wilton	South Newton	Laverstock	Nunton	East Mills	Knapp Mill
2010	0.098	0.138	0.082	0.086	0.061	0.117	0.110
2011	0.098	0.138	0.082	0.082	0.062	0.115	0.107
2012	0.098	0.138	0.082	0.078	0.063	0.112	0.104
2013	0.098	0.137	0.082	0.075	0.063	0.109	0.101
2014	0.098	0.137	0.081	0.073	0.063	0.107	0.098
2015	0.098	0.137	0.081	0.072	0.062	0.106	0.096
2016	0.098	0.138	0.080	0.071	0.061	0.105	0.094
2017	0.098	0.138	0.079	0.069	0.059	0.104	0.091
2018	0.099	0.138	0.079	0.068	0.058	0.103	0.088
2019	0.099	0.136	0.078	0.066	0.058	0.102	0.086
2021	0.097	0.131	0.077	0.065	0.057	0.099	0.082 [#]
2022	0.096	0.128	0.077	0.064	0.056	0.097	0.080 [#]
2023	0.095	0.126	0.076	0.063	0.055	0.095	0.078 [#]
2024	0.094	0.124	0.076	0.062	0.055	0.094	0.075 [#]
2025	0.093	0.122	0.076	0.061	0.054	0.092	0.073 [#]

[#]There was a reduced dataset due to capacity issues at the national laboratory starcross

9 References

1. The impact of phosphorus inputs from small discharges on designated freshwater sites
- 9.1.1.1 (NECR170) -<http://publications.naturalengland.org.uk/publication/6150557569908736>
2. Bingham et al, 2020. Rates of hydroxyapatite formation and dissolution in a sandstone aquifer; Implications for understanding dynamic phosphate behaviour within an agricultural catchment.
3. CSMG targets
<http://publications.naturalengland.org.uk/publication/4520877345472512?category=432368>
4. Dodd, R. J., McDowell, R. W., & Condon, L. M. (2012). Predicting the changes in environmentally and agronomically significant phosphorus forms following the cessation of phosphorus fertilizer applications to grassland. *Soil Use and Management*, 28(2), 135-147.
5. Evangelos Mouchos et al, 2022. Geochemical Cycling in Aquifers Contributing to the Transport, Storage and Transfer of Anthropogenically Derived Phosphorus to Surface Waters
6. River Avon Special Area of Conservation Nutrient Management Plan for phosphorus and
Annex 4: Phosphorus in the Hampshire Avon Special Area of Conservation;
[Nutrient Management Plan: Hampshire Avon - GOV.UK](#)
7. Withers, P et al (2024). Phosphorus and Water Quality in the Catchments of the Somerset Levels and Moors (Draft) Lancaster University 2024.
8. River Avon SAC- Phosphate Neutral Development; Wood 2019 :
<https://cms.wiltshire.gov.uk/documents/s157886/HRA0501RiverAvonSACPhosphateIDPMannualReport.pdf>
9. **Developing a stable isotope approach to trace the sources and metabolism of phosphorus in freshwaters. / Davies, Ceri.**
10. Gatiboni, L., Schmitt, D., Tiecher, T., Veloso, M., Rheinheimer Dos Santos, D., Kaminski, J., Brunetto, G. (2021). Plant uptake of legacy phosphorus from soils without P fertilization. *Nutrient Cycling in Agroecosystems*, 119, p. 129-151.
11. Catchment Sensitive Farming Evaluation Report – Water Quality Phases 1 to 4 (2006-2018) - NE731
12. European Site Conservation Objectives for River Avon SAC - UK0013016
13. UK0013016 RiverAvon SACv2018.pdf
14. Cole, B.; De la Barreda, B.; Hamer, A.; Codd, T.; Payne, M.; Chan, L.; Smith, G.; Balzter, H. (2021). **Corine land cover 2018 for the UK, Isle of Man, Jersey and Guernsey.**
15. Hampshire Avon Diffuse water Pollution Plan Modelling Outputs, 2024 Operations Catchment Services (OCS) Nutrients and Nature recovery Programme, Environment Agency.

16. <https://doi.org/10.5285/44c23778-4a73-4a8f-875f-89b23b91ecf8> - Morton, R.D.; Marston, C.G.; O'Neil, A.W.; Rowland, C.S. (2020). **Land Cover Map 2019 (land parcels, GB)**. NERC Environmental Information Data Centre.
17. NERC EDS Environmental Information Data Centre. <https://doi.org/10.5285/084e0bc6-e67f-4dad-9de6-0c698f60e34d> Any communication and publication by the beneficiary shall acknowledge that the action was carried out “with funding by the European Union”.
18. UPDATING THE ESTIMATE OF THE SOURCES OF PHOSPHORUS IN UK WATERS A Defra funded project WT0701CSF Philip J. White² and John P. Hammond.
19. Hampshire Avon Nutrient Management Plan Annex 4 Phosphorus in the Hampshire Avon Special Area of Conservation Technical Report; Giles Bryan April 2015. River Avon Special Area of Conservation (SAC) Nutrient Management Plan (NMP)
20. PSYCHIC – A process-based model of phosphorus and sediment mobilisation and delivery within agricultural catchments. Part 1: Model description and parameterisation
21. GOODAY et al., 2014. Gooday, R.D., Anthony, S.G., Chadwick, D.R., Newell-Price, P., Harris, D., Duethmann, D., Fish, R., Collins, A.L., Winter, M. 2014. Modelling the cost-effectiveness of mitigation methods for multiple pollutants at farm scale. *Science of the Total Environment*, 468-469, 1198-1209.
22. NEWELL-PRICE et al. 2011 Newell-Price, J.P., Harris, D., Taylor, M., Williams, J.R., Anthony, S.G., Duethmann, D., Gooday, R.D., Lord, E.I., Chambers, B.J., Chadwick, D.R., Misselbrook, T.H. 2011. User manual — ‘ALL’. An inventory of methods and their effects on diffuse water pollution, greenhouse gas emissions and ammonia emissions from agriculture. Final report for Defra Project WQ0106 (5), 162pp.
23. A.L. Collins, Y.S. Zhang, M. Winter, A. Inman, J.I. Jones, P.J. Johnes, W. Cleasby, E. Vrain, A. Lovett, L. Noble; Tackling agricultural diffuse pollution: What might uptake of farmer-preferred measures deliver for emissions to water and air?, *Science of The Total Environment*, Volume 547,
24. 2016, Pages 269-281, ISSN 0048-9697,

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