pCEA Synthesis Report
NUTRIENTS

1. Summary

Phosphorus (P)

- The extent of non-compliance with the proposed P standards for good ecological status of rivers and lakes in England, and to a lesser extent Wales, is significant. Half the river length in England is of less than good status (with 95% confidence) based on compliance for P. Further measures to control P pollution are a priority for consideration in the initial rounds of River Basin Planning. It is important to note that a weight-of-evidence approach will be applied to the standards, such that supporting information, including biological data, is used in addition to failure of the nutrient standard, in confirming whether control action for eutrophication (the impact of concern as regards P) appears necessary.

- Despite significant reductions in P loadings from sewage treatment works in recent years, the Water Industry remains the main source of P pollution in England (No figures for Wales re agriculture, but we assume that this statement also applies to Wales). Agriculture is the second most important source nationally. Detergents and P Dosing of drinking water are a smaller but not insignificant source. (Cath's figures) P dosing of drinking waters is estimated to account for between 4% and 11% of the phosphorus entering sewage treatment works. The contribution of intermittent combined sewer overflow discharges e.g. following storms to P loadings is more difficult to quantify. Other non-agricultural diffuse sources, such as forestry and abandoned mines, are less significant nationally, as are direct industrial inputs. The magnitude and balance of point and diffuse sources will vary across river basin districts.

- The regulatory mechanisms to control P from STWs are tried and tested. In terms of technical control methods there are two main options - chemical dosing or biological nutrient removal. The latter has not been widely used in the UK and appears expensive in terms of financial, energy and carbon costs. For chemical dosing, the costs of P reduction, in terms of £/kg P removed, vary considerably depending on the size of STW, increasing from £8/kg for the largest works to around £157/kg at small works (national averages). The financial cost of chemical dosing to UWWTD effluent standards for STWs in England (excluding works already funded) discharging to rivers "at risk" from P is estimated to be £284.3 million/yr. The benefits of this treatment to river P compliance have not been assessed so the work does not assess whether all this expenditure would be required. Costs for discharges to "at risk" lakes have not been estimated but will, in part, be included in the river based estimates.

- P pollution from agriculture has received less attention than that from the Water Industry. Defra's Catchment Sensitive Farming Policy work has examined economic, supportive/voluntary and regulatory mechanisms for controlling diffuse pollution. It indicated that extending the England CSF Delivery Initiative and Environmental Stewardship would help in achieving WFD targets, but uncertainty remained in farmer take-up of advice, voluntary changes in practice (for costly measures) and the take-up of Environmental Stewardship water options. As the measures have only been in place for under a year, analysis of their effectiveness is difficult, but a regulatory option is likely to be needed to give greater certainty of meeting WFD requirements. The regulatory mechanism considered was Water

Protection Zones. The pCEA Agricultural Group accepted the analysis from the CSF Policy Team at Defra that agriculture, on average, needs to reduce phosphorus loss by 48% to achieve the WFD standards for agriculture's share of the pollution load. The costs per kg of P abated have been assessed and vary widely depending on the level of abatement and whether or not the measure includes supportive measures alongside regulatory ones.

- The Non-agricultural Diffuse Pollution (NADWP) pCEA Group has considered national measures to control P in detergents. Options include a total ban, aimed at a 100% reduction of phosphates used in laundry detergents, or a partial ban aimed at reducing this phosphate content by 50%. Each option would be supported by either EU or domestic regulation, a cost of £3.34 million for England was estimated. Whilst the reduction in total P loadings will be relatively small, this source control measure could be a useful national measure to complement targeted measures for the water industry and agriculture, reducing P inputs from CSOs and small treatment plants and potentially reducing P removal costs at STWs.

- Other mechanisms considered by the NADWP group may also have a beneficial impact on P loadings, for example general binding rules to cover site management, washing activities and misuse of the drainage system and the use of SUDS. But the data on both the costs and effectiveness of these mechanisms are currently limited and the precise impact on loadings is therefore difficult to quantify. Mechanisms to address diffuse pollution from forestry have not been assessed as part of the pCEA as, based on current evidence, the impact of forestry is considered to be comparatively low. Should future evidence suggest otherwise, the cost effectiveness of mechanisms to address diffuse pollution from forestry will assessed separately. Abandoned mines have been identified as a NADWP priority area for action but are not considered to contribute significantly to nutrient levels.

- The implementation of chemical dosing by the water industry would have high certainty as regards levels of phosphorus removal, with costs dependent on the size of the plant. Measures to tackle diffuse pollution are relatively high cost, with considerably less certainty of achieving any planned reductions. Such uncertainty also applies to measures for non-agricultural diffuse pollution due to the lack of information about apportionment and the effectiveness of measures. An exception is the implementation of phosphorus removal from laundry detergents. This measure is low cost and will provide a more certain outcome in terms of P reduction. There is considerable uncertainty as regards the extent and timescales of ecological improvements in response to reductions in P inputs.

- There are some possibilities for the phasing of measures to increase affordability for example by implementing a 30% reduction target for agriculture initially and then a 48% reduction in phase two. There is also potential to implement phosphorus removal treatment in only size C sewerage treatment works initially based on the Ribble catchment modelling work.

- The results of case study and preliminary modelling in the Ribble of the likely benefits of P reduction measures indicate that meeting the proposed P standards will be a considerable challenge in many RBDs. Taken together with the uncertainties, this appears to indicate that the way forward will require a mix of alternative objectives (extended deadlines, less stringent objectives), national measures and catchment-based planning to prioritise and target water industry and agricultural diffuse control measures in the most effective way. [N.B. To be amended in include national SIMCAT findings]

Nitrate

- Nitrate pollution can affect both groundwaters and surface waters and comes principally from agriculture and sewage treatment works discharges (agriculture 61%, sewage treatment works 32% nationally (Defra 2004)). The magnitude and balance of diffuse and point sources will vary across river basin districts, as will the extent of inputs to surface and groundwaters. The environmental consequences of nitrate pollution fall into two areas. First, the risks to human health of drinking high-nitrate water (although there is disagreement to the extent of the issue) and the related need to meet the 50 mg/l nitrate standard for drinking water. Second, the undesirable ecological changes associated with eutrophication. Nitrate is the main nutrient governing eutrophication in marine ecosystems and can also have an influence in some freshwater systems. [Apportionment + Extent of Pressure sections]

- The Environment Agency's risk assessments for the WFD indicate that 40% of our rivers, over 50% of groundwaters and a small number of estuaries, mostly in England, are at risk of not achieving Good Ecological and good chemical quality by 2015, under the objectives of the directive[1]. Some 55% of England and 3% of Wales are currently designated as Nitrate Vulnerable Zones (NVZs) under the Nitrate Directive, as a result of nitrate pollution (elevated nitrate or eutrophication). 13 estuaries are designated as affected by eutrophication under UWWT and/or Nitrate Directives. The outcome of the latest 4-yearly designation reviews under both Directives is imminent. [Extent of pressure]

- Pollution by nitrates is the most widespread form of groundwater pollution, particularly in the south, east and midlands of England where groundwater provides half the drinking water supply. In such areas, high concentrations and rising trends in nitrate are causing extra costs to water companies and local abstractors in supplying drinking water. The position in Wales is slightly different, in that while there is a small proportion of waters at risk, generally nitrate pollution of both ground and surface waters is much less of an issue. [Extent of Pressure]

- The UK Technical Advisory Group for the WFD has proposed new standards for nitrogen in transitional and coastal waters, linked to ecological status. If adopted by government, these standards, together with biological data, will inform the targeting of any further controls on marine eutrophication. For freshwaters, no equivalent standard to support ecological status is proposed at present, as the science does not support it, but the 50 mg/l drinking water nitrate target continues to (indirectly) guide control action. [Objectives]

- Reduction of water pollution by nitrate will be a priority for action in the first cycle of river basin management planning under the Water Framework Directive, primarily through the implementation of the Nitrate Directive, and to a lesser extent the UWWT Directive, as important basic measures under the WFD. Government consultations on revised NVZ designations and changes

[1] These include the objectives for Protected Areas such as existing Nitrate Vulnerable Zones under the Nitrate Directive and Sensitive Areas and the Urban Waste Water Treatment Directive, where measures to meet the objectives of those directives are already in place.

to NVZ action programmes are planned for later in 2007. [Objectives + Measures]

- Nitrate loadings originating from non-agricultural diffuse sources are considered a small part of the national apportionment. As with phosphates, some of the mechanisms under consideration to tackle non-agricultural diffuse water pollution may also reduce any diffuse nitrate loadings from urban areas (for example general binding rules to cover site management, washing activities and misuse of the drainage system and the use of SUDS). However, the data on both the costs and effectiveness of these mechanisms are currently limited and the precise impact on loadings is therefore difficult to quantify.

- Contribution of N in surface and ground waters from deposition of ammonia or oxides of nitrogen (NOx) is unclear but is believed to be significant in uplands and in some agricultural areas. The majority of ammonia is of agricultural origin while NOx is emitted from many sources, including power and road transport. Further analysis is required to provide a more accurate assessment of the true contribution of air pollution to N levels in UK waters. Controls on air pollution, including on ammonia and NOx are in place, driven primarily through the ceilings agreed under the EU National Emission Ceilings Directive and UNECE Gothenburg Protocol.

- Our current analysis, prior to the detailed development of WFD objectives, is that for saline waters there will be further measures/costs under the UWWT and Nitrate Directives, to control eutrophication, but the WFD itself is unlikely to be a significant driver of further measures. The main nitrate sources – agriculture and STWs - are addressed by the UWWT and Nitrate Directives. For freshwaters, there may be a need to go beyond current or planned measures, in order to address elevated nitrates in groundwaters and rising nitrate trends in surface freshwaters and groundwaters, including Drinking Water Protected Areas under the WFD. However we do not currently have comprehensive information on the extent of rising nitrate trends, particularly in groundwaters. Furthermore, the waters with elevated nitrates and/or rising trends will primarily be those designated under the Nitrate Directive and the benefits of the anticipated revisions to the NVZ action programme need to be assessed in order to judge whether more is required.

Therefore it is proposed that the need for, the costs and effectiveness of any further measures to meet WFD objectives, should be kept under review in the coming years. On this basis it is also premature to assess, at present, whether alternative objectives may need to be considered under the WFD.

2. Relevant WFD Objectives

2.1 Phosphates

It is anticipated that 'Good Ecological Status' will be the default WFD objective for phosphorus in rivers and lakes and it is the ecological changes associated with eutrophication which are being addressed. An absence of eutrophication problems is part of Good Ecological Status.

Table 1 shows the proposed WFD limit values for phosphorus in rivers. These are the standards for rivers proposed by UKTAG. Work is still in progress on standards for lakes (final draft proposals to UKTAG are set out in Table 1a below).

Table 1 - proposed WFD limit values for phosphorus in rivers (in milligrams)

SOLUBLE REACTIVE PHOSPHORUS (MG/L)		
ANNUAL MEAN		
RIVER TYPE	HIGH ECOLOGICAL STATUS	GOOD ECOLOGICAL STATUS
Low alkalinity (altitude less than 80m)	0.03	0.05
Low alkalinity (altitude 80m and above)	0.02	0.04
High alkalinity	0.05	0.12

Table 1a – Standards for phosphorus in lakes

Type of lake		Reference Conditions		Class Boundaries			
				High		Good	
		Range	Type	Range	Type	Range	Type
		Annual (geometric) mean (µg/l)					
High Alkalinity – deep		There are too few lakes of this type					
High Alkalinity shallow	Northern/ Atlantic	8-17	13	10-22	16	14-30	23
	Central	12-27	20	16-34	25	22-46	35
High Alkalinity very shallow	Northern/ Atlantic	12-29	18	15-36	23	21-48	31
	Central	18-44	28	23-55	35	33-75	49
Moderate Alkalinity, Deep		3-8	6	5-11	8	7-16	12
Moderate Alkalinity – shallow		5-11	8	7-15	11	10-21	16
Moderate Alkalinity – very shallow		8-19	12	10-25	15	15-36	22
Low Alkalinity – deep		2-7	4	2-9	5	3-15	8
Low Alkalinity – shallow		2-10	5	3-13	7	4-19	10
Low Alkalinity – very shallow		3-17	7	4-23	9	6-34	14
Marl – shallow		N/a	N/a	N/a	9	N/a	20
Marl – very shallow		N/a	N/a	N/a	10	N/a	24

The standards for phosphorus in rivers and lakes will be applied in accordance with the “indirect model” referred to in the UKTAG standards reports. This involves a weight-of-evidence approach to decision making for environmental standards of this type, whereby supporting information, including biological data, is used in addition to failure of the nutrient standard, in confirming whether control action appears necessary. Weight-of-evidence is the accepted approach to the assessment and control of eutrophication under existing international and domestic policies.

There are additional WFD objectives which are relevant in the context of phosphorus control, notably those involving Protected Areas (for example Sensitive Areas under the Urban Waste Water Treatment Directive) and the requirement to prevent deterioration of status. However the pCEA work has focussed on the measures to meet Good Ecological Status.

3. Extent of Pressure, Trends and Associated Uncertainty

3.1 Pressure

The environmental consequence of phosphorus enrichment of the water environment is eutrophication. This involves adverse effects on the ecology, quality and uses of water bodies as a result of nutrient enrichment. Phosphorus (P) is accepted as the main cause of eutrophication in freshwater ecosystems (rivers and lakes). It can also play a supporting role in saline waters where nitrogen is the main nutrient of concern.

Since the 1970s, eutrophication has been recognised as a major water quality issue in many parts of the world. Tackling it remains a major long-term challenge, linked to progress towards sustainable development. This is certainly the case in Europe, as borne out by a succession of important reports on the state of Europe's environment (EEA, various reports from 1994 to date).

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For England freshwater eutrophication has been recognised a significant issue since the early 1990s. The Royal Commission on Environmental Pollution in its 16th report (RCEP, 1992) referred to the widespread occurrence of eutrophic and hypertrophic lakes and reservoirs. The Environment Agency, in its 1998 report on the state of fresh waters and its eutrophication strategy (2000) identified nutrient enrichment as one of the top priority issues, both for rivers and lakes.

The recent Environment Agency (EA) risk assessments for WFD support the earlier findings, with a large proportion of lakes and rivers in England identified as "at risk" from phosphorus. It should be noted that the work amounts to a risk screening rather than a comprehensive assessment of eutrophication.

In early 2006, the EA published proposals for environmental standards under WFD, including phosphorus in rivers and lakes [http://www.wfduk.org/stakeholder_reviews/]. In line with the risk assessment outputs, a significant proportion of our rivers and lakes fail these proposed standards, underlining the perception that nutrients are one of the main challenges as regards national water quality issues[2].

3.2 Trends

P concentrations in our rivers have fallen significantly since the late 1980s, as shown by our GQA data, but much less so in recent years. EA estimates of P loadings entering marine waters indicate a similar position, with a significant fall followed by a

[2] In terms of detail, the standards report indicates that the percentage of river length less than Good Status based on the proposed P standards will be 50% at 95% confidence. For lakes the equivalent figure, based on the final draft (June 2007) of the UKTAG Phase 2 standards report is 67% of lakes are less than Good with 95% confidence for England.

much flatter profile in recent years. The decrease is attributable to improvements in sewage treatment levels in England (secondary treatment and P reduction treatment) and reduced contributions from detergents (due to low-P and no-P formulations). In areas where (point source) P controls are now in place, there are likely to be some increases in P loadings from point sources in areas where the local population increases for example looking forward the predicted increase in housing particularly in the south-east will add to the pressure.

For the agricultural sector generally there are predicted reductions in livestock of approximately 25% by 2015 with a general move away from farming in the uplands to the lowland[3] areas of England. This may lead to local hot spots of pollution. Additionally there is a predicted continuation of the trend for land to move out of agricultural production, at a national level this is not significant but again locally this may have an impact. It is also likely that set aside will no longer be a part of agriculture. Work is currently under way to assess the potential impact of this and potential policy responses if required.

3.3 Uncertainty

There is a limited understanding of the relative importance of water and sediment sources of phosphorus for vegetation (macrophyte) growth in both rivers and lakes. Thus the impact of particulate sources of P or sediment-bound P on important diagnostic ecological communities is less well understood, but it is likely that even in faster flowing river systems P will impact on ecological status.

Work is continuing on steadily improving the understanding of the processes of phosphorus loss from land to water, the contribution of in-river/in-lake sediments to phosphorus budgets, and the links to ecological impacts. This is an ongoing area of research and the science is complex. Similarly there is a need for improved information and understanding of the extent of pollution of groundwaters by phosphorus from anthropogenic sources and the contribution from groundwaters to eutrophication in surface waters.

Over all there will be a substantial variation in the pressure across England and Wales. The magnitude and balance of point and diffuse sources will vary across river basin districts.

4. Apportionment and Associated Uncertainty

4.1 Apportionment

This can be divided into Point Sources and Diffuse Sources, which can be further broken down to:

Point Sources	Diffuse Sources
- Sewage Treatment works	- Agriculture
- Other Industries	- Non-Agriculture

There is limited information on P apportionment in the various sector group reports. Figures that were provided do not give a full apportionment picture with regards to point and diffuse sources. However estimated P losses for each sector/industry provided is listed below and is based on the EA pollution inventory, except agriculture which is based on the CSF Programme analysis.

[3] Business as Usual Studies

Table 2

Sector		England only P losses tonnes/year 2005	England and Wales P losses Tonnes/year 2005
Sewage Treatment Works		36,598	39,970
Non-sewage industries		Not provided.	434
Agricultural Diffuse Based on CSF analysis		6-13,000	Not provided
Non-Agriculture Diffuse	Detergents	1,495	1,660
	Misconnections	1,282	1,438
Total annual tonnage of loss		52,375	43,502

[N.B. Further information to be added on P dosing to drinking water supplies, detergent and Combined Sewer Overflows].

4.2 Uncertainty

Only one new national study on P apportionment has been carried out since the 1993 Morse study - the 2006 Warwick HRI Study. The figures within this study are still being discussed and the results disseminated to the various interested parties.

There are three main issues of uncertainty surrounding P (i) the variable bioavailability of different sources of P (ii) the timing of P losses to water and (iii) where in the catchment the P enters the waters.

The outputs from sewage treatment works are relatively constant through the year and the P in sewage effluents is mostly (70-100%) in a form that is immediately available for uptake by algae/plants. In contrast, agricultural P inputs are much more seasonally variable and event-driven, linked to rainfall. This means a large proportion of P loss from agricultural land occurs during the autumn and winter period, which is a biologically inactive period. In addition, the P is mostly in forms which are not immediately bioavailable, being bound to soil/sediment. Against this sewage treatment plants tend to discharge lower down the catchment or into marine waters.

Again there will be a great deal of variation across England on the apportionment levels for point and diffuse sources. As an example of this the Warwick Study apportioned approximately 10% agriculture and 87% point sources in the Thames while for Severn the apportionment was 43% agriculture and 48% point sources.

Further work is planned later this year on the question of apportionment by Defra and the Environment Agency.

5. Groups of Measures to Meet WFD Objectives Under the Four Scenarios

Each of the sector group considered a number of measures in order to achieve WFD standards, these ranged from the implementation of new technologies, application of regulation and advisory campaigns. The measures discussed in the working group reports are examined below.

5.1 Agriculture

There are three potential generic measures available to tackle diffuse pollution from agriculture; economic, supportive/voluntary and regulatory. The CSF work examined all three to determine which would be the most cost effective measures available to achieve the WFD standards.

CSF analysis examined the business as usual case for agricultural pollution looking forward to 2015 (i.e. the low reference case). The business as usual case included all measures that are already in place to tackle agricultural water pollution including measures such as Environmental Stewardship and the English Catchment Sensitive Farming Delivery Initiative (ECSFDI) as well as non-targeted measures such as the effect of CAP reform. This enabled the 'gap' to be calculated i.e. the additional levels of pollution that would need to be reduced to achieve the WFD standards on top of the business as usual scenario. The work then examined three generic delivery measures to bridge said gap (economic, supportive/voluntary and regulatory) looking broadly at three diffuse problem areas; nutrient management, transportation/pathways and incidental losses.

For economic instruments tradable permits were examined. However research[4] showed that due to the spatially dependent nature of the pollution and the high administration costs of a scheme, tradable permits were not an efficient measure to achieve WFD targets. The research indicated that in order to achieve a reduction in total costs there would need to be a target of reduction loads greater than 30% and there had to be a substantial cost differential in mitigation measures between the farms (greater than three times).

Two supportive measures were examined, the extension of the English Catchment Sensitive Farming Delivery Initiative (ECSFDI) across the whole country, and an extension of Environmental Stewardship (ES) options relating to water quality. The analysis showed that both the extension of the ECSFDI and ES would help in achieving WFD targets, but uncertainty remained in farmer take up of advice, voluntary changes in practice (specifically on costly changes) and the necessary take up of water options under Environmental Stewardship. As the measures have only been in place for under a year, analysis of their effectiveness is difficult, but it may mean that an regulatory option would be required to give greater certainty of achievement of closing the gap,. The regulatory mechanism considered was Water Protection Zones (WPZ). These are similar to the nitrate vulnerable zones (in designation) and would allow specific problem areas where the ECSFDI or ES have failed to achieve WFD targets to be designated so that the standards are achieved. Further information on how WPZs would work will be in the CSF Consultation.

5.2 Non-agricultural diffuse

<u>5.2.1 Phosphates in detergents</u>

Due to the potentially adverse effects of phosphate-free dishwasher detergents on crockery, controls on phosphate use in laundry detergents only have been examined.

Regulatory controls on phosphates in detergents have been considered in the form of either a total ban or partial ban and, for the purposes of this assessment, would aim to achieve a 100% and 50% reduction in phosphates in detergents respectively.

[4] ADAS (2007), Catchement Sensitive Farming – Tradable Permit Schemes , Project Number WQ0106

Regulatory controls could be implemented by either an amendment to the EU Detergents Regulation or via domestic legislation. The Commission will take a decision on whether to amend the Detergents Regulation in 2008. For the purposes of the pCEA, voluntary mechanisms have not been considered for phosphates in detergents due to the difficulty of quantifying the effectiveness of voluntary controls.

5.2.2 Misconnections

Local authorities have the power to remedy misconnections, whilst water companies are also required to deal with misconnections in response to complaints. The Environment Agency records the number of pollution incidents and this information is used to target remedial actions for misconnections. Current practice is that there is little pro-active monitoring of the misconnections; only after recording of a number of pollution incidents is the misconnection investigated.

Local Authorities (LAs) are able to prevent misconnections at newly built estates, but it is the existing illegal connections that form the largest problem. Existing misconnections are tackled via legal action against householders, which can take several years. As a result there is a significant disincentive to this action. It is envisaged that large-scale financial incentives would be needed in order to encourage local authorities to use these powers. Water companies may be forced to remedy misconnections using hard engineering solutions, rather than correcting the fault at source.

Various measures have been analysed to reduce the pollution originating from misconnections including leaflets[5], inclusion in vocational courses[6], more monitoring for current regime[7], ban on households doing their own plumbing[8] , transfer of power from Local Authorities to water companies[9], improved Local Authority awareness of the problem and their powers and incentivise their use[10].

5.2.3 Urban drainage

Sustainable Drainage Systems (SUDS) is the collective term used for systems which are designed to manage surface water drainage in accordance with the principles of sustainable development. If appropriately designed, constructed and maintained, SUDS are more sustainable than traditional sewer networks.

The systems may often form part of public open space, providing the opportunity to enhance the amenity and aesthetic value of developed areas and contribute towards habitats for wildlife in urban areas, potentially resulting in an increase in biodiversity. However, effective sediment management and maintenance is essential in order to maintain these benefits over the life of the system used.

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[5] The distribution of the existing Environment Agency leaflets to increase public awareness of the risks of misconnections, and to provide information on the options available to reduce this risk.

[6] The expansion of vocational courses with information on the risks of misconnections could contribute to prevention of future misconnections.

[7] The expansion of monitoring might include surveys of the catchments and correction of the misconnections detected. No central record of statistics regarding the number of misconnections reported or the expenses on correction of misconnections are held[7].

[8] - Individual persons currently executing their own plumbing activities will, under the proposed regulation, be forced to be registered with a competent person scheme or to employ a registered plumber.

[9] The current situation on powers could be changed by transferring the responsibility to the water companies as a whole. It is envisaged that water companies would increase the amount of preventative action taken, but that efficiency gains could be made in carrying out this work through use of strategic agreements.

[10] Because legal action on misconnections can result in lengthy court cases it is assumed that a lack of funds / personnel is the main cause of poor LA action. If funds were increased, and awareness within the LAs of the impact of misconnections raised it is assumed that the LAs would be more likely to use their regulatory power.

5.2.4 General Binding Rules (GBRs)

GBRs have been considered for commercial, institutional and industrial sites, washing activities, misuse of the drainage system and petrol station forecourts. The GBRs would be based on existing best practice and it is therefore anticipated that the cost to stakeholders would be minimal. Because of the diversity of activities and sites that would be covered, the effectiveness of the general binding rules is difficult to identify. As a result, there is no detailed assessment of the cost-effectiveness of general binding rules within this chapter.

5.3 Water Industry

The water industry currently utilises two methods for removing phosphorus from wastewater during the secondary treatment stage. These are commonly referred to as chemical or biological nutrient removal.

Chemical phosphorus removal requires the addition of metal salts (commonly iron or aluminium) to the wastewater to encourage the precipitation of less soluble phosphates. The resulting precipitates settle out as suspended solids and are removed in the sludge. The metal salts are in finite supply and the increased sludge must be disposed of. The use of ferric salts may also require a consent to discharge for iron to be applied to the works. Chemical phosphorus removal can normally be added to most existing sewage treatment works as a bolt on process.

Biological phosphorus removal occurs during the energy intensive activated sludge process. It requires a stage of anaerobic digestion to occur prior to an aerobic digestion phase. This leads to the formation of flocculent settle able solids that are subsequently removed by gravity settling in humus tanks. This is a more complex process than chemical dosing and is highly energy intensive. It has the advantage that the process can be altered to include an anoxic phase to also remove nitrogen from the wastewater. However, ASP may not be compatible at all STWs and involves a high capital expenditure.

Both of the above processes are limited in their ability to remove phosphorus from wastewater. The current understanding is that a final effluent concentration of 1mg/l is achievable irrespective of the influent concentration for both processes. Additional tertiary treatment, such as sand filters, may be required to meet iron consents for chemical dosing and may make a small difference to phosphorus levels as more particulate phosphorus may be removed from the effluent(the extra treatment is to meet iron standards rather than P standards and the extra treatment may remove a bit more P).

It should be noted that an additional pressure from the water industry is P dosing of drinking water supplies. This is to prevent leaching of lead from pipes. The replacement of lead pipes is prohibitively expensive however it may be possible to envisage a soft "measure" that involves optimisation of the P dosing process so as to minimise losses to the water environment. It would be rather like the proposed detergent controls - a source control that reduces the overall loadings to water a little and helps as regards smaller STWs (that lack P removal), CSOs, septic tanks etc as well as perhaps reducing P reduction costs at STWs.

5.4 Industry

Generically, the possible measures for industry include:

- Process optimisation/increased efficiency;

• Substance substitution;
• End of pipe treatment; or
• Reduced activity/production.

The potential for further increase in efficiency is very site specific. The requirements of the IPPC directive imply the use of BAT and in principle there should be limited additional scope for process improvements. The fact that most of the significant contributing industries have already invested in wastewater treatment technology to comply with current discharge consents indicates that no further efficiency improvements exist (or are more expensive than additional treatment). To achieve further significant reduction in the discharge of nutrients and sanitary determinants the main measure is to upgrade their current treatment works. For these substances, the analysis is focusing on estimation of the costs of relevant treatment technologies.

The plant construction method will change depending on the throughput capacity demand; at the smaller scale package type plant will be more competitive whilst bespoke site construction will prevail at the higher capacity. The boundary between the construction techniques will vary from site to site depending on individual conditions

5.5 Scenarios

As part of the working group reports the low reference case (i.e. the current situation included all funded measures) was identified only by the agricultural and water industry working groups. The CSF Policy Team's analsis, that fed into the Agricultural Group Work, established that agriculture, on average, needs to reduce phosphorus loss by 48% to achieve the WFD standards for the sectors share of the pollution load. The water industry assessed the low reference case in terms of those measures agreed and funded measures under AMP 2, 3, and 4. It was then calculated what further reductions in P loading would result from putting in P removal to either 1 or 2 mg/l (in the effluent) at STWs discharging to rivers "at risk" (under RBC1) of failing good ecological status. The industry group calculated the costs of achieving ELV[11] 1mg/l and ELV 2 mg/l. The non-agricultural diffuse report did not identify a low base case or what the measures could achieve due to lack of information.

Very limited information in the working group papers has made the construction of scenarios problematic. All the sector reports state there are limited advantages to be gained from the phasing of measures. The agricultural group saw no savings in the phasing of mitigation measures although acknowledged that the longer a farm has to plan for changes the more cost effectively those changes can be made. The water industry and industry groups concluded that although phasing would save operating costs it would have no impact on capital costs. The non-agricultural diffuse group did not consider the effect of phasing in their report.

Other measures including other technologies were ruled out in the work of the sector groups due to the uncertainty of the availability or efficiency of technologies. It is possible that in the future more information will be available on potential technologies but it is difficult to anticipate their implementation at present, therefore no scenarios have been constructed around technology. As always it is important to note that these costs will very across space.

Six scenarios have been constructed around the impact of phasing, cost effectiveness and levels of uncertainty. The costs per annum and annual P load

[11] ELV = Emission Limit Value

reductions from the scenarios are shown in table 3. The scenarios can be divided into three man categories. Scenario 1 is the cost and effect of implementing all measures at once, scenarios 2 and 3 calculate the effect of phasing and 4 to 6 vary levels of cost and certainty -scenario 4 being the most cost effective and certain and 6 the least cost effective and most uncertain scenario. It is important to note that some key assumptions have been made in order to calculate the costs

- Chemical rather than biological treatment is used in the water industry
- The costs of industry measures have not been included due to the nature of the data
- The costs of the implementation of SUDs has not been included due to the nature of the data
- It has been assumed that measures relating to agriculture would not exceed a 48% reduction as the 54% reduction costed for this work would effectively require the collapse of the arable sector.

Scenario 1 – all measures implemented namely chemical dosing in all STW, agricultural pollution reduced to 48% through WPZ, detergents banned, misconnections dealt with through all costed measures and industry measures implemented.[12]

Scenario 2 – water industry 100% STW C only. Relates to Ribble modelling awaiting further data.

Scenario 3 – the implementation of a 30% reduction in agricultural P in the first phase of the WFD would result in a reduction of approximately 700 tonnes of P. The increase to 48% reduction in P in phase 2 would result in a further 700 tonnes of P reduction totalling 1400 tonnes.

Scenario 4- the implementation of phosphorus removal from laundry detergents.

Scenario 5 – the implementation of chemical dosing in the water industry. This measure would bring certain levels of phosphorus removal but the cost would be dependent on the size of the plant. Large plants provide a very cost effective option for achieving P removal but as the size of the plant decreases the cost effectiveness reduces.

Scenario 6 – the implementation of measures for industry, agricultural diffuse and non-agricultural diffuse (excluding removal of P in detergents). The implementation of measures to tackle diffuse pollution are relatively high cost and very uncertain. The measure for industry is also highly uncertain in addition to being a small contributor to the problem. The uncertainty in agriculture is due to the unknown time taken to translate changes on farm to improvements to edge of field improvements and the actual effectiveness of the mitigation measures in the real world. For non-agricultural pollution the uncertainty arises from the lack of information about apportionment and the effectiveness of measures.

Table 3 – cost and tonnes of P removed under the 6 scenarios

Scenario	Cost £m/yr			tonnes P removed per year			Uncertainty	Not included
	England	Wales	Total	England	Wales	Total		

[12] Although as noted above the industry measures and measures for SUDs have not been costed due to lack of information.

1	669.7	18.76	688.6	21832	442	22279.35	Mixed	Industry costs, biological treatment, Suds
2	83.3	0.5	83.8	2960	87	3047	Low	N/A
3 - phase 1	18.3	-	18.3	697.37	-	697.37	High	N/A
3 - phase 2	147.1	-	147.1	1397.35	-	1397.35	High	N/A
4	3.3	0.4	3.7	1299	141	1440	Low	N/A
5	284.3	3.3	287.6	17233	185	17418	Low	biological dosing
6	235	15.06	397.3	1908	116	3421	High	Industry costs, Suds

6. Costs of groups of measures

6.1 Agricultural Diffuse

There are a limited number of approaches that are capable of achieving the WFD standard in P for agriculture. Research has determined that it is likely that any policy implemented would contain the establishment of a regulatory tool (the proposed Water Protection Zone (WPZ) option) as this adds to the certainty of achieving the standards. This is mainly because of the uncertainty surrounding the effectiveness of the extension of the ECSFDI (referred to in the below table as advice) and additional options in Environmental Stewardship (refereed to in the table as scheme). This uncertainty means that even if the scheme or advice options are implemented or extended, the regulatory tool of WPZ is needed to tackle pollution in areas where the scheme or advice has failed to achieve the WFD standards. As a result of the similarity of the policy options examined, the ranking of the cost effectiveness of measures is entirely dependent on the level of P reduction agriculture has to achieve and whether or not the measure includes supportive measures alongside regulatory ones. As can be seen in table 4 , the cost per kg of P abated increases rapidly from 38%-50%-54% P reductions. It should be remembered that the cost per kg of P also achieves the WFD targets for Eutrophication of TraC waters, siltation and biological oxygen demand.

Table 4 – cost effectiveness of agricultural measures

Policy Option	Aim Percentage of P abated (per year)	Actual percentage of P abated (per year)	Cost per kg of P abated by policy instrument (except BAU – compared to 2000) (£/kg/year)		
			Diary /Beef	Arable	Pig & Poultry (inc outdoor pigs)
BAU to 2015 (2000 baseline)	26	26	208		
WPZ	30	38	26.2		
Scheme + WPZ	30	38	67.2		
Scheme + advice + WPZ	30	39	165.0		
WPZ	48	50	105.3		
Scheme + WPZ	48	50	107.0		
Scheme + advice + WPZ	48	50	150.5		
WPZ	54	54	267.2		
Scheme + WPZ	54	54	256.6		
Scheme + advice + WPZ	54	54	261.4		

6.2 Non Agricultural Diffuse

Three main pressures on nutrients from non-agricultural diffuse pollution have been examined as part of the pCEA - detergents, misconnections and urban drainage. As the apportionment of non agricultural diffuse pollution is uncertain the effectiveness figures shown reflect the effectiveness of the measures being implemented rather than the ability of the measures to reduce pollution by a known amount.

6.2.1 Detergents

Table 5 provides a summary of the cost and effectiveness data generated for the proposed measures for Phosphates in Detergents[13]. The measures are a total ban and a partial ban. A partial ban would aim to achieve a 50% reduction of P in detergents

Table 5 Cost and effectiveness for Phosphates in Detergents Proposed Measures

Measure ID	Measure description	Sectors (and numbers) affected	Cost (in £, EAV*)	Effectiveness of Measure	Remarks
1.1	Total ban	Detergent formulators		90%	Rising input costs; possible savings for WWTPs
	England	18	£3,342,000	£100/tonne	32,499 tonnes TP over 25 years

[13] Refer to results spreadsheet for detailed cost calculations

Measure ID	Measure description	Sectors (and numbers) affected	Cost (in £, EAV*)	Effectiveness of Measure	Remarks
	Wales	2	£413,000	£120/tonne	3,537 tonnes TP over 25 years
1.2	Partial Ban				Rising input costs; possibly savings for WWTPs
1.2	*EU or National regulation*	Detergent formulators		90%	
	England	18	£1,677,000	£75/tonne	22,749 tonnes TP over 25 years
	Wales	2	£207,000	£85/tonne	2,476 tonnes TP over 25 years
Total cost England			£3,341,000 (ban) Measures mutually exclusive; 1 cost figure applied		
Total cost Wales			£413,000 (ban) Measures mutually exclusive; 1 cost figure applied		

*Equivalent Annual Value

6.2.2 Misconnections

Table 6 shows the cost and effectiveness of measures to reduce the incidents of misconnections.

Table 6 Cost and effectiveness for Misconnections Proposed Measures

Measure ID	Measure description	Sectors (and numbers) affected	Cost[14] (in £, EAV)	Effectiveness of Measure	Remarks
2.	Misconnections				
2.1a	Awareness raising: leaflets	No of DIY-stores and HIPs (no of houses sold annually.) + no of white goods sold annually		15%	

[14] Refer to results spreadsheet for detailed cost calculations

Measure ID	Measure description	Sectors (and numbers) affected	Cost[14] (in £, EAV)	Effectiveness of Measure	Remarks
	England	1381+ 1.3 million p/a + 1,920,000	£1,645,000	£490/tonne TP £27,420/tonne Cu £29,375/tonne Zn	3,344t TP, 60 t Cu, 56t Zn, and 1.7 t of other metals, and 8.7 t of Priority Substances removed over 25 years
	Wales	80 + 78,692 + 112,000	£ 92,000	£440/tonne TP £30,670/tonne Cu £30,670/tonne Zn	208t TP, 3t Cu, 3t Zn, and 100kg of other metals, and 500kg of Priority Substances removed over 25 years
2.1b	Inclusion in vocational training	No of plumbers		62%	Plumbers registered at association
	England	103,000	£1,187,000	£85/tonne TP £4825/tonne Cu £5115/tonne Zn	13,820t TP, 246t Cu, 232t Zn, and 6.9 t of other metals, and 36 t of Priority Substances removed over 25 years
	Wales	6,150	£71,000	£80/tonne TP £5070/tonne Cu £5460/tonne Zn	859 t TP, 14t Cu, 13t Zn, and 400kg of other metals, and 2.1 t of Priority Substances removed over 25 years
2.2	More monitoring with current regime	No of repaired misconnections (100%)		85%	
	England	1,383,000	£220,575,000	£14,770/tonne TP £829,230/tonne Cu £878,780/tonne Zn	14,935t TP, 266t Cu, 251t Zn, and 7.5 t of other metals, and 39 t of Priority Substances removed over 25 years
	Wales	88,000	£14,314,000	£15,400/tonne TP £954,265/tonne Cu £954,265/tonne Zn	929t TP, 15t Cu, 15t Zn, and 0.43 t of other metals, and 2.3 t of Priority Substances removed over 25 years
2.3	Ban on households doing plumbing	No of households +		80%	

Measure ID	Measure description	Sectors (and numbers) affected	Cost[14] (in £, EAV)	Effectiveness of Measure	Remarks
		extra regulatory staff (FTE)			
	England	13,928 + 30	£11,728,000	£750/tonne TP £42,190/tonne Cu £44,760/tonne Zn	15,603t TP, 278t Cu, 262t Zn, and 7.8 t of other metals, and 40.7 t of Priority Substances removed over 25 years
	Wales	889 + 8	£642,000	£690/tonne TP £40,125/tonne Cu £42,800/tonne Zn	929t TP, 16t Cu, 15t Zn, and 0.5 t of other metals, and 2.4 t of Priority Substances removed over 25 years
2.4	Institutional change				
	Transfer power from Local Authorities to Water Companies		Cost neutral	90%	Intergovernmental payments
	Improve Local Authorities awareness of regulatory power	Additional EA Officers		35%	
England and Wales	1	£58,000	N/A	No quantification possible	
	Provide incentives to Local Authorities to use powers		Cost neutral	45%	
				N/A	No quantification possible
Total cost England	*£ 235 million*				
Total cost Wales	*£ 15 million*				
Total cost England and Wales	*£ 250 million*				

6.2.3 Urban Drainage

Sustainable Drainage Systems (SUDS) is the collective term used for systems which are designed to manage surface water in accordance with the principles of sustainable development. Due to their potential to alleviate pollutant loading in surface water runoff and peak flows following rainfall events, the installation of SUDS in high risk areas may provide opportunities for cost savings where hard engineering solutions can be avoided. However, no detailed information was found which indicated the density of sustainable or traditional drainage systems installed within high risk areas in England[15].

Table 7 - Costs of SUDS, exemplary (expected life time 50 years)

Element	Description	Effectiveness**	Investment	Investment costs	Maintenance	Maintenance costs (£ per year)
Permeable surface	200x500m, high maintenance required, economies of scale factor: 0.75		Infrastructure	£3,543,839	Annual high-level maintenance	£ 645
			Planning/design	15% of Infrastructure cost	Intermittent maintenance cost (every 25yrs)	£ 2,967,000
			Construction overhead	15% of Infrastructure cost		
Filter strips and swales	Mentioned in DTI/CIRIA (2001), no cost information found in UK WIR	70-90%	No economies of scale	£ 15k to £ 40k*)		£ 350*
Infiltration devices	7,500m x 0,75m wide x 0,85m depth; economies of scale factor: 0.75	80-90% except Cu	Infrastructure	£ 234,174	Annual high-level maintenance	£ 1,060
			Planning/design	15% of Infrastructure cost	Sediment removal (1x per 10yrs)	£ 3,840
			Construction overhead	15% of Infrastructure cost		
			Land purchase	£ 1,125,000		
Basins and ponds	27,000 m^3 attenuation volume, 26,000 m^3 water quality volume; economies of scale factor: 0.75	60-90% except Cu and Pb	Infrastructure	£ 394,495	Annual high-level maintenance	£ 3,990
			Planning/d	15% of	Intermittent	£ 22,000

[15] Consultation with HR Wallingford (R Kellagher) revealed that there are no mechanisms currently in place to allow this information to be found readily.

Element	Description	Effectiveness**	Investment	Investment costs	Maintenance	Maintenance costs (£ per year)
			esign	Infrastructure cost	maintenance cost (every 4 yrs)	
			Construction overhead	15% of Infrastructure cost	Sediment removal (per 10 yr)	£ 4,160
			Land purchase	£ 5,777,740	Vegetation replacement (per 25 yr)	£ 12,000
					Construction sediment removal	£ 3000
Reference information traditional systems						
Gully/Pipe/ Kerb systems		10-30%	Construction	£ 180-220k	Annual or 6-montly cleaning	£ 1,000

6.3 Water Industry

The financial costs of P removal for the water industry are calculated from the capital costs and the estimated operating costs to ascertain the revenue that would need to be recovered from water customers to finance this work programme.

The costs have been calculated by the size of sewerage treatment works (STWs) and by using either a chemical or biological treatment. The sizes are shown in table 8, the costs of chemical dosing is shown in table 9, table 10[16] shows the costs of phosphorus removal at existing biological nutrient removal works and table 11 shows the costs for phosphorus removal at new build biological nutrient removal works.

Table 8 – bands of sewerage treatment works

Size band	Population equivalent
<250	0 – 249 pe
Band A	250 - 1,999 pe
Band B	2,000 - 9,999 pe
Band C	10,000 - 99,999 pe
Band D	100,000 pe and over

Table 9 shows the P load reduction is for works that are 'at risk' or 'probably at risk' that could potentially have phosphorus removal technology installed. The figures do not included works that have already been funded in AMP4. This data indicates that

[16] It should be noted that for both tables 9 and 10 some companies are revising their carbon data and therefore this information will be updated in the future when this data becomes available.

the financial costs of removing P from STWs effluent do not increase in a linear relationship with the size of the works. These figures are national averages, and there are significant variations between river basin districts, which need to be considered when deciding on the particular programmes of measures in each RBD. Also much depends on the extent of P removal in a RBD by the year 2010. These vary considerably.

Table 9a - Costs of chemical dosing in England

Size of STWs	P load reduction (tonnes per year)	Financial costs (£m/year)	Financial cost of P removal (£/kg)
< 250	22	3.5	157
STW A	255	40.1	157
STW B	1024	55.4	54
STW C	2960	83.3	28
STW D	12971	102	8
Total	**17233**	**284.3**	**16**

Table 9b – Costs of chemical dosing in Wales

Table 3.A.3 Costs of chemical dosing in Wales

Size of STWs	P load reduction (tonnes per year)	Financial costs (£m/year)	Financial cost of P removal (£/kg)
< 250	0	0.	0
STW A	17	1.2	67
STW B	81	1.6	20
STW C	87	0.5	6
STW D	0	0.0	0
Total	**185**	**3.3**	**18**

As part of the pCEA process water companies also reviewed the potential load reductions, costs and energy/carbon impact of two other processes for reducing P levels.

- Biological P removal using existing plant
- Biological P reduction building new plant to do so.

Obviously the extent of removal at existing plant is dependant on the existing plant and whether the activated sludge plants are suitable for additional P removal. Also by 2010 many of the large plants would already have P removal under the UWWTD or Habitats directive.

The data supplied by the industry for existing ASP does not cover all 'at risk' or 'probably at risk' STWs (according to the figures submitted by the companies, the industry has 1,962 STWs discharging to 'at risk' or 'probably at risk' water bodies that do not currently have specific P removal. We do not currently have a figure for the number of these 1,962 STWs that have ASP fitted. However, we have costs for 176 ASP works that could be converted to include specific P removal) and there is not, therefore, a direct comparison to the chemical data supplied above. In particular some companies have little or no experience installing and running activated sludge plants and have not estimated costs within the pCEA for this.

From the data received for existing ASP an estimated 4898 tonnes per year could be removed from the wastewater; this equates to 21% of the 2010 discharge to 'at risk' water bodies. This would be at a financial cost of £124m per year and an increase in annual carbon emissions of over 220,000 tonnes.

Table 10 – Summary load and financial information for phosphorus removal at existing biological nutrient removal works in England and Wales

Existing ASP		<250	STW A	STW B	STW C	STW D	**Total**
P load reduction by existing ASP	tonnes per year	1	14	85	755	4043	**4898**
Estimated financial costs	£m per year	1	3	6	41	73	**124**
Costs of P removed from effluent by existing ASP plant	£ per kilogram	1351	185	72	54	18	**25**
Additional carbon emissions	tonnes per year	128	651	2794	51048	167089	**221709**
Additional Carbon produced	tonnes per tonne of P removed	149	45	33	68	41	**45**

Table 11 – Summary load and financial information for phosphorus removal at new build biological nutrient removal works in England and Wales

New ASP		<250	STW A	STW B	STW C	STW D	**Total**
P load reduced by new ASP	tonnes per year	1	88	356	1011	238	**1695**
Estimated financial costs	£m per year	11	30	54	90	15	**200**
Costs of P removed from effluent by new ASP	£ per kilogram	7408	344	151	89	62	**118**
Additional carbon	tonnes per year	2137	6565	13802	92316	28132	**142952**
Additional carbon produced	tonnes per tonne of P removed	1426	75	39	91	118	**84**

The opportunity for additional P removal by existing plant is limited. Often because these plants already have P removal in the 2000-2010 programme – albeit possibly chemical stripping. It is important to note that the financial and energy costs of the biological treatment plan to reduce P levels is high. The key point is that the amount of P which can be removed from the effluent is limited – these estimates are not open-ended. Also as well as the very substantial financial costs, the environmental disbenefits of the carbon emissions also need to be considered. An extra 0.36million tonnes per year (at £85 per tonnes – some £30m per year is a serious additional factor).

6.4 Industry

The Industry group examined a generic measure that can be implemented in any industrial process. The Industry group paper presumed that the companies already discharging to surface water treat their wastewater to a certain minimum quality. This quality was 'standardised' to provide a generic wastewater which broadly can be compared to effluent produced from secondary treatment systems typical for the wastewater treatment sector. This means that the 'bulk' of phosphorous has been removed leaving only tertiary (polishing) type techniques to be employed to meet the Water Framework Directive (WFD) requirements.

The main treatment process comprises a Balancing System followed by chemical treatment and gravity settlement. The higher quality ELV – 1 mg/L – requires additional sand filtration. By and far the largest contribution to operating cost is that of ferric sulphate – the coagulant/precipitant required to precipitate phosphate. Sludge disposal, electrical power and operating/maintenance costs are also significant. The Ofwat unit costs for phosphorus removal are approximately 50% of the costs identified in the Industry working group study. However, it is unclear from the report whether the denitrification cost relates to denitrification only or to nitrification/denitrification. The Ofwat capital costs should be inflated by approximately 30% and it is likely that the capital annualisation method could add approximately 50%: operating costs are likely to have inflated by 30 – 50%. The unit costs for the 2 and 1 mg/L ELV are similar, if not the same given the tolerances within the assessment. The saving in capital and operating cost is offset by the slight reduction in removal.

The costs to treat to the higher quality (ELV – 1 mg/L) are presented below in Table 12 and for the lower quality (ELV – 2 mg/L) in Table 13.

Table 12 - Total-Phosphorus: ELV 1 mg/L

		Very Small	Small	Medium	Large	Very Large
Flow	m^3/d	200	900	4000	9000	14000
Load	kg/d	2	9	40	90	140
Pop. Equivalent	-	667	3000	13333	30000	46667
Capital Cost	£	936,596	2,296,512	4,096,458	6,594,802	8,563,335
Operating Cost	£/a	26,743	82,628	245,986	451,905	629,450
Annualised Cost	£/a	92,643	244,213	534,217	915,922	1,231,975
Unit Cost	£/kg	141	83	41	31	27

Table 13 - Total-Phosphorus: ELV 2 mg/L

		Very Small	Small	Medium	Large	Very Large
Flow	m^3/d	200	900	4000	9000	14000
Load	kg/d	2	9	40	90	140
Pop. Equivalent	-	667	3000	13333	30000	46667
Capital Cost	£	763,377	1,837,178	3,355,061	5,388,766	6,991,192
Operating Cost	£/a	24,802	76,629	225,701	414,638	577,542
Annualised Cost	£/a	78,514	205,894	461,766	793,798	1,069,450
Unit Cost	£/kg	134	78	40	30	26

6.5 Summary table comparing cost effectiveness

The nature of the data for the cost effectiveness of the measures for each sector make the construction of a summary table difficult as the majority of the categories are incomparable. It is possible to compare ranges of costs but these should not be used to draw any firm conclusions. It should also be noted that these values are on an average national basis and the costs at a catchment level may vary considerably.

Table 13 – ranges of costs for sector measures

Sector measures	£/kg	
	Minimum	Maximum
Agriculture	26.2	267.2

Non Ag Diffuse[17]	Detergents	0.075	0.1
	Misconnections	0.085	14.77
	Urban drainage	No data	No data
Water Industry		8	7400
Industry		26	141

6.6 Additional Costs and Benefits

6.6.1 Agricultural Diffuse

A number of net benefits occur from the implementation of measures to tackle P from agriculture including the achievement of standards relating to the eutrophication of TraC waters, nitrate in drinking water, reduction of faecal indicator organisms, siltation and biological oxygen demand. The implementation of farming practice changes will also bring additional net benefits of ammonia and carbon dioxide reductions. The monetary values of these net benefits are shown in table 14[18].

Table 14: additional benefits from P reduction policy options

	Nitrate-N		**Sediment**		**NH3-N**		**CO2-C equivalent**
	LB (£m)	**UB (£m)**	**LB (£m)**	**UB (£m)**	**LB (£m)**	**UB (£m)**	**(£m)**
Policy option							
WPZ48	15.8	32.4	56.3	75.0	0.5	2.7	19.0
WPZ48 +scheme	16.1	32.9	59.1	96.6	0.5	2.3	20.4
WPZ48 + advice + scheme	16.7	34.1	59.6	97.4	0.5	2.4	22.2
WPZ30	9.9	20.3	34.8	54.2	0.0	0.0	8.4

LB equals Lower Band and UB equals Upper Band.

6.6.2 Non Agricultural Diffuse

6.6.2.1 Phosphorus in Detergents

The introduction of zeolites replacing phosphates in detergents will lead to a reduction of phosphates to process by the waste water treatment plants, thus saving costs[19]. On the other hand, some extra sludge could be produced, but this will be a relatively small amount related to total quantity of sludge produced by a waste water treatment plant.

No calculations have been performed to determine the possible benefits and costs of these effects, but the extra costs are expected to be limited. Furthermore, demand for zeolites might increase, thus affecting the zeolite producing industries positively, although this will be off-set by the extra costs incurred by the sellers. This is not expected to produce an effect at the national scale and has therefore not been included in this cost-effectiveness analysis.

6.6.2.2 Misconnections

[17] Cost per tonne figure from tables Z and X divided by 1000 to give cost per kg.
[18] Due to the time scale of the pCEA process analysis on the additional benefits of the 30 and 54% reductions in P could not be established.
[19] Cost savings per kilogramme phosphate reduced: £ 4.5 / kg (source: Royal Haskoning water cleaning expert)

Tackling misconnections to reduce phosphorus pollution would result in other pollutants such as hydrocarbons, metals, faecal pathogens, priority substances and suspended solids also being reduced.

- No additional costs and benefits have been identified for leaflet distribution, increased monitoring, a ban on households doing their plumbing or institutional change.
- Inclusion of vocational courses is expected to result in limited costs to the regulator. Additional costs may come from translating courses and written material as it is believed that a large number of plumbers currently operating in England and Wales are from other European countries.

6.6.2.3 Urban Drainage

Although no additional costs and benefits have been identified for the implementation of SUDS it should be noted that the implementation of SUDS to tackle nutrients would also reduce other pollutants in surface water including suspended sediment, BOD, COD, metals and hydrocarbons. The use of SUDS to improve water quality could also mitigate storm water runoff and therefore reduce the possibility of localised flooding and the frequency of combined sewer overflows.

6.6.3 Water Industry

Water companies submitted estimates of the additional carbon emissions from treatment as CO_2 equivalent[20]. It appears from this outline data that the use of chemical stripping of P from just the works at risk will have a major impact on the potential increase in emissions of greenhouse gases as CO_2 equivalent. It has been estimated that currently the water companies in England & Wales emit 4 million tonnes per year. Just the addition of chemical stripping to works 'at risk' or 'probably at risk' will increase this by0.36 million tonnes per year.

Table 15 - summary of the financial and carbon costs of the three available technologies to the water industry.

	Chemical stripping		Existing ASP		New Build ASP	
Size of works	P removed from effluent by chemical stripping £/kg	Additional Carbon produced in tonnes per tonne of P removed	P removed from effluent by existing plant £/kg	Additional Carbon produced in tonnes per tonne of P removed	P removed from effluent by new ASP plant £/kg	Additional Carbon produced in tonnes per tonne of P removed
< 250	157	16	1351	149	7408	1426
STW A	151	21	185	45	344	75
STW B	54	21	72	33	151	39
STW C	28	19	54	68	89	91
STW D	8	21	18	41	62	118

[20] However, the industry is currently at an early stage in its carbon accounting and the level of data available differs significantly between companies. 8 out of the 10 water and sewerage companies provided data on estimated additional carbon emissions. The figures provided have not been scaled up to estimate an industry total and may, therefore, be an underestimation.

6.6.4 Industry

No information is available on any additional costs or benefits of measures to tackle P removal from industry.

6.7 Affordability

6.7.1 Agricultural Diffuse

Analysis of the WPZ policy options for a 48% reduction in P loads, in the context of cumulative burdens, suggests that the impact on farmers, especially small farmers could be significant. Table I shows the estimated average farm level cost by sector for each of the 48% P reduction policy options.

Table 16[21]: average farm level cost of P measures

	WPZ 48%	WPZ+ Scheme	WPZ + Scheme + Advice
Cereals	£4,800	£3,500	£2,900
Dairy	£700	£600	£600
General cropping	£5,500	£3,800	£3,200
Horticulture	£600	£400	£300
LFA Grazing Livestock	£600	£600	£400
Lowland Grazing Livestock	£700	£700	£500
Mixed	£1,900	£1,600	£1,300
Pigs	£300	£200	£200
Poultry	£100	£100	£100
Average	£2,200	£1,600	£1,300

To establish the affordability of the policy measures it is helpful to compare the costs in Table 16 to farm income. Table 17 presents the estimated farm-level costs as a percentage of average farm business profit (FBP) calculated using an average of three years of farm business survey data.

Table 17 - Farm-level costings for CSF options –averaged income figures
Figures using average of 2003/4, 2004/5 and 2005/6

	% of FBP		
	WPZ	WPZ +	WPZ +

[21] These costs have been estimated by Defra by applying the unit costs of mitigation measures to farm business Survey 2005/6 data. The costs pertain to farms in England with a labour requirement of at least half a full-time equivalent. Average costs are presented by 'farm type', which is defined on the basis of principal output type. As many farms have mixed output, some costs are registered for farms classified under farm types that would not usually be expected to incur costs under these policy options, e.g. pigs and poultry. Average farm-level costs have also been calculated by region and by farm size, which provides a further indication of the likely spread of costs. Costs are in 2006 prices.

	48%	Scheme	Scheme + Advice
Cereals	12%	9%	7%
Dairy	2%	2%	2%
General cropping	11%	8%	6%
Horticulture	2%	1%	1%
LFA Grazing Livestock	4%	4%	3%
Lowland Grazing Livestock	6%	6%	4%
Mixed	6%	5%	4%
Pigs	1%	1%	1%
Poultry	0%	0%	0%
Average	6%	5%	4%

The income measures used include the Single Payment Scheme payment. As these indicators are being used to build up a picture of likely affordability it is important to include all sources of income received by the farm business. While the SPS payment - as a decoupled payment - should not impact on production decisions, it is still income against which regulatory costs can be compared. It is however worth noting that that income for agriculture is £1.84 bn with a subsidy at £1.88 bn [22] and the lack of SPS payment would obviously have a large effect on affordability.

The data in tables 16 and 17 show that the costs particularly to cereals and general cropping farms are potentially significant. It should also be noted that the costs are averages and are likely to vary depending on location, farm size and farm type. Additionally costs would also vary by catchment depending on the level of pollution reduction required.

6.7.2 Non Agricultural Diffuse

6.7.2.1 Detergents

Defra study on Cost of Generic Measures provides detailed information on costs and effectiveness [23] and gives an indication for the costs of a total ban. The administrative burden is expected to be similar to the costs of an environmental permit, as similar paperwork and inspections need to be carried out. This will amount to between approximately £500 and £1,000 per formulator, with a best estimate of £ 750 per formulator to be inspected per year. As the estimated total number of formulators in England is 18, the total annual costs are estimated to be £12,900 for England.

The impact of a partial ban on industries will be similar to the impact of a total ban. Both a total and a partial ban could be implemented via either EU or domestic legislation. In either case the cost of implementing controls on phosphates in detergents is expected to fall to the UK.

6.7.2.2 Misconnections

[22] http://statistics.defra.gov.uk/esg/statnot/account.pdf
[23] XX

- For *awareness raising – distribution of leaflets* there are no affordability issues as the cost would be borne by Defra and the Environment agency.
- For the *inclusion of vocational courses* – it has been estimated that a training course would have a duration of ½ day, and a cost per plumber of £50.
- For *increasing monitoring under the current regime* the impact of this measure will be borne by LAs.
- For a *ban on households doing their own plumbing* the affordability picture will be mixed. The cost for individuals interested to get the self-certification is a 5-day course at £ 820 + VAT. As the self-certified plumbers will be requested to send a notification of each plumbing activity they have undertaken to the Building Control, administrative burdens are foreseen. Households previously undertaking their own plumbing work might be forced to employ a certified plumber if this measure were to be enforced. This could result in extra costs for households for this type of work. The plumbing industry could be positively affected by this ban, as the barrier for households doing their own plumbing will become higher by the need of a self-certification. However, as the expected uptake of this measure is high, the impact of this ban on industry is expected to be very small. The regulator will need to monitor the applications for self-certification and the notifications of plumbing activities undertaken. This implies an administrative burden. The cost for this burden is estimated as follows:

Table 18 Administrative burden for regulator: self-certification

	England	**Wales**
Estimated extra time input for all Building Control offices (as FTE)*	30	8
Estimated annual salary cost for Building Control officers	60,000	60,000
Total annual equivalent cost per region	£ 1,739,000	£ 464,000

* no of Building Controls: 150 in England and 22 in Wales (source: Audit Commission 2006, no of councils); it is estimated that 1/3 FTE per council is needed to facilitate this measure.

- For the *transfer of power from local authorities to water companies* the private water companies will be affected by the proposed measure. Capital cost savings may be made through a reduction in the need for hard engineering solutions, whilst minimal costs are expected to be incurred as a result of increases in preventative work[24]. Some administrative processes will be required for the transfer of power.
- For institutional change to *improve local authority awareness of the problem and their powers and incentivisation of use*, the plumbing industry could be affected if the Local Authorities increase monitoring activities. The work load for the plumbing industry may increase as a result of the increased number of detected misconnections.

6.7.2.3 Urban Drainage

No affordability data is available for the implementation of SUDs.

[24] Information provide by Steering Group

6.7.3 Water Industry

Calculations have been made to estimate the range of impacts the measures for the water industry would have on bill payers. This is shown in table 19. The estimated bill impacts are calculated on a company basis and are shown in current price base. It should be noted that the costs submitted were estimates and not intended for price setting. (To derive these figures, it was necessary to work outside of the normal range of the model used (due to the high capital costs incurred). Although these figures should be treated with caution they give an impression of the potential impact on customer bills).

Table 19 - Estimated bill impacts in England and Wales

				Range of estimated bill impacts of the sewerage providers	
	Tonnes P removed	**Capex (£m)**	**Opex (£m/year)**	**Low (£)**	**High (£)**
Chemical dosing	17481	2078	112	3	38
Existing biological ASP	4898	933	44	0.9	27
New build biological ASP	1695	1675	57	9	52

6.7.4 Industry

No information is available on the affordability of measures to tackle phosphorus from industry.

6.8 Sensitivity of costs to phasing and technical approaches

6.8.1 Agricultural Diffuse

The Agriculture Working Group does not believe that by having a phasing in of mitigation measures any savings will be made to the individual mitigation costs, but intuitively believe that the longer a farm business has to plan for changes the more cost effective it is for these changes to be made .
There may be technological developments in dietary manipulation or genetic development for the livestock sector, but it is difficult to assess the sensitivity of this. In the arable sector there have been technology advancements in equipment, such as GPS for field work, but again it is difficult to assess the sensitivity of this.

6.8.2 Non Agricultural Diffuse

The phasing of mechanisms to tackle non-agricultural diffuse pollution would not create any savings, with the exception of the removal of P from detergents. If controls were implemented via an amendment to the EU Detergents Regulation, those amendments would be immediately applicable in domestic law. Delaying until the Commission amended the Regulation could therefore create a minimal saving in terms of resources as controls via domestic legislation would require additional resources to implement.

6.8.3 Water Industry

Some of the water industry believed that the phasing of chemical dosing treatment will have no effect on the capital costs required although savings may be made on the operational costs due to deferring the need to buy chemicals and dispose of extra sludge produced. Specific points made included:

- Phasing would be beneficial but companies are not currently in a position to quantify
- Benefits of a longer period of implementation may be offset if there is no long term strategy in place
- Major sites may require capacity enhancement and capital maintenance by 2015 so phasing the work will not result in cost savings
- As chemical dosing is a 'bolt on' process the only savings from phasing the work would be operational costs

The water industry has costed for the current best available technologies that exist to remove phosphorus from wastewater therefore there is no sensitivity of costs to alternative technical approaches.

6.8.4 Industry

For reduction of nutrients implementation of the identified solutions for industry is unlikely to vary significantly with time. It is likely that the supply of some of the chemical utilities will become scarce since demand will inevitably grow. Perhaps supply contracts that are established earlier will be subject to less marked variation.

It is likely that the processes selected for assessment will, in the main, be the treatment techniques of choice. There are various technologies that could be adopted to implement the processes and, there are numerous proprietary equipment types for each technology. In broad terms, when evaluated from a whole life perspective with an appropriate cost/quality risk balance, there is unlikely to be a significant variation in the unit cost for removal. Specific cases may be cited where one particular technology has a clear benefit but on average this is not considered to be a significant factor.

7. Measures ruled out

7.1 Agricultural Diffuse

The use of tradable permits was considered as an option to reduce phosphorus pollution as part of the CSF programme. One of the reasons this option not pursued further was because it was technically infeasible to create a scheme to take account of the spatial location of individual farms within a trading area and thus their damage on the local water quality. This would have reduced the effectiveness of the scheme as those farmers causing the most damage in a trading area could buy permits from farmers whose damage was much less thus maintaining the status quo and not reducing the specific areas of pollution needed to achieve WFD standards.

As well as being technically infeasible trading permits are also not cost effective. CSF analysis[25] found that the cost of setting up a scheme would not equal its effectiveness. This was due mainly to the consideration that specific types of farmers, e.g. dairy or arable, all tend to farm in the same area and therefore opportunities to trade on different practices are limited thus reducing the effectiveness of the scheme. Equally our analysis informed us that on the whole arable farmers tend to use phosphorus fertiliser at the appropriate level and that there would be little room to reduce inputs.

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[25] ADAS (2007), Catchment Sensitive Farming – Tradable Permit Schemes , Project Number WQ0106

Additionally no work was conducted on livestock diet. Early discussions with the Feed Industry highlighted the fact that work is ongoing on diets and that substantial improvements had been made to pig and poultry feeds. Other analysis on diffuse pollution also indicated that greater improvements could be achieved by tackling how and when manures are used rather than examining the content.

7.2 Non Agricultural Diffuse

7.2.1 Detergents

It may not be possible to substitute zeolites for phosphates in dishwasher detergents, since their abrasiveness can lead to scratching of kitchenware. Therefore controls on phosphate use in laundry detergents only has been examined. Controls on phosphates in dishwasher detergents are however currently in place in Italy and are in the process of being implemented in Sweden.

7.2.2 Food and Drink

The removal of phosphate from manufactured food and drink products has not been considered.

7.2.3 Urban Drainage

Only the implementation of SUDs has been considered to tackle urban drainage.

7.3 Water Industry

The water industry has approached this exercise on a semi site-specific basis[26]. Not every technology is applicable to every STWs and, therefore, some processes have been ruled out (eg some works may not be suitable for activated sludge plants). Also, some companies have not costed for biological phosphorus removal due to their lack of experience with the process. Specifically:

- Chemical dosing with aluminium sulphate has been ruled out due to EA concerns over the release of aluminium in to water courses.
- Ongoing R&D project in to the scope, costs and benefits of P removal at source. It is not feasibly possible to estimate the efficacy of this at the current time. This is also being addressed in the NADWP work.
- STWs without specific P reduction may reduce P concentrations by 2-3 mg/l, so reduction of the incoming P concentration may give rise to lower concentrations in effluent for STWs without specific P removal. However, this is outside of the water company's control.
- In favourable conditions both chemical dosing and biological nutrient removal can achieve effluent concentrations of less than 1mg/l. This may require additional tertiary treatment such as sand filters to prevent discharging excess levels of residual dosing chemicals. This was not costed and in discussions in the Water Sector Group companies were sceptical about achieving lower levels on a consistent basis.

[26] The water industry sector group was able to be site-specific when identifying sewage treatment works (STWs) 'at risk' or 'probably at risk', and were also aware of the different technologies already installed at these works. However, company-specific (i.e. not site-specific) 'cost curves' or modelling databases were used to develop the financial estimates.

The processes costed are the industry current best available technology and limited information is available regarding processes available to achieve tighter consents. Companies commented that:

- Processes to deliver tighter consents are unproven and the costs to achieve these small reductions will be disproportionate.
- Chemical dosing should be able to achieve a consent limit of 0.5mg/l but this would require tertiary treatment to be installed, greater on-line process monitoring and regular site visits and water companies did not cost this.
- Membrane technology may be able to achieve an annual average phosphorus consent limit of 0.4 mg/l although lack of experience of operating such equipment has prevented costs being estimated. It would, however, be expensive and energy intensive.
- Ion exchange or barrier methods (membranes with nano scale pores) have little application in the wastewater industry and would incur excessive costs in the pre-treatment of effluent and additional pumping.

7.4 Industry

Only chemical phosphorus removal was considered as part of the Industry working group report.

8. Measures to Reduce Uncertainty

Both Defra and the Environment Agency will continue to carry out research and actions into phosphorus apportionment, phosphorus losses to water and the links to ecological impacts, mitigation mechanisms and measures. For example the English Catchment Delivery Initiative, run in partnership with Defra, EA and Natural England, is piloting a supportive approach to dealing with agricultural diffuse pollution, which includes the use of mitigation measures in the User Manual. Improving our understanding of the processes involved in nutrient pollution and eutrophication, from sources through to impacts and the benefits of control measures, is a major area of continuing international research. In the UK there are significant ongoing research programmes to support the development and implementation of policies in this area, sponsored by the UK environmental regulators.

Additionally enhanced monitoring and modelling will be available to increase the certainty of actions taken to target control measures and mitigate phosphorus pollution.

9. Further considerations: Costs, Distributional Trade Offs, Uncertainty

<u>9.1 Costs</u>

The ranges of costs of the measures presented by the working groups are shown in table 19. This shows that the costs within and between sectors vary considerably. Table 20 shows the order of cost effectiveness of all the measures proposed by the working groups.
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Table 20 – order of cost effectiveness of measures

Ranking	Sector	Measure	Cost per kg
1	Non-ag diffuse	P removal in detergents – partial ban	0.075
2	Non-ag diffuse	Misconnections – vocational training	0.085
3	Non-ag diffuse	P removal in detergents – total ban	0.1
4	Non-ag diffuse	Misconnections – leaflets	0.49
5	Non-ag diffuse	Misconnections – ban on hh plumbing	0.75
6	Water Industry	Chemical Dosing – STW D	8
7	Non-ag diffuse	Misconnections – more monitoring	14.77
8	Water Industry	Biological - Existing ASP – STW D	18
9	Industry	Very Large 2mg/l	26
10	Agriculture	WPZ 30%	26.2
11	Industry	V large 1mg/l	27
12	Water Industry	Chemical Dosing – STW C	28
13	Industry	Large 2mg/l	30
14	Industry	Large 1mg/l	31
15	Industry	Medium 2mg/l	40
16	Industry	Medium 1mg/l	41
17	Water Industry	Chemical Dosing – STW B	54
18	Water Industry	Biological - Existing ASP – STW C	54
19	Water Industry	Biological - New ASP – STW D	62
20	Agriculture	WPZ + scheme 30%	67.2
21	Water Industry	Biological - Existing ASP – STW B	72
22	Industry	Small 2mg/l	78
23	Industry	Small 1mg/l	83
24	Water Industry	Biological - New ASP – STW C	89
25	Agriculture	WPZ 48%	105.3
26	Agriculture	WPZ + scheme 48%	107.0
27	Industry	Very small 2mg/l	134
28	Industry	Very small 1mg/l	141
29	Agriculture	WPZ + scheme + advice 48%	150.5
30	Water Industry	Biological - New ASP – STW B	151
31	Water Industry	Chemical Dosing – STW A	151
31	Water Industry	Chemical Dosing - <250	157
32	Agriculture	WPZ + scheme + advice 30%	165.0
33	Water Industry	Biological - Existing ASP – STW A	185
34	Agriculture	WPZ + scheme 54%	256.6
35	Agriculture	WPZ 54%	267.2
36	Agriculture	WPZ + scheme + advice 54%	261.4
37	Water Industry	Biological - New ASP – STW A	344
38	Water Industry	Biological - Existing ASP – <250	1351
39	Water Industry	Biological - New ASP – <250	7408

Table 20 shows that removing phosphates in detergents is the most cost effective method available to tackle phosphorus pollution, followed by methods to solve misconnections and chemical dosing in large sewerage treatment works. However it should be noted that these measures result in different actual reductions in tonnage for example removing P from laundry detergents would reduce P loads by 22749 tonnes over 25 years whereas implementation of chemical dosing in large sewerage works would remove 12971 tonnes every year.

9.2 Distributional trade offs

There are two ways to consider the distributional trade offs regarding phosphorus abatement. Firstly by examining the distribution of the costs within and between sectors (together with an assessment of the affordability of these costs where they fall) and secondly to consider how well the costs and benefits of measures align.

With regards to the costs to the sector it is worth noting that all the costs presented by the working groups are national averages and therefore at a local level the costs could be much higher in some areas, this is especially relevant for the water industry and agriculture.

The cost of implementing phosphorus removal systems in the water industry will be borne by water consumers. The implementation of the measures put forward would increase water bills from between £3 and £52 per year depending on the technology implemented and the spatial distribution of the implementation of measures. No information is available on the affordability of these increases in bills to water consumers.

On average the cost to farmers of achieving a 48% reduction in phosphorus loss varies between 1% and 12% of annual income depending on the policy adopted and the sub-sector, for example the impact on arable sectors will be much greater than that on poultry (see tables I and J). In actual terms this is on average between £100 and £4800 per farm per year.

The non-agricultural diffuse and industry working groups have not identified any issues surrounding affordability.

It may therefore be argued that the distributional impacts of the agricultural measures are likely to be the largest although there is uncertainty over the impact of a rise in water bills on consumers.

The second aspect of distributional tradeoffs is the alignment of costs and benefits. It is helpful to consider each sector in turn.

The costs of implementing measures within the water industry are passed onto water customers i.e. the general public. The benefits of achieving the WFD standards are public benefits that will be enjoyed by society as a whole. Therefore it could be argued that in the case of the water industry there are no distributional trade offs between those who pay the costs and those who receive the benefits.

For agriculture the picture is not quite as clear. The distribution of costs and benefits depends on how property rights are defined. If property rights are assigned to the farmer then society should pay the farmer for the benefits of the WFD standards. In this case the cost of mitigation should not be borne by the farmer but by society as a whole. However if property rights are assigned to society then the polluter pays principle applies and the farmer must pay for mitigation measures to reduce pollution from the farm. The assignment of property rights will determine whether there are any distributional issues within the agricultural measures. If it is determined that the farmer owns the property right then a transfer is required to help fund the mitigation measures – this could be seen as partly what is occurring in the measures that where proposed by the agriculture working group that include schemes and advice.

For Industry and the removal of phosphorus from detergents the cost may be passed onto consumers and therefore society pays and society receives the benefits.

In conclusion, in relation to the alignment of costs and benefits, there only appears to be an issue surrounding distributional tradeoffs with regards to agriculture and this will be determined by the theoretical allocation of property rights to either farmers or society.

9.3 Uncertainty

The main uncertainty within this report is the cost estimates. These cost estimates are national averages and practise will vary enormously at the local level. There is also uncertainty surrounding the accuracy of the costs as many are based on assumptions that may or may not be correct.

The effect of implementing measures to tackle phosphorus loss from agriculture is very uncertain. The modelling work that has been carried out reduces the loss from the farm into the water but there is a lack of information regarding how long these on farm changes will take to translate in actual changes in water quality. It is therefore important to note that the implementation of agriculture measures would not result in a certain achievement of the WFD standards.

The most certain of the measures is the introduction of chemical and biological stripping in sewerage treatment works and the measures for industry. The removal of phosphate from laundry detergents will have certain effect but the uncertainty surrounding apportionment means that is unclear how big this effect would be and if it would be significant.