Chapter 4.6

Sanitary

1. Introduction

This chapter considers pressures arising from the presence of “sanitary” parameters; ammonia and biological oxygen demand (BOD). The main focus is on ammonia as, while not universally the case, measures to reduce ammonia levels will also, in general, provide lower BOD.

The information currently available is incomplete and mostly provided by the Water Industry working group. This information points to discharges from sewage treatment works (STWs) as being the most significant source of ammonia, although locally and in certain regions, diffuse inputs from agriculture or urban run-off may be important The measures assessed to close the “gap” are therefore targeted at continuous inputs of ammonia and BOD from the Water Industry (mainly STWs). The limited availability of information from sectors other than the Water Industry cannot be assumed as meaning that they have no contribution to make. Once this information becomes available, it should be included so that a holistic estimate of cost effectiveness can be determined. One of the main outcomes of this chapter may well be agreement on the need for further monitoring and/or modelling work to apportion the contribution of the various sectors; and then to develop mechanisms for identifying which of the available measures (or combination of measures) to address ammonia and BOD pressures are the most practical and cost effective in any particular circumstance.

2. Relevant Water Framework Directive Objectives

The two relevant default Water Framework Directive (WFD) objectives are: prevention of deterioration and achievement of good chemical and good ecological status (GES)[1]. Additional objectives may be relevant in the case of waters designated as “protected areas”.

The relevant water quality standards for ammonia and BOD in rivers are expected to be based on those currently proposed by UKTAG (UK Environmental Standards and Conditions (Phase 1), Final Report, August 2006). These are as set out in Table 1, Table 2 and Table 3.

[1] “Good status” means Good Chemical and Good Ecological status.

Table 1 Standards for ammonia

Standards for ammonia		
Total ammonia (mg/l)		
(90-percentile)		
Type	**High Status**	**Good Status**
Upland and low alkalinity	0.2	0.3
Lowland and high alkalinity	0.3	0.6

Existing standards[2]	
Total ammonia (mg/l)	
(90-percentile)	
High Status	**Good Status**
0.25	0.6

Table 2 Standards for oxygen conditions (BOD)

Standards for oxygen conditions (BOD)		
Biological Oxygen Demand (mg/l)		
(90-percentile)		
Type	**High Status**	**Good Status**
Upland and low alkalinity	3	4
Lowland and high alkalinity[4]	4	5

Existing standards[3]	
Biological Oxygen Demand (mg/l)	
(90-percentile)	
High Status	**Good Status**
2.5	4

Table 3 Standards for oxygen in rivers

Standards for oxygen in rivers		
Dissolved Oxygen (per cent saturation)		
(10-percentile)		
Type	**High Status**	**Good Status**
Upland and low alkalinity	80	75
Lowland and high alkalinity	70	60

<table>
<tr><td colspan="3">Existing standards</td></tr>
<tr><td colspan="3">Dissolved Oxygen (per cent saturation)</td></tr>
<tr><td colspan="2">(10-percentile)</td><td>(5-percentile</td></tr>
<tr><td colspan="2">High Status</td><td>Good Status</td></tr>
<tr><td colspan="2">Existing classification schemes[5]</td><td>Freshwater Fish Directive[6]</td></tr>
<tr><td>80</td><td>70</td><td>65-75
Salmonid
45-55
Cyprinid</td></tr>
</table>

Ammonia is directly toxic to fish and aquatic animals in rivers, particularly in its un-ionised form. Its degradation in the aquatic environment also contributes to oxygen depletion. BOD is the measure of the oxygen uptake of an effluent, i.e. the oxygen required to facilitate its degradation by aerobic microbial activity. The higher the BOD the greater the potential of the effluent to cause a drop in

[2] The existing values are the thresholds used for the River Quality Objectives, RE1 and RE2, for England and Wales, and for Class A and B of the General Quality Assessment.

[3] The existing values are the thresholds for the River Quality Objectives, RE1 and RE2 for England and Wales, and for the best two classes of the schemes used in all countries.

[4] Where a lowland, high alkalinity water body is a salmonid river then the standards for the upland, low alkalinity type will apply.

[5] The existing values are those for River Quality Objectives, RE1 and RE2 for England and Wales and for the best two classes of the schemes used in all countries.

[6] The values from the Freshwater Fish Directive as 6 mg/l would typically represent a 10-percentile of percentage saturation of approximately 65 to 75%. The value of 4 mg/l would represent a 10-percentile of percentage saturation between 45 to 55%.

dissolved oxygen (DO) in the receiving water potentially killing fish and other aquatic life.

UKTAG suggest that the DO standard is used for assessing and reporting compliance of rivers, and that the BOD standards, developed on the basis of oxygen conditions associated with macroinvertebrate communities, are used for deciding action to meet the DO standard in the river. This is because the levels of BOD can be misleading in clean rivers, and because the link between BOD and DO is a complex and uncertain issue if dealt with on a site by site basis. The ammonia standards have been developed on the basis of ammonia conditions associated with macroinvertebrate communities at high and GES. Further work will be done during the first cycle of river basin management plans (RBMPs) to confirm that the proposed values also protect communities of freshwater fish.

Standards for DO in lakes have also been derived by UKTAG; these standards are based on the protection of fish (Table 4). Oxygen consumption in lakes depends on the natural productivity of the lake and the shape of its basin. UKTAG propose two morphological types; mixed, and stratified during summer. They also propose to divide lakes into those that support natural populations of salmonid fish, and those with natural populations of cyprinids.

It is proposed by UKTAG that DO in lakes is measured on a single occasion each year of a 3 to 5 year period, and that this is done in July or August, as this is when oxygen levels are likely to be lowest. The proposed standard is the mean of the whole water column in fully mixed lakes and the water column below the thermocline in stratified lakes.

Table 4 Standards for DO in lakes

Status	*Proposed boundary in UK lakes* *Mean in July to August (mg/l)*	
	Salmonid	**Cyprinid**
High Status	9	8
Good Status	7	6
Moderate Status	4	4
Poor Status	1	1

Further work, during the first RBMP cycle, is proposed to develop standards for transitional and coastal waters (estuaries and inshore sea).
UKTAG has not proposed standards for ammonia in lakes. Where needed for discharge control purposes, it is expected that the ammonia standards for rivers would apply.

For protected areas, where standards are relevant, the UKTAG standards are expected to almost invariably apply where more stringent than those under the legislation creating the protected area.

3. Pressures, trends and associated uncertainty

3.1 Pressures

Typical sources of ammonia and BOD are sewage effluents, food and related industry effluents and diffuse agricultural and urban run-off. Effluent treatment systems that limit BOD and ammonia discharges usually involve aerobic biological treatment. Ammonia is more difficult to remove than BOD and reducing ammonia levels is usually the limiting factor in the treatment of sewage and related effluents.

The first river basin characterisation (RBC1) exercise for England and Wales assessed

- 23% of river length (11 852 km of 51 183 km) as "at risk "; and
- 81% of transitional and coastal waters (2 195 km^2 of 2 964 km^2) and 8% of coastal waters (1 162 km^2 of 14 458 km^2) as "probably at risk" of failure to meet GES because of point source sanitary discharges.

3.2 Trends

The Urban Waste Water Treatment Directive (UWWTD) sets treatment levels and BOD emission limits applicable to all continuous sewage discharges above a size threshold. This and other European Union (EU) and national measures already in force have resulted in improvements in water quality. The general load of BOD being discharged to controlled waters has decreased markedly over the last 17 years (particularly to coastal waters) as major improvement programmes to deliver secondary treatment under UWWTD and tertiary treatment in UWWTD Sensitive areas have been delivered. However, in many cases, additional measures will be required to meet expected WFD standards, even taking into account measures delivered already or planned for the current investment cycle (AMP4).

3.3 Uncertainties

RBC1 identified point sources as the most likely cause of failure to meet WFD objectives. However, in view of the many uncertainties regarding ammonia and organic enrichment, further work during the early part of river basin management plan (RBMP) 1 to inform RBMP2 will be required to clarify sanitary pressures particularly in relation to transitional and coastal waters. Further, while it is recognised that diffuse pollution and intermittent discharges contribute to ammonia and BOD loads in water bodies, insufficient information has been made available to the authors to permit an estimate of apportionment or the costs of reducing ammonia and BOD loads to surface water from these sources.

4. Apportionment and associated uncertainty

4.1 Apportionment

The main sectors contributing to this pressure are:

- Water industry (through sewage discharges);

- Agriculture (principally the dairy, beef, pig and poultry sectors and horticulture); (both direct and in-direct pathways of ammonia arising from manure and slurry in livestock farming and application of nitrogen fertilisers. Ammonia emissions to air can be absorbed into rainfall and enter surface waters directly and via drains and sewers); and

- Other industry.

The Environment Agency's (EA) Strategic Assessment indicated that approximately 65% of ammonia in rivers is attributed to STWs, with approximately 20% attributed to urban pollution (sewer overflows and misconnections). However, further modelling is required to firm up this apportionment, both for continuous and intermittent inputs of ammonia and BOD. Ongoing EA SIMCAT modelling at national and regional level should provide more detail on apportionment. The UKTAG standards report (Table 5) indicates that in England 14.6% of rivers fail existing ammonia standards and it is predicted that 17.3% will fail the proposed WFD standards (1.4% and 2.7% respectively in Wales). In light of the information available it is reasonable to infer STW effluent, combined sewer overflows, storm tanks and misconnections are the dominant source of failures.

Table 5 Implications of proposed UKTAG standards for BOD and ammonia

Location	*BOD*		*Ammonia*	
	Percent of river length reported as less than good			
	Existing	**Proposed**	**Existing**	**Proposed**
England	25.6	18.7	14.6	17.3
Wales	3.7	3.7	1.4	2.7
Scotland	8.2	7.6	7	10.7
Northern Ireland	19.0	16.3	4.4	16.3

The indication at present is that half of the failures of water quality standards could be put right solely by improvements to discharges from STWs and it is anticipated that further investigation at a regional level will indicate that the majority of the remaining failures can be attributed to sewerage infrastructure.

Sources of organic enrichment (BOD) include discharges of sewage effluent (both continuous and intermittent) and other industrial discharges (e.g. paper mill effluent). Diffuse urban and agricultural run-off can also be relevant. However, currently there is little available information to make this assessment and therefore further monitoring and research (water quality and biological) is required.

4.2 Uncertainties

It has not been possible to identify information which gives a comprehensive assessment of apportionment of ammonia and BOD pressures across all water bodies or particular groups of bodies (e.g. rivers, lakes). There are preliminary data from the Ribble pilot study which indicates that, in that particular case, 95% of ammonia comes from water industry discharges and 5% from urban run-off. Overall the evidence from consents and flow suggest that a high proportion of ammonia in rivers comes from the water industry, with industry discharges and agricultural sources playing a smaller part.

More information is required on the contribution from individual sectors so that local solutions can be determined or the local or national impacts assessed. For example, minor STWs are generally located in rural areas where other sectors such as agriculture could be making the greater contribution. Another example might be that the extent to which effluent produced in a catchment is discharged to estuarial, coastal or inland waters may affect the impact of point source discharges.

5. Groups of measures to meet WFD objectives

The Water Industry working group refers to the EAs request to assess costs for 1, 3 and 5 mg/l ammonia consent limits. Although these are 95-percentiles not maxima, performance data shows that where tight ammonia limits apply mean effluent levels substantially less than the limit values are achievable.

Within the water industry, technology is available to achieve very low ammonia concentrations in final effluents from STWs. Currently a high proportion of STWs are operating to ammonia consents of between 5 and 10 mg/l. 1 mg/l ammonia is on the boundary of what is technically achievable with current technology on a regular basis owing to the natural variation in temperature and the effectiveness of biological sewage treatment processes.

Therefore, for future improvements in sanitary conditions, the following options were explored in the Water Industry working group report:

- 5 mg/l ammonia with 15 mg/l BOD;
- 3 mg/l ammonia with 10 mg/l BOD; and
- 1 mg/l ammonia with 5 mg/l BOD.

The choice of which set of limits might apply will depend on the current quality of the receiving water and dilution available for natural degradation and attenuation. In all cases therefore, the final decision on the level of treatment needed will be made at a local level; in some cases it will be less than the limit values considered, in other cases greater. This will depend, in part, on the spatial arrangement of discharges within catchments, as there might be little benefit, for example, of improving a STW if those downstream were not improved.

In general, the water companies agreed that processes are available to achieve tighter consents but that these may have high financial and environmental costs in terms of energy and maintenance. Process breakpoints are dependent on individual site circumstances. Although activated sludge should be able to achieve <5 mg/l ammonia there are environmental dis-benefits (increased CO_2 emissions from energy use). Similarly BOD standards <10 mg/l will normally require tertiary treatment to be provided, which also has associated environmental dis-benefits in terms of power consumption.

The non-agricultural sector did not identify measures which would specifically target ammonia or BOD but some identified some measures that deal generally with preventing water pollution by run-off (e.g. dealing with misconnections of domestic sewage into surface water drains, and implementing sustainable urban drainage systems (SuDs) where appropriate) that would contribute to the reduction of the ammonia and BOD load.

To reduce ammonia emissions from agricultural sources measures can be aimed at reducing gaseous emissions to tackle ammonia independently or employing husbandry or attenuation techniques that reduce the entry into surface waters of diffuse pollutants in general.

While there is limited empirical evidence to quantify and apportion diffuse ammonia losses (quantified pathways), it is likely that agricultural and non-agricultural diffuse water pollution (NADWP) measures (such as general binding rules to cover site management, reducing misconnections, the use of SuDs, agricultural incentives, water protection zones and voluntary and local partnership measures) to tackle other pollutants (e.g. nitrate phosphorus, sediment, microbial pathogens and BOD) will also reduce inputs of organic and inorganic ammonia. However, there is no specific empirical evidence that we are aware of to quantify or apportion the extent to which these measures would have a significant impact on ammonia. There is therefore no defensible method for estimating costs or effectiveness.

5.1 Scenarios

Three options have been suggested:

1. Hard enforcement: change consents at STWs which are at risk of failing to meet the WFD standards as proposed by UKTAG. This will be done where detailed water quality modelling has demonstrated with sufficient certainty that the pressure is due to the STW alone and cannot be achieved by contributing improvements by other sectors. This could be done in conjunction with the other measures mentioned in Section 6, although there is no information as to the effectiveness of these measures or their costs. An appropriate monitoring programme should be set up to provide the necessary evidence to prevent an over conservative approach and unwarranted investment.

2. Only change consents when assets require upgrading or when there are multiple reasons for doing so (e.g. at same time as N and P removal). This should only be done where detailed water quality modelling has demonstrated with sufficient certainty that the pressure is due to the STW alone and could not be achieved by contributing improvements by other sectors. This could be done in conjunction with the other measures mentioned in Section 6, although there is no information as to the effectiveness of these measures or their costs

3. Try innovative measures - performance or system management - rather than capital expenditure - e.g. flow balancing. There is no information as to the effectiveness of these measures or their costs.

6. Costs of groups of measures

6.1 Water Industry

The costs of measures to meet the consents at STWs which are “at risk” of causing a failure to meet the proposed UKTAG standards (for Scenario 1) depend on the level of consent imposed as well as site- and catchment-specific conditions. For England, it is estimated that for all “at risk” STWs to upgrade to meet 5 mg/l the cost would be £296.4 m/year; to meet 3 mg/l would cost £508.4 m/year and to meet 1 mg/l would be £824.7 m/year (Table 6).

Table 6 Financial costs of achieving consents of 5, 3 and 1 mg/l at STWs which are currently "at risk" in England of meeting proposed UKTAG standards for ammonia and the percentage reduction in load this equates to

	Size of STW[7]	Total financial costs per party per annum (£m/year)	Reduction of total load from STW at risk (%)
5 mg/l	<250	7.8	
	STW Band D	109.8	
	Total	**296.4**	**65.2**
3 mg/l	<250	8.8	
	STW Band D	155.6	
	Total	**508.4**	**73.52**
1 mg/l	<250	13.4	
	STW Band D	227.3	
	Total	**824.7**	**87.17**

For Wales, it is estimated that for all "at risk" STWs to upgrade to meet 5 mg/l the cost would be £7.8 m/year; to meet 3 mg/l would cost £15 m/year and to meet 1 mg/l would be £23.8 m/year (Table 7).

Table 7 Financial costs of achieving consents of 5, 3 and 1 mg/l at STWs which are currently "at risk" in Wales of meeting proposed UKTAG standards for ammonia and the percentage reduction in load this equates to

	Size of STW[8]	Total financial costs per party per annum (£m/year)	Reduction of total load from STW at risk (%)
5 mg/l	<250	0.0	
	STW Band D	3.5	
	Total	**7.8**	**65.2**
3 mg/l	<250	0.0	
	STW Band D	155.6	
	Total	**15.0**	**73.52**
1 mg/l	<250	0.0	
	STW Band D	227.3	
	Total	**23.8**	**87.17**

A targeted approach where there are current failures is considered a sensible approach though the Water Industry working group has concerns over the level of consent proposed. It considers that a 1 mg/l ammonia limit is on the boundary of what is technically achievable on a consistent basis owing to the natural variation in temperature and the effectiveness of biological sewage treatment processes. Achieving this effluent standard on a consistent basis, even with well-designed plant, would be difficult. Once ammonia standards of 1 mg/l or less are needed,

[7] STW Band D: 100 000 people equivalent and over.

[8] STW Band D: 100 000 people equivalent and over.

substantial process upgrading is required (rebuild rather than add-on, as is reflected in costs which are approximately 2.5 times greater than to achieve 5 mg/l).

Scenario 2 which suggests only changing consents when assets require upgrading or when there are multiple reasons for doing so, in theory should reduce costs, but there is no cost information available to quantify this. The pCEA exercise asked companies for separate information for P, N and ammonia, not for overlaps and so companies would need to cost this overall package of measures on a site specific basis as it depends on what is there already.

For the 5 mg/l ammonia consent standard there may be opportunities to combine maintenance/refurbishment work with quality improvements. For the tighter consents of 3 mg/l and 1 mg/l there would be fewer opportunities as specialised tertiary treatment would be required.

Improved primary and secondary treatment for ammonia/BOD would assist with P reduction, so there would be a technology overlap (but the effect is not quantifiable at this stage). There is potential incompatibility with N reduction technologies.

Under Scenario 3 innovative measures could be employed to try and reduce ammonia levels without the need for rebuilding or retrofitting. This is in line with the acknowledgement by water companies that the WFD will drive significant development of modelling techniques and tools, in addition to an increased understanding of ecosystems. However, this option may require substantial time and resources in developing new techniques and in testing their effectiveness.

While innovation may deliver cheaper, less energy intensive solutions there is an associated lower level of certainty in delivery, if the decision is to proceed with this scenario.

Water companies recommend that further development of modelling tools and techniques, and research into sustainable technological developments for subsequent investment should be supported in AMP5.

For smaller STWs, there is a stronger case for trialling technologies and phasing in work to reduce the overall cost.

6.2 Agriculture

Investigation of specific measures to reduce gaseous emissions of ammonia suggest that store covers for manure have the lowest marginal cost in reducing ammonia emissions to air (cost-effective means of reducing ammonia emissions from UK agriculture using the NARSES model, Webb *et. al*), though these measures would be unlikely to cause a substantial emission reduction used in isolation.

Immediate incorporation of dairy sludge to arable by disc (rather than spraying) has the highest reduction in emissions at the lowest marginal cost; an emission change of 3.080 t x 10^3 for a marginal cost of £0.49 kg $^{-1}$
Storing all broiler type manure would also have a considerable reduction in emissions; 3.789 t x 10^3 for a marginal cost of £0.64 kg $^{-1}$

Such measures are in addition to those that would be employed to prevent P reaching watercourses.

One measure costed to reduce ammonia; storing all pig farmyard manure which would reduce emissions by 3.281 t x 10^3 at a marginal cost of £1.73 kg^{-1}, would also be likely to reduce P and so can be considered as a cross-cutting measure. Other measures specific to reducing nutrients will have no impact on ammonia levels (e.g. by reducing P in fertilisers).

Alternative measures used to reduce other pressures; techniques such as using buffer zones, reducing use of ammonium nitrate fertiliser and reducing stocking density should also have a beneficial impact on reducing ammonia emissions, though these have not been quantified. With an anticipated reduction in agricultural livestock stocking density of 25% by 2015, the ammonia component that derives from agricultural sources should be considerably reduced.

6.3 Diffuse sources

While it is assumed that the majority of ammonia in rivers is largely due to sewage discharges at a national scale, contribution from other sectors may be more significant at local levels. For example, agriculture could potentially contribute a greater proportion in rural areas than STWs. However, there is little existing information on this, and further research and modelling is required to quantify it.

Situation specific investigations would be required to ensure cost-beneficial investment is made. Water companies are strongly recommending a programme of investigations in AMP5 (2010 to 2015) which would help determine the scale of diffuse input of ammonia to aquatic systems at a more regional level, ensuring the “polluter pays principle”.

6.4 Non-agriculture

It is recognised that non-agricultural measures could be implemented to reduce ammonia and BOD loads. However, there is little information available for this at present and further research and monitoring is required to meet this gap (e.g. direct industry discharges, highway discharges, sewer exfiltration and misconnections of sewage to surface water sewers).

7. Measures not considered

7.1 Measures ruled out as obviously not cost-effective

It was determined by the Water Industry working group that more detailed analysis would need to be carried out to provide technical and economic comparisons between conventional treatment, new technologies and abandonment options. However, most companies were of the view that ammonia consent levels below 1 mg/l would not be cost effective nor would they necessarily result in improved effluent quality. The processes used for the removal of ammonia are biological and based on forced aeration to achieve this standard. On the basis of current technology, a further reduction in the consent level would not result in an improved effluent quality with respect to ammonia; rather, it would result in increased risk of failure to the water company.

Other measures not favoured by water companies include:

- replacing existing biological filter STWs with Activated Sludge Plants (ASP), as it was considered likely that this option would greatly increase the costs (operational expenditure, capital expenditure and greenhouse gas emissions);

- various technologies involving harvesting of algae for ammonia removal and carbon sorption due to lack of land available or impracticality/cost at many of the sites concerned; and

- the design standard of 1 mg/l ammonia with 5 mg/l BOD (rather than 10 mg/l BOD). Although technically feasible this was dismissed as financially and environmentally inappropriate due to an operating expenditure increase of over 100% and a power and subsequent CO_2 increase of approximately 200%[9].

The Agriculture working group primarily dealt with the policies to tackle P pollution, because of the complex nature and lack of data on other pressures. (It is likely that the most significant ammonia sources from agriculture are from farmstead surface water drainage and access roadways, not from fields).

The Non-Agriculture working group report did not focus on ammonia/BOD and neither group has identified any specific measures to be ruled out (or in!) in relation to these pressures.

8. Measures to reduce uncertainty

The most obvious requirement and first step in resolving the various uncertainties identified in this chapter is an information gathering and analysis exercise. This should include increased effort in monitoring of environmental activities (i.e. sources, pathways and receptors) and discharges and modelling scenarios and options. Much of this work using currently available data is being carried out by the EA in its SIMCAT modelling. The costs of such an exercise have not been identified but are likely to be significantly lower than the potential costs of unnecessary expenditure on measures which go beyond what might be required to contribute to meeting WFD objectives. No costs have been provided by the working groups for this.

There is a clear need for much improved monitoring, and subsequent modelling of urban run-off, and mapping and monitoring of surface water sewer systems. Similarly there is a clear need for significantly increased monitoring and modelling of agricultural land use and run-off. No costs have been provided by the working groups for these.

9. Conclusions

The key messages that emerge from this investigation are the following:

[9] Note that this standard of treatment is only likely to be required at a small proportion of the works that contribute or are likely to contribute to failure of UKTAG standards.

1. 23% of the length of rivers in England and Wales are "at risk" of failing the proposed UKTAG standards for ammonia and BOD and so appropriate measures are required.

2. The available evidence points to STWs as the most significant source of continuous input of ammonia (~65%) nationally. Approximately 20% of the load is derived from urban pollution (sewerage overflows and misconnections). Diffuse input from agriculture while not significant on a national level may be more important at a regional or local level.

3. Processes are available for STWs to achieve tighter consents but these are expensive and have high energy and maintenance costs and so a blanket approach should not be applied.

4. It is possible that innovative measures such as performance or system management may deliver cheaper, less energy intensive solutions. However, these also have a lower level of certainty in delivery. This uncertainty could be reduced by research into sustainable technological developments.

5. To achieve a high certainty that the proposed WFD standards are going to be met would require upgrading those STWs at sites identified as "at risk" or changing consents when other upgrades (e.g. for P reduction) are being carried out.
6. The measures to limit diffuse agricultural input may include attenuation techniques and good husbandry/farming practices to decrease loading of ammonia as for other pollutants. Ammonia originating from non-agricultural sources could be prevented from entering water bodies if SuDs were implemented to replace existing surface water drainage systems.

These key messages must, however, be interpreted within the overall context of the report. The context is that the information presented in this report is currently incomplete and mostly provided by the Water Industry working group. Limited information was available from the Agriculture and Non-Agriculture working groups on diffuse pollution, and there is little national information available on intermittent discharges of ammonia and BOD. It is anticipated that updated SIMCAT modelling is likely to provide better information on apportionment. Once this information becomes available, it will need to be assessed and used to develop mechanisms for identifying which of the available measures (or combination of measures) to address ammonia and BOD pressures are the most practical and cost effective in any particular circumstance. One of the main conclusions of this chapter is therefore agreement on the need for further monitoring and/or modelling work to apportion the contribution of the various sectors.

Although there are gaps in the evidence available, the EA still considers that the majority of ammonia levels in water can be attributed to sewage discharges (either from domestic or industrial origin) and problems with sewerage infrastructure. Site investigations have routinely found that point releases of ammonia from STW, especially in storm conditions or other times when they are not operating at optimal efficiency, have resulted in fish kills. However, further research and monitoring is required to verify this conclusion.

While most evidence points to STWs being the principal source of ammonia on a national scale, this is not likely to be uniform across the UK. In rural catchments with smaller STWs, agricultural sources of ammonia may prove to be more significant and so more detailed modelling at a regional level should be employed to aid decisions on ameliorative action.

Although agriculture is responsible for 80% of gaseous ammonia emissions into the environment there is little evidence to point to much of this entering the aquatic environment. The ammonia in rainfall is dilute and readily degraded by soil microbiology and chemistry. The direct input of ammonia from rainfall entering surface waters directly and via land drains and sewers is minimal.

The impact ammonia has on the ecology of a water body while well understood, also varies as a function of the population the STW deals, flow dynamics, temperature and alkalinity of the receiving water body. Therefore a one size fits all approach to ammonia consenting is not advisable for planning measures.