Appendices

A Water Quality Assessment

A.1 Introduction

The increased discharge of effluent due to a growth in the population served by a Water Recycling Centre (WRC, former known as Waste Water Treatment Works - WwTW) may impact on the quality of the receiving water. The Water Framework Directive (WFD) does not allow a watercourse to deteriorate from its current class (either water body or element class).

It is Environment Agency (EA) policy to model the impact of increasing effluent volumes on the receiving watercourse. Where the scale of development is such that a deterioration is predicted, a new Environmental Permit (EP) may be required for the WRC to improve the quality of the final effluent, so that the extra pollution load will not result in a deterioration in the water quality of the watercourse. This is known as a “no deterioration” or “load standstill".

EA guidance states that a 10% deterioration in the receiving water can be allowed in some circumstances as long as this does not cause a class deterioration to occur.

If a watercourse fails the 'good status' target, further investigations are needed in order to define the 'reasons for fail' and which actions could be implemented to reach such status.

Anglian Water (AW) prepared a RAG analysis of the capacity and performance of all WRCs within East Lindsey which may see increased flows due to housing allocations. This analysis identified eight WRCs with potential future capacity issues due to growth. For the preparation of the phase II Water Cycle Study (WCS), East Lindsey District Council requested that a water quality impact assessment should be carried out at these eight WRCs:

- Coningsby
- Horncastle
- Ingoldmells
- Legbourne
- Louth
- Manby
- Sibsey
- Woodhall Spa

This report assesses the potential water quality impacts due to growth in WRC effluent flows and loads at 7 of these WRC discharge points. Ingoldmells was not assessed because it discharges to the sea. Please note that, whilst the other WRCs not considered in this assessment may have capacity within their consents to accommodate the planned growth scenarios, this does not necessarily imply that the watercourse would, with the existing consent, be able to meet Good Status, nor that future increases in discharges within the permitted consent would not lead to a deterioration occurring.

A.2 Standards

The WFD targets for Good Ecological Stats (GES) for Biological Oxygen Demand (BOD), Ammonia (NH_4) and Phosphorus (P) set by the EA for lowland and high alkalinity water bodies are shown in Table 1 below:

Table 1: WFD targets for lowland and high alkalinity water bodies.

Determinand	Statistic	Target
BOD	90 percentile	5gm/l
NH4	90 percentile	0.6mg/l
P	Mean	site specific

The EA has provided WFD 2015 set catchment/reach-specific targets for phosphorus.

On this basis the following targets (see Table 2) have been used at the WRC discharge points assessed:

Table 2: Phosphorus targets by WRC.

WRC	P mean mg/l	Waterbody/ WQ point
Coningsby	0.092	GB105030062450
Horncastle	0.092	GB105030062450
Legbourne	0.097	GB105029061670
Louth	0.092	GB104029061990
Manby	0.097	GB105029061670
Sibsey	0.101	GB205030056405
Woodhall Spa	0.093	GB205030062425

A.3 Methodology

The contaminants assessed were Biochemical Oxygen Demand (BOD), Ammonia (NH_4) and Phosphorus (P).

The selected approach was to use the EA River Quality Planning (RQP) tool in conjunction with their recommended guidance documents: "Water Quality Planning: no deterioration and the Water Framework Directive" and "Horizontal guidance". This uses a steady state Monte Carlo Mass Balance approach where flows and water quality are sampled from modelled distributions based on data where available.

The data required to run the RQP software were:

Upstream river data:

- Mean flow
- 95% exceedance flow
- Mean for each contaminants
- Standard deviation for each contaminant

Discharge data:

- Mean flow
- Standard deviation for the flow
- Mean for each contaminants
- Standard deviation for each contaminant

River quality target data:

- No deterioration target
- 'Good status' target

The above data inputs should be based on observations where available. In the absence of observed data EA guidance requires that:

- If the observed WRCs discharge flow and quality data were not available the following values were used:
- Flow mean: 1.25*DWF.
- Flow SD: 1/3*mean.
- Quality data: permit values or assumed values.
- If observed river flows were not available these were obtained from an existing model or a low-flows estimation software.
- If observed water quality data were not available these were obtained from an existing model or a neighbouring catchment with similar characteristics, or the mid-point of the WFD class.

The observed data available for WRCs discharges were analysed in Aardvark and the values reported as "less than" (these are samples where was not possible to get an accurate value and a limit value was assigned) were multiplied for 0.5 as agreed with the EA.

A.4 Study objectives

RQP models were required to be set up and run using the present-day and five future scenarios as reported in Table 3 below:

Table 3: five future scenarios to model.

Location	Water Recycling Centre (WRC)	(Scenario 1) Potential Housing Numbers	(Scenario 2) Potential Housing Numbers Scenario 1 plus 20%	(Scenario 3) Scenario 1 plus coastal housing adjustment	(Scenario 4) High level housing numbers	(Scenario 5) same figures as shown in Scenario 3 only change is in Burgh le Marsh
Coningsby / Tattershall	Coningsby	486	583	486	991	486
Horncastle	Horncastle	605	726	605	1411	605
Legbourne	Legbourne	54	65	98	72	98
Louth	Louth	1434	1721	1748	3347	1748
Grimoldby & Manby	Manby	140	168	184	194	184
Sibsey	Sibsey	168	202	212	231	212
Woodhall Spa	Woodhall Spa	347	416	391	473	391

The study was required to assess changes to effluent flows as a result of development from each settlement to assess the impact of the increased contaminant loads on the receiving watercourses. These results were required to assess the potential impact on the watercourse which could cause the failure of one of the targets: Good ecological status (GES), no more than 10% deterioration and no class deterioration.

Where a WRC is predicted to lead to a WFD class deterioration, or a deterioration of greater than 10%, or a Good status failure it is necessary to determine a possible future permit value which would prevent a class deterioration or a >10% deterioration or the Good status targets failure. The value is determined using the RQP tool function that calculates the required discharge quality according to the specified river target.

For each WRC the present-day situation was assessed first. Where failure of any of the targets was predicted for the present-day scenario, no future scenarios were assessed. Where the present-day scenario did not predict any failures, the worst-case future scenario was assessed next. Where this worse-case scenario did not predict failure of any target no further modelling was required. Otherwise, the next worse scenario was modelled, until a scenario was arrived at where no failure of any target was predicted, or until all future scenarios were modelled.

Where failure was predicted for any of the scenarios, and the upstream river quality did not achieve 'good status', the model was re-run assuming that the river had 'good status'. The reason of this approach is to assess the actual impact of the effluent if upstream point and/or diffuse sources were to be resolved.

When a new consent value was calculated, due to a target failure, this was compared against the effluent quality that can be achieved using Best Available Technology (BAT). The EA advised that the following permit values are achievable using best available technology, and that these values should be used for modelling all WRC potential capacity irrespective of the existing treatment technology and size of the works:

- BOD (95%ile) = 5mg/l
- Ammonia (95%ile) = 1mg/l
- Phosphorus (mean) = 0.5mg/l.

Note that phosphorus removal is the subject of ongoing national trials investigating novel techniques and optimisation of existing methods. This major study, which involves all UK water companies, is not due to report until 2017, therefore this assessment is based on the current

assumption of BAT for phosphorus. AW is assuming 1 mg/l as BAT till the study's results will be available.

This assessment did not take into consideration if it is feasible to upgrade each existing WRC to such technology due to constraints of cost, timing, space, carbon costs etc.

The increase of DWF for each WRC was calculated by using an occupancy rate of 2.3 persons per dwelling and a consumption of 133 l/p/d as considered by Anglian Water "Water Resource Management Plan (WRMP)"[1] with 100% of flow reaching the WRC.

A.5 Data collection

The datasets required to assess the discharge permits were the following:

- River flow data (received from the EA)
- River quality data (received from the EA)
- Current WRC permits (received from the EA)
- RQP tool (received from the EA)
- Existing water quality models: GIS SIMCAT model (not available)
- Current river classifications (received from the EA)
- 2015 WFD river target for BOD, P and NH_4 (received from the EA, see section A.2)
- EA guidance documents (received from the EA)
- WRC flow and quality data (received from the EA)
- WRC discharge information e.g. location, receiving watercourse, etc. (received from the EA)

A.6 WFD Compliance

Compliance against WFD targets for the scenarios modelled was calculated using the Present Day situation as the baseline. Compliance / or non-compliance is indicated on the results tables as follows:

Modelled water quality is within the WFD target for the determinand in question.	Modelled water quality does not meet the WFD target for the determinand in question.

The status of the receiving watercourse is reported using the same traffic-colour used by the EA "Method statement for the classification of surface water bodies v3" as shown in Figure 1. The 'Ecological status' is defined as the lowest class element between the 'Biological quality elements', the 'General chemical and physicochemical quality elements' and the 'Hydromorphological quality elements'. Each element is classified as bad, poor, moderate, good or high. The 'Chemical status' is defined as the lowest classed substance defined in the 'Priority substances and other EU-level dangerous substances'. Each substance is classified as fail or good.

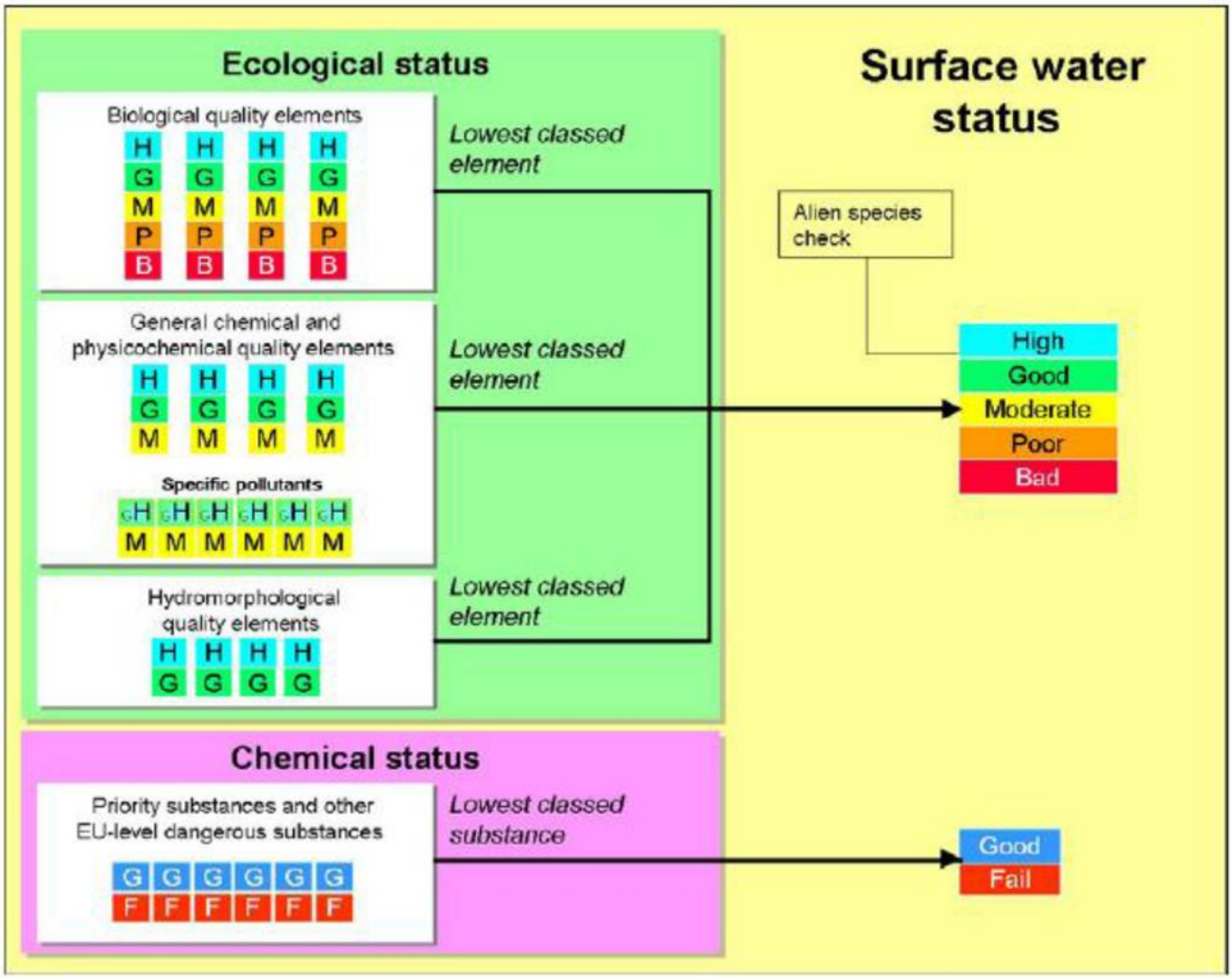
For each WRC a summary table (based on Table 4) for the receiving watercourse reports the single status for BOD, 'NH4' and 'P', and the Overall status, and the 2015 WFD classifications, and the overall objective for the watercourse. The EA did not provide the 'Ecological' and 'Chemical' status.

Table 4: Summary table representing 2015 status, watercourse status and its objective.

	Overall	BOD	Ammonia	Phosphorus
2015 status	Overall watercourse's status	Watercourse's status for BOD	Watercourse's status for NH4	Watercourse's status for P
Objective	Overall watercourse's objective	Watercourse's objective for BOD	Watercourse's objective for NH4	Watercourse's objective for P

1 http://www.anglianwater.co.uk/environment/our-commitment/our-plans/water-resource-management.aspx

Figure 1: Classification of Surface Water Status from "Method statement for the classification of surface water bodies v3".



A.7 Input data and results

The input data and RQP result table used to summarise the modelling exercise contain also the data source. The list below explains the meaning of the source used:

- EA data "year": provided by the EA related to the specific year.
- Mid class "class": mid class of the actual pollutant class. This was used when non observed data were available.
- Assumed mid class "class": the mid class of the pollutant class is assumed. This was used when no observed and classification data were available.
- Measured data: obtained from statistical analysis of observed data.
- EA suggested value: valued used by the EA when no observed or consent data are available.
- Calculated using AW parameters: an occupancy rate of 2.3 p/h and a water consumption of 133 l/p/d was used to calculate the future DWF.

The colour code used is the classification code as shown in Figure 1.

The DWF limit assessment was carried out by comparing the DWF limit against the Q90 according to the EA approach[2]. Both data were provided by the EA and these are reported on Table 5 below:

Table 5: DWF limit and Q90

WRC	DWF limit	Q90
Coningsby	1400	1138
Horncastle	2315	1730
Legbourne	157	153
Louth	6000	5408
Manby	894	783
Sibsey	414	270
Woodhall Spa	1406	1145

The determinands consent limits were assessed by comparing the current limit against the RQP calculated value. These are reported on Table 6 below:

Table 6: determinands consent limits and RQP calculated value.

WRC	Scenario	BOD		NH4	
		95%ile consent value	RQP 95%ile	95%ile consent value	RQP 95%ile
Coningsby	Present day	15	5.24	8	3.73
	S4		5.24		3.73
Horncastle	Present day	15	8.17	5	1.57
	S4		8.17		1.57
	S2		8.18		1.56
	S1, S3, S5		8.17		1.57
Legbourne	Present day	50	19	NA	7.25
	S3, S5		19		7.25
Louth	Present day	17	11.95	5	2.57
	S4		11.95		2.57
	S2, S3, S5		11.95		2.57
	S1		11.95		2.57
Manby	Present day	15	6.29	5	0.67
	S4		6.28		0.67
Sibsey	Present day	20	10.59	15	0.65
	S4		10.59		0.65
	S2, S3, S5		10.59		not calculated
	S1		10.59		not calculated
Woodhall Spa	Present day	12	11.91	5	1.83
	S4		11.91		1.83

2 An Improved Definition of Sewage Treatment Works Dry Weather Flow: http://pioneer.tynemarch.co.uk/tynemarch/publications/msciwemymp.pdf

A.7.1 Coningsby WRC

Coningsby WRC discharges into River Bain as shown in Figure 2. The status of the receiving watercourse is summarised in Table 7 below:

Table 7: River Bain status.

	Overall	BOD	Ammonia	Phosphorus
2015 status	Moderate	Not available	High	Moderate
Objective	Good by 2027	Not available	High	Moderate by 2015

Figure 2: Coningsby WRC and discharge location.

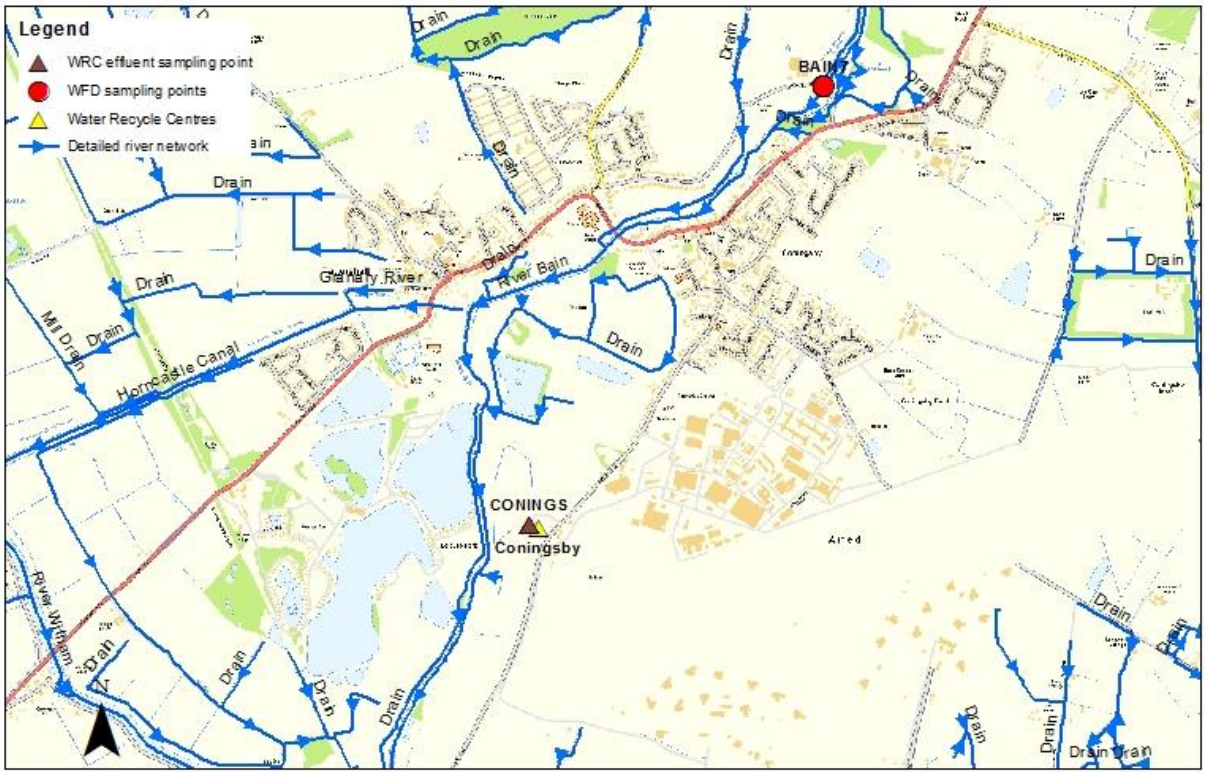


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Table 8 shows the input data and RQP results for Coningsby. The works has permitted values for DWF, BOD and NH4 and is currently operating within the limits for all of them. Future scenarios predict that the WRC will be working within its current permits for BOD and NH4. It was no possible with the data available to assess future DWF consent.

Table 8: Input data and RQP results for Coningsby WRC

Parameter	Statistic	River	Source	Present day			S4			S2			S1, S3 and S5		
				WRC	Source	RQP Result	WRC	Source	RQP Result	WRC	Source	RQP Result	WRC	Source	RQP Result
Flow (Ml/d)	Mean	104.50	EA data 2014	1.63	EA data 2014		1.92	calculated using AW parameters		1.80	calculated using AW parameters		1.77	calculated using AW parameters	
	SD			0.63			0.74			0.69			0.68		
	5%ile	9.00													
BOD (mg/l)	Mean	2.58	Assumed mid class good	2.51	Measured data	4.38	2.51	Measured data	4.36						
	SD	1.55		1.41			1.41								
	Target 90%ile	5.00	Assumed												
NH4 (mg/l)	Mean	0.09	Mid class high	1.49	Measured data	0.26	1.49	Measured data	0.28						
	SD	0.05		1.18			1.18								
	Target 90%ile	0.30	2015 WFD high												
P (mg/l)	Mean	0.15	Mid class moderate	5	EA suggested value	0.35	5	EA suggested value	0.38	5	EA suggested value	0.36	5	EA suggested value	0.36
	SD	0.15		3.00			3			3.00			3.00		
	Target Mean	0.217	2015 WFD moderate												
P (mg/l)	Mean	0.07	Assumed mid class good	5	EA suggested value	0.27							5	EA suggested value	0.28
	SD	0.07		3.00									3.00		
	Target Mean	0.092	2015 WFD moderate												

There is an upstream water quality (WQ) point circa 3km from the discharge point with 11 samples for P and 31 for BOD of which 11 "less then". Due to the low number of samples the mid class value was used.

The model results indicate that for BOD and NH4 there is no class or deterioration target failure. For P all the scenarios cause a failure of the class target from moderate to poor even assuming good class upstream of the works.

The RQP function was used to calculate the required discharge quality for P to meet the river targets, both good and moderate, using the worst case scenario S4 as input data. The model results in Table 9 indicate that the targets can be achieved for both situations using BAT.

Table 9: discharge quality required to meet moderate and good WFD targets for P at Coningsby WRC.

Pollutant	Target	Upstream river quality	Scenario	Mean	SD	95%ile
P	0.092 - good	Assumed mid class good	S4	**0.54**	0.31	1.14
P	0.092 - good	Mid class moderate	S4	**Not achievable**		
P	0.092 - good	Mid class moderate	Present day	**Not achievable**		
P	0.217 - moderate	Mid class moderate	S4	**1.59**	0.92	3.35

A.1 Aardvark analysis for Coningsby discharge data

BOD and NH4 observed data are available for Coningsby WRC discharge flow.

BOD

There are 44 samples for BOD from 2012 till 2015 of which 1 is "less than". Figure 3 shows the summary statistic for Coningsby WRC.

There were not outlier and Aardvark did not detect any step change (see Figure 4).

Figure 3: Aardvark summary for BOD for Coningsby WRC

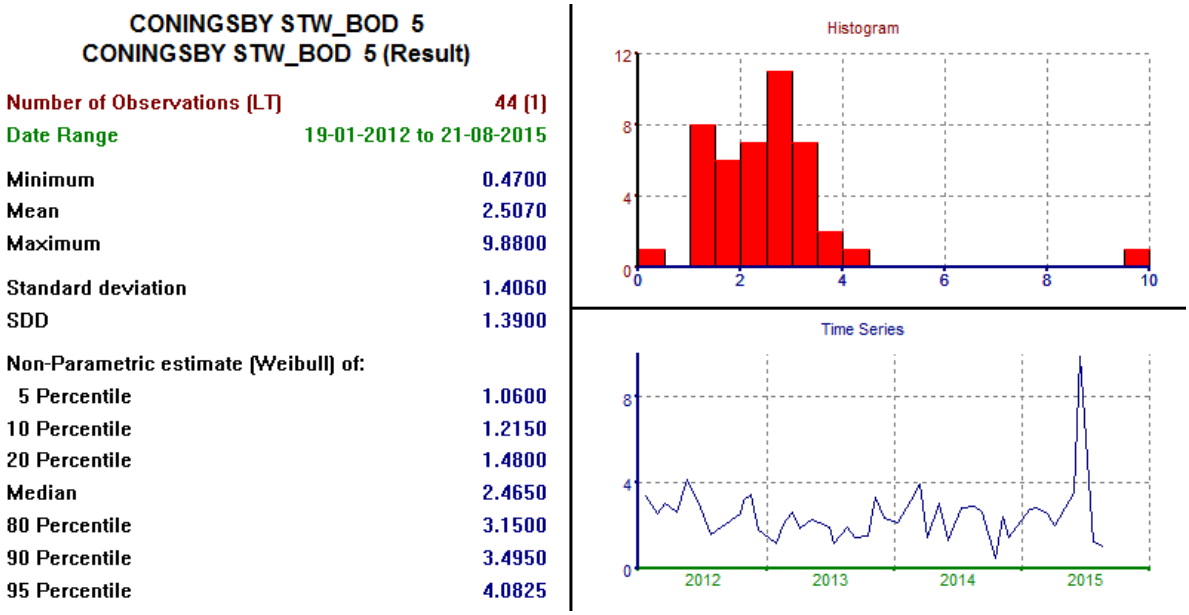
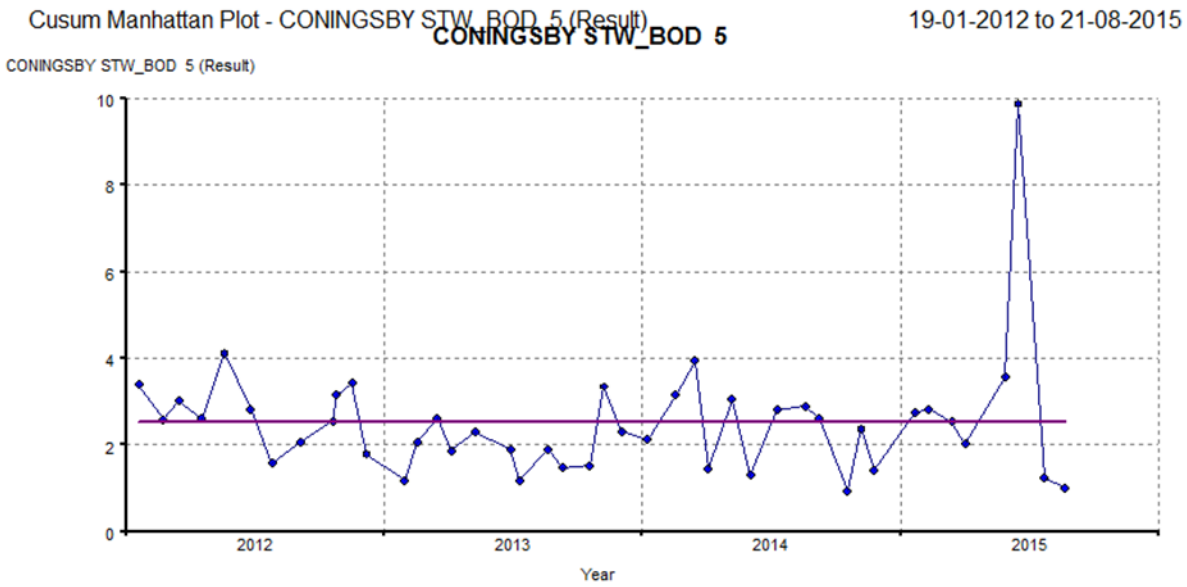


Figure 4: Aardvark cumulative analysis for BOD for Coningsby WRC



NH4

There are 44 samples for BOD from 2012 till 2015 of which 1 is "less than". Figure 5 shows the summary statistic for Coningsby WRC.

There were not outlier and Aardvark did not detect any significant step change (see Figure 6)

Figure 5: Aardvark summary for NH4 for Coningsby WRC

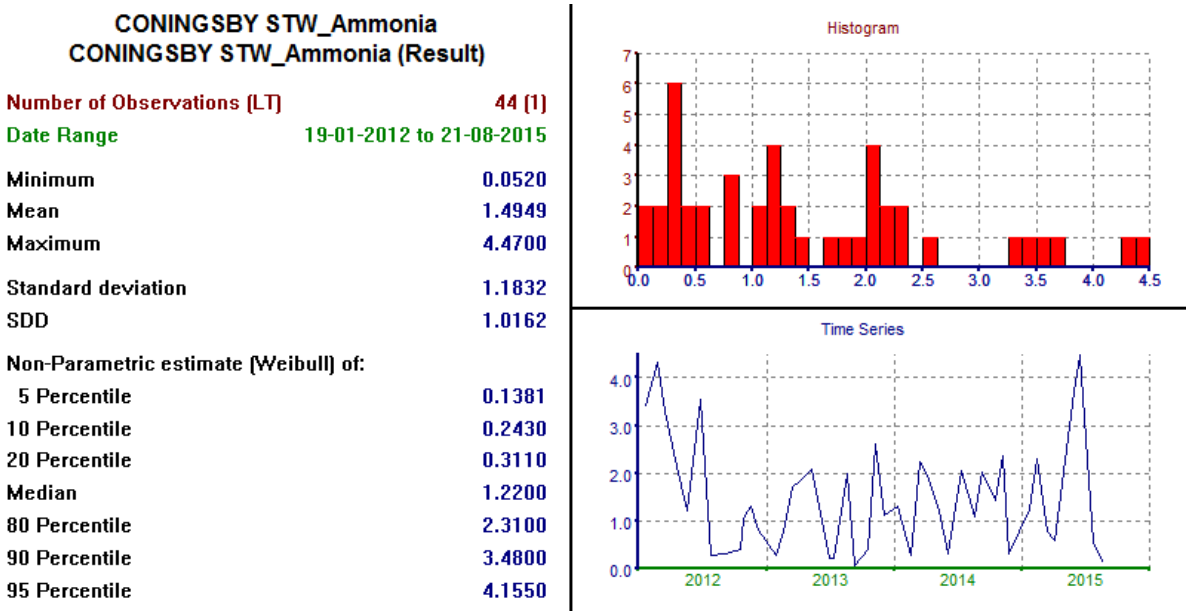
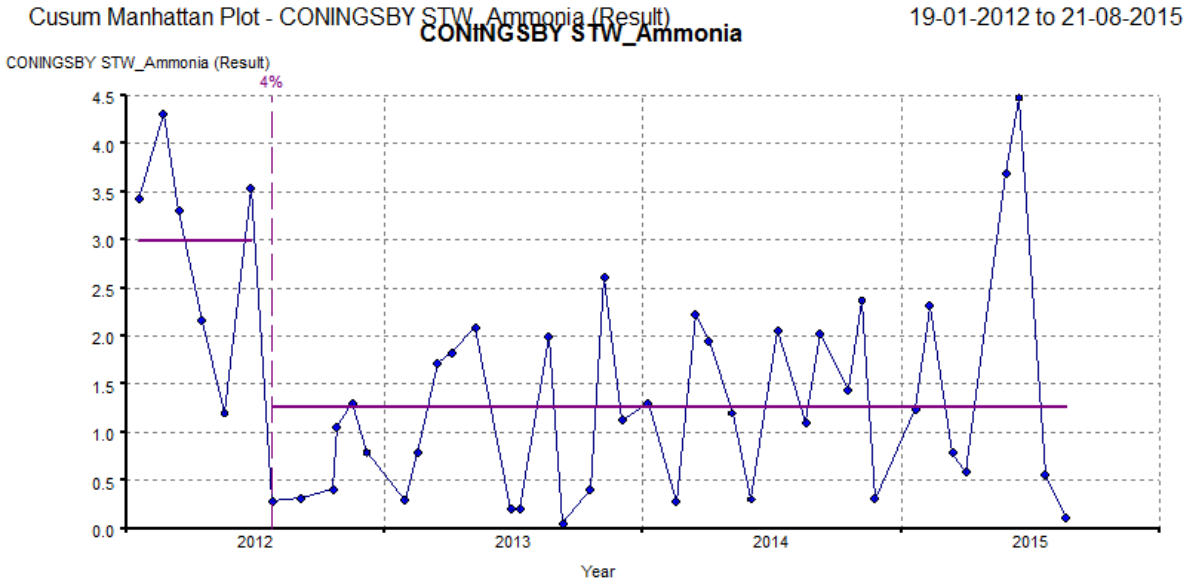


Figure 6: Aardvark cumulative analysis for NH4 for Coningsby WRC



A.7.2 Horncastle

Horncastle WRC discharges into the Old River Bain as shown in Figure 7. The status of the receiving watercourse is summarised in Table 10 below:

Table 10: Old River Bain status.

	Overall	BOD	Ammonia	Phosphorus
2015 status	Moderate	Not available	High	Moderate
Objective	Good by 2027	Not available	High	Moderate by 2015

Figure 7: Horncastle WRC and discharge location.

Table 11 shows the input data and RQP results for Horncastle. The works has permitted values for DWF, BOD and NH4 and is currently operating within these limits for all of them. Future scenarios predict that the WRC will be working within its current permits for BOD and ammonia. It was no possible with the data available to assess future DWF consent.

The model results indicate that for all pollutants there is a class target failure for all scenarios. For P all the scenarios cause a failure of the target from moderate to poor even assuming good class upstream of the work.

The RQP function was used to calculate the required discharge quality for BOD, NH4 and P to meet the river targets. The model results in reported in Table 12 indicate that the targets can be achieved using BAT only for BOD for all scenarios. Target cannot be achieved for any scenarios for NH4 and P. For the latter also the current "moderate" class target cannot be achieved for any scenarios.

Table 11: Input data and RQP results for Horncastle WRC.

Parameter	Statistic	River	Source	Present day			S4			S2			S1, S3, S5		
				WRC	Source	RQP Result	WRC	Source	RQP Result	WRC	Source	RQP Result	WRC	Source	RQP Result
Flow (Ml/d)	Mean	12.10	EA data 2014	2.74	EA data 2014		3.15	calculated using AW parameters		2.95	calculated using AW parameters		2.91	calculated using AW parameters	
	SD			0.89			1.02			0.95			0.94		
	5%ile	0.26													
BOD (mg/l)	Mean	2.58	Assumed Mid class good	5.02	Measured data	5.60	5.02	Measured data	5.71	5.02	Measured data	5.64	5.02	Measured data	5.65
	SD	1.55		1.67			1.67			1.67			1.67		
	Target 90%ile	5.00	2015 WFD												
NH4 (mg/l)	Mean	0.09	Mid class high	0.47	Measured data	0.57	0.47	Measured data	0.60	0.47	Measured data	0.59	0.47	Measured data	0.59
	SD	0.05		0.68			0.68			0.68			0.68		
	Target 90%ile	0.30	2015 WFD												
P (mg/l)	Mean	0.15	Mid class moderate	5	EA suggested value	2.41	5	EA suggested value	2.54	5	EA suggested value	2.48	5	EA suggested value	2.47
	SD	0.15		3			3			3			3		
	Target Mean	0.217	2015 WFD												
P (mg/l)	Mean	0.07	Assumed mid class good	5	EA suggested value	2.37							5	EA suggested value	2.43
	SD	0.07		3.00									3.00		
	Target Mean	0.092	2015 WFD												

Table 12: discharge quality required to meet good WFD targets for BOD, NH4 and P at Horncastle WRC.

Pollutant	Target	Upstream river quality	Scenario	Mean	SD	95%ile
BOD	5 - good	Assumed mid class good	S4	5.02	1.67	**8.12**
NH4	0.3 - high	Mid class high	S4	0.22	0.28	**0.72**
NH4	0.3 - high	Mid class high	S1, S3, S5	0.23	0.28	**0.74**
P	0.092 - good	Assumed mid class good	S4	**0.12**	0.07	0.24
P	0.092 - good	Assumed mid class good	S1, S3, S5	**0.12**	0.07	0.25
P	0.092 - good	Assumed mid class good	Present day	**0.12**	0.07	0.25
P	0.217 - moderate	Mid class moderate	S4	**0.29**	0.17	0.61
P	0.217 - moderate	Mid class moderate	Present day	**0.3**	0.17	0.62

A.1 Aardvark analysis for Horncastle discharge data

BOD and NH4 observed data are available for Horncastle WRC discharge flow.

BOD

There are 43 samples for BOD from 2012 till 2015. Figure 8 shows the summary statistic for Horncastle WRC.

There were not outlier and Aardvark did detect any significant step change (see Figure 9) but due to the low number of values available after the step change all data set was considered.

Figure 8: Aardvark summary for BOD for Horncastle WRC.

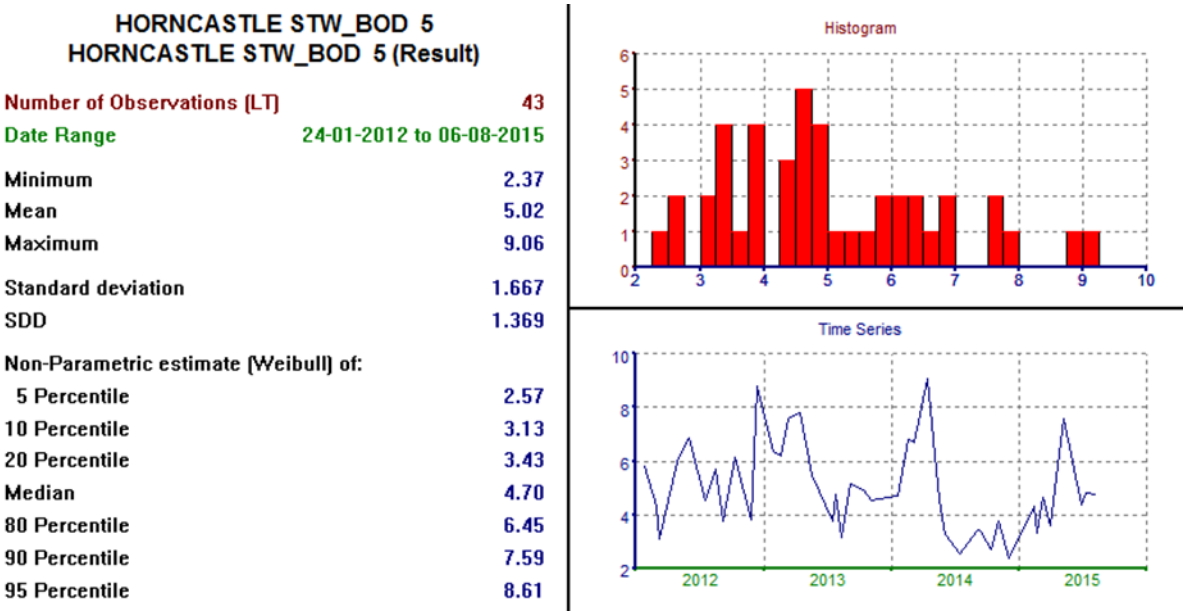
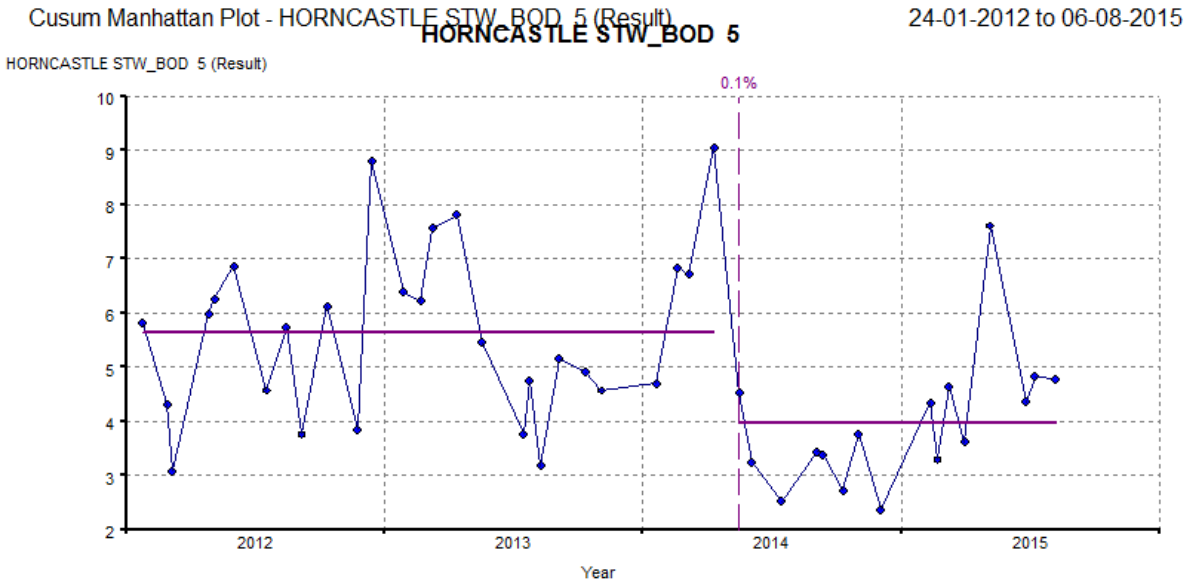


Figure 9: Aardvark cumulative analysis for BOD for Horncastle WRC.



NH4

There are 43 samples for BOD from 2012 till 2015 of which 4 are "less than". Figure 10 shows the summary statistic for Horncastle WRC.

There were not outlier and Aardvark did not detect any step change (see Figure 11).

Figure 10: Aardvark summary for NH4 for Horncastle WRC.

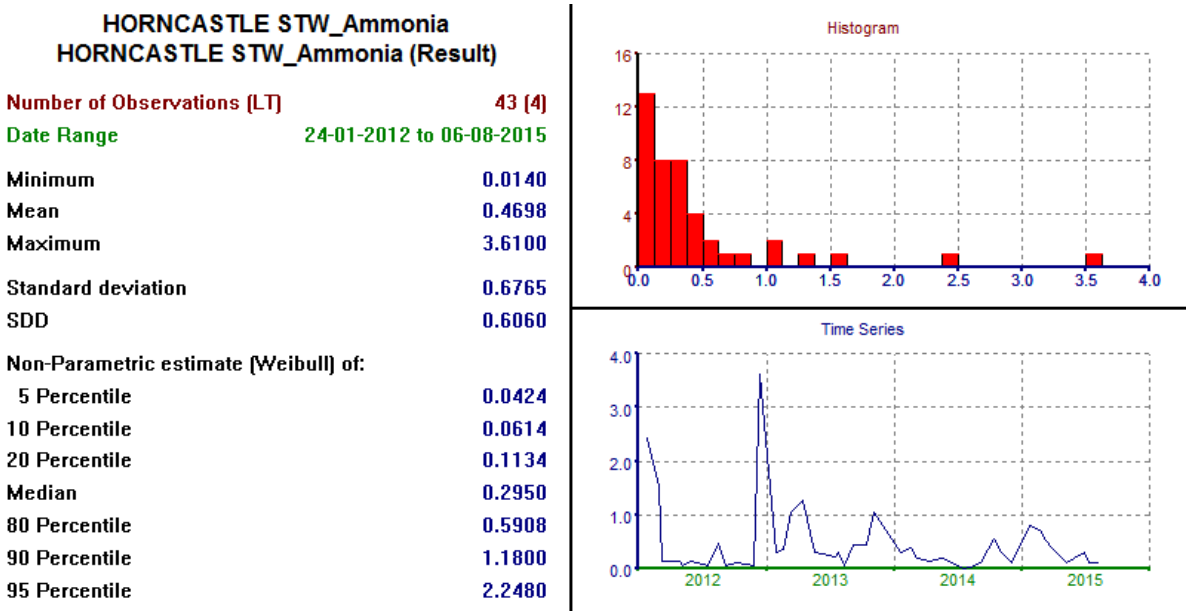
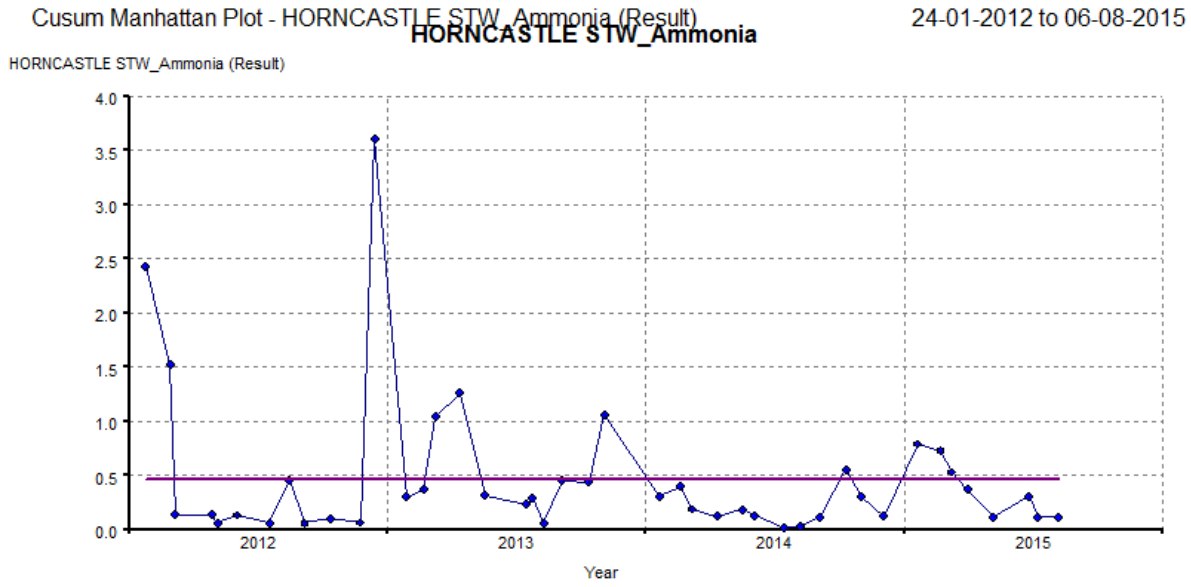


Figure 11: Aardvark cumulative analysis for NH4 for Horncastle WRC.



A.7.3 Legbourne

Legbourne WRC discharges into an unnamed drain as shown in Figure 12. The status of The Beck that is the nearest watercourse with WFD classification is summarised in Table 13 below:

Table 13: The Beck status.

	Overall	BOD	Ammonia	Phosphorus
2015 status	Moderate	High	High	Poor
Objective	Good by 2027	High	High	Good by 2015

Figure 12: Legbourne WRC and discharge location.

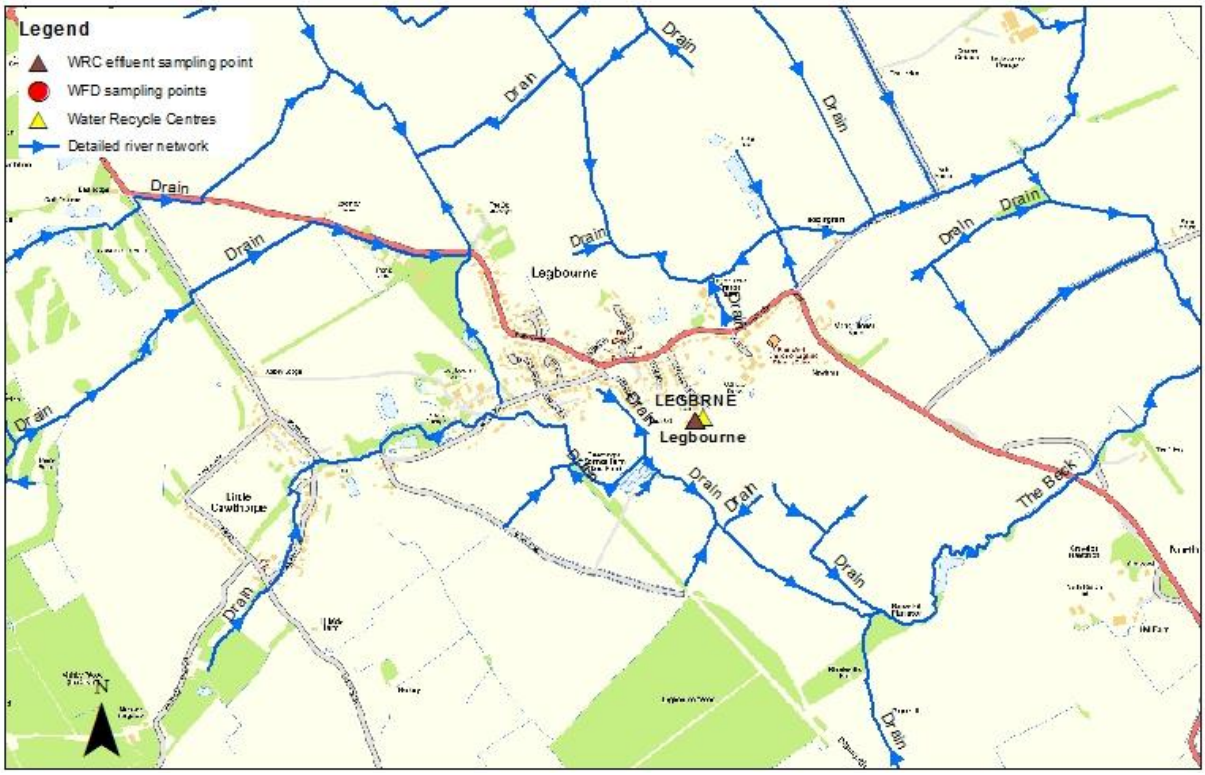


Table 14 shows the input data and RQP results for Legbourne. The works has permitted values for DWF, and BOD and is currently operating within these limits but for all them. Future scenarios predict that the WRC will be working within its current permits for BOD. It was no possible with the data available to assess future DWF consent.

The model results indicate that for NH4 and P there is a class target failure for all scenarios. For P all the scenarios cause a failure of the target from moderate to poor even assuming good class upstream of the work.

The RQP function was used to calculate the required discharge quality for NH4 and P to meet the river targets. The model results reported on Table 15 indicate that the targets can be achieved using BAT only for NH4 for all scenarios. The 95%ile of 4.77 is in the 10% model tolerance / variability. Target cannot be achieved for any scenarios for P even assuming good class upstream of the work.

Table 14: Input data and RQP results for Legbourne WRC.

Parameter	Statistic	River	Source	Present day			S3, S5			S1,S2, S4		
				WRC	Source	RQP Result	WRC	Source	RQP Result	WRC	Source	RQP Result
Flow (Ml/d)	Mean	13.30	EA data 2012	0.27	EA data 2014		0.30	calculated using AW parameters		0.29	calculated using AW parameters	
	SD			0.15			0.16			0.16		
	5%ile	1.20										
BOD (mg/l)	Mean	1.15	Mid class high	10.16	Measured data	2.57	10.16	Measured data	2.65			
	SD	0.69		4.60			4.60					
	Target 90%ile	4.00	2015 WFD									
NH4 (mg/l)	Mean	0.09	Mid class high	2.38	EA suggested value	0.37	2.38	EA suggested value	0.40	2.38	EA suggested value	0.39
	SD	0.05		2.77			2.77			2.77		
	Target 90%ile	0.30	2015 WFD									
P (mg/l)	Mean	1.57	Mid class poor	5.00	EA suggested value	1.74	5.00	EA suggested value	1.76	5.00	EA suggested value	1.75
	SD	1.57		3.00			3.00			3.00		
	Target Mean	0.097	2015 WFD									
P (mg/l)	Mean	0.08	Assumed mid class good	5.00	EA suggested value	0.31			0.33	5.00	EA suggested value	0.32
	SD	0.08		3.00						3.00		
	Target Mean	0.097	2015 WFD									

Table 15: discharge quality required to meet good WFD targets for BOD, NH4 and P at Legbourne WRC.

Pollutant	Target	Upstream river quality	Scenario	Mean	SD	95%ile
NH4	0.3 - high	Mid class high	S3, S5	1.61	1.69	**4.77**
NH4	0.3 - high	Mid class high	S1, S2, S4	1..69	1.78	**5.02**
P	0.097 - good	Assumed mid class good	S1, S2, S4	**0.42**	0.24	0.89
P	0.097 - good	Assumed mid class good	S3, S5	**0.41**	0.23	0.86
P	0.097 - good	Assumed mid class good	Present day	**0.44**	0.26	0.94

A.1 Aardvark analysis for Legbourne discharge data

BOD observed data are available for Legbourne WRC discharge flow.

BOD

There are 40 samples for BOD from 2012 till 2015. Figure 13 shows the summary statistic for Legbourne WRC.

There were not outlier and Aardvark did not detect any step change (see Figure 14).

Figure 13: Aardvark summary for BOD for Legbourne WRC.

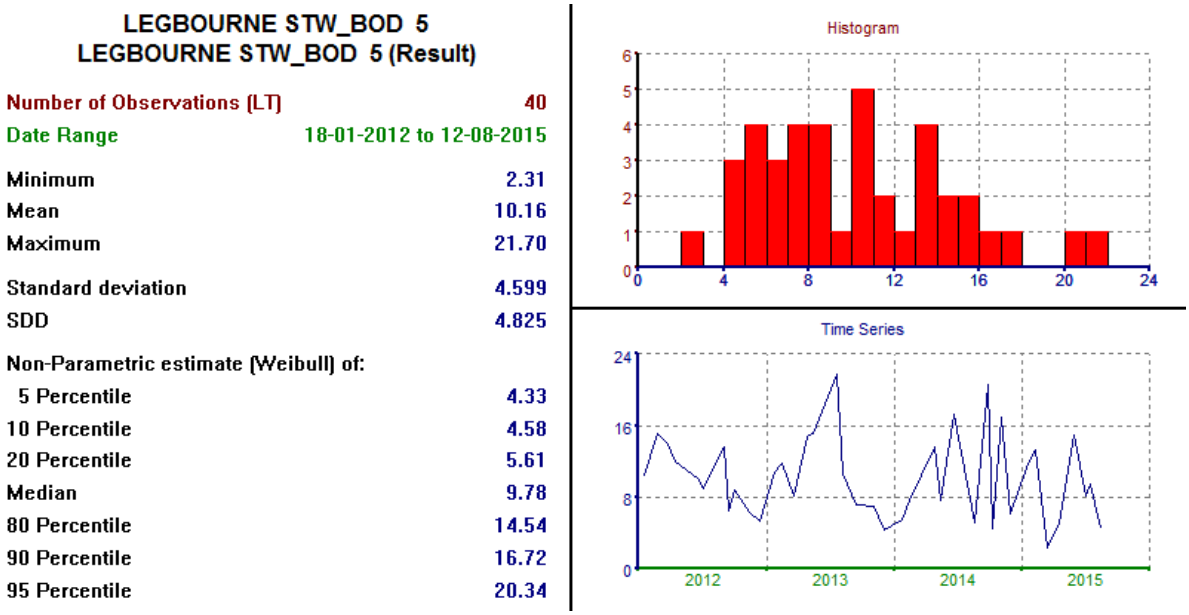
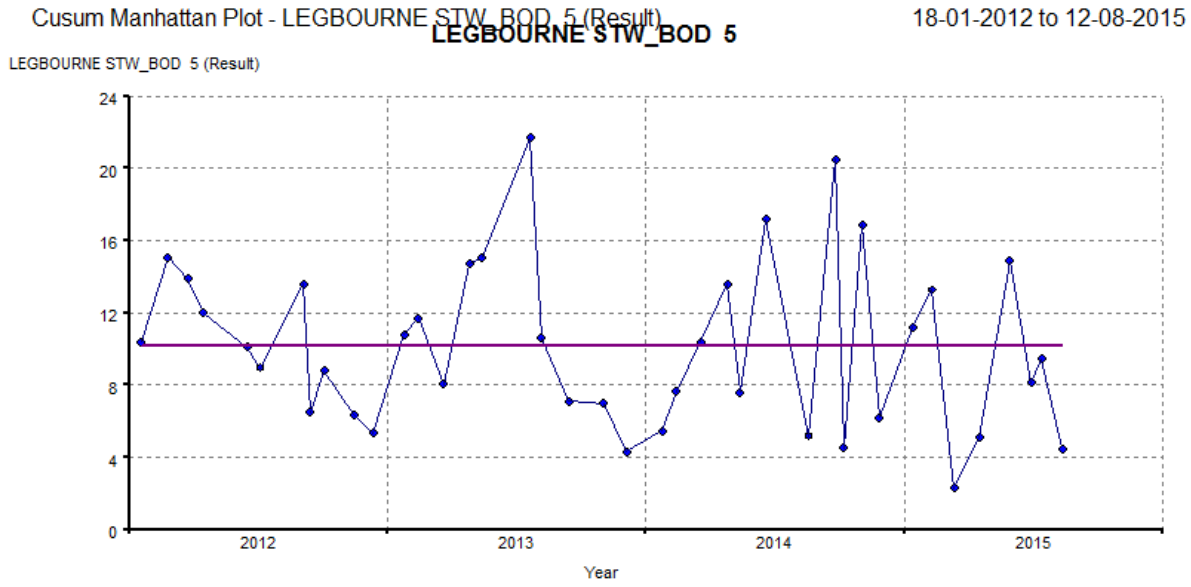


Figure 14: Aardvark cumulative analysis for BOD for Legbourne WRC.



A.7.4 Louth

Louth WRC discharges into Louth Canal as shown in Figure 15. The status of the receiving watercourse is summarised in Table 13 below:

Table 16: Louth Canal status.

	Overall	BOD	Ammonia	Phosphorus
2015 status	Poor	High	High	Good
Objective	Moderate by 2027	High	High	Good

Figure 15: Louth WRC and discharge location.

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Table 17 shows the input data and RQP results for Louth. The works has permitted values for DWF, NH4 and BOD and is currently operating within these limits for all of them. Future scenarios predict that the WRC will be working within its current permits for NH4 and BOD. It was no possible with the data available to assess future DWF consent.

The model results indicate that for NH4 and P there is a class target failure for all scenarios.

Table 17: Input data and RQP results for Louth WRC.

Parameter	Statistic	River	Source	Present day			S4			S2, S3, S5			S1		
				WRC	Source	RQP Result	WRC	Source	RQP Result	WRC	Source	RQP Result	WRC	Source	RQP Result
Flow (Ml/d)	Mean	40.10	EA data 2012	7.72	EA data 2014		8.69	calculated using AW parameters		8.22	calculated using AW parameters		8.13	calculated using AW parameters	
	SD			2.48			2.80			2.64			2.62		
	5%ile	9.20													
BOD (mg/l)	Mean	1.15	Mid class high	8.10	Measured data	4.02	8.10	Measured data	4.22	8.10	Measured data	4.13	8.10	Measured data	4.11
	SD	0.69		2.08			2.08			2.08			2.08		
	Target 90%ile	4.00	2015 WFD												
NH4 (mg/l)	Mean	0.09	Mid class high	1.32	Measured data	0.62	1.32	Measured data	0.66	1.32	Measured data	0.64	1.32	Measured data	0.64
	SD	0.05		0.65			0.65			0.65			0.65		
	Target 90%ile	0.30	2015 WFD												
P (mg/l)	Mean	0.07	Mid class good	5.00	EA suggested value	1.14	5	EA suggested value	1.24	5.00	EA suggested value	1.19	5.00	EA suggested value	1.18
	SD	0.07		3.00			3			3.00			3.00		
	Target Mean	0.09	2015 WFD												

Table 18: discharge quality required to meet good WFD targets for BOD, NH4 and P at Louth.

Pollutant	Target	Upstream river quality	Scenario	Mean	SD	95%ile
BOD	4 - high	Mid class high	S4	7.65	1.93	**11.16**
NH4	0.3 - high	Mid class high	S4	0.51	0.24	**0.98**
NH4	0.3 - high	Mid class high	S2, S3, S5	0.54	0.26	**1.03**
P	0.092 - good	Mid class good	S4	**0.16**	0.09	0.34
P	0.092 - good	Mid class good	S2, S3, S5	**0.17**	0.10	0.35
P	0.092 - good	Mid class good	S1	**0.17**	0.10	0.35
P	0.092 - good	Mid class good	Present Day	**0.17**	0.10	0.36

The RQP function was used to calculate the required discharge quality for all pollutnts to meet the river targets. The model results reported on Table 18 indicate that the targets can be achieved using BAT only for BOD and NH4 for all scenarios. The 95%ile of 0.98 for NH4 for S4 scenario is in the 10% model tolerance / variability. Target cannot be achieved for any scenarios for P.

A.1 Aardvark analysis for Louth discharge data

BOD and NH4 observed data are available for Louth WRC discharge flow.

BOD

There are 43 samples for BOD from 2012 till 2015. Figure 16 shows the summary statistic for Louth WRC.

There were not outlier and Aardvark did not detect any step change (see Figure 17).

Figure 16: Aardvark summary for BOD for Louth WRC.

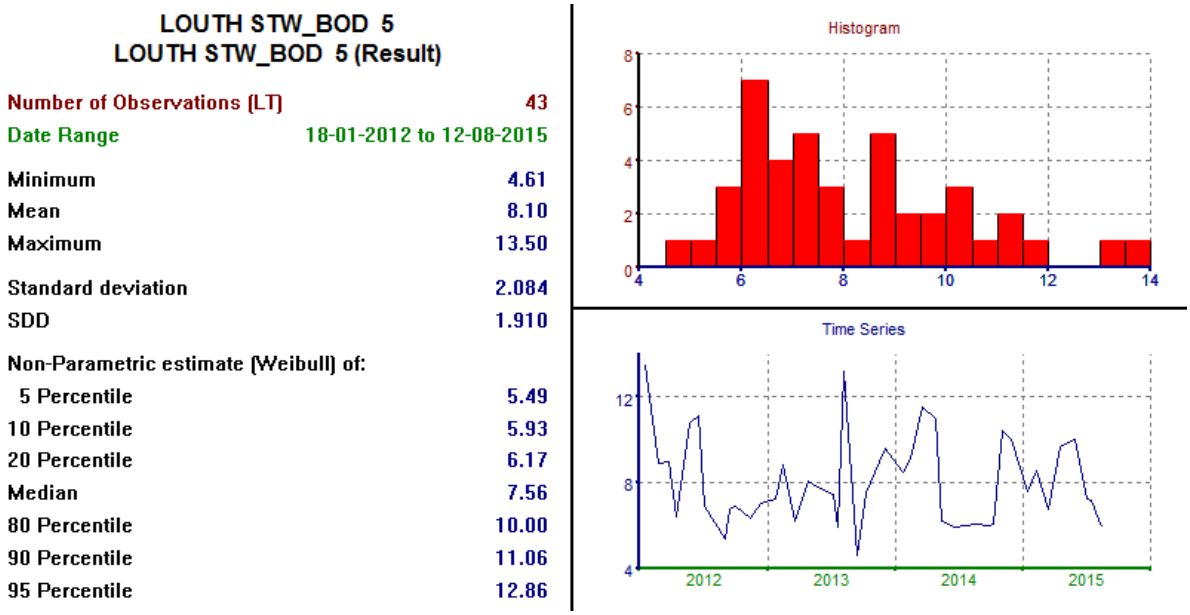
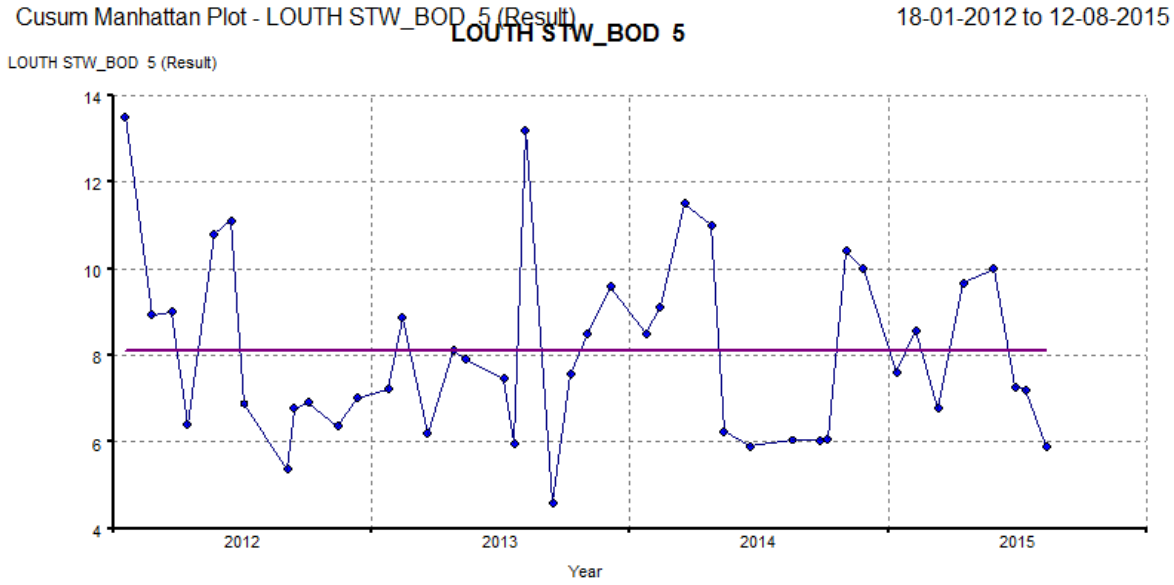


Figure 17: Aardvark cumulative analysis for BOD for Louth WRC.



NH4

There are 43 samples for BOD from 2012 till 2015. Figure 18 shows the summary statistic for Louth WRC.

There were not outlier and Aardvark did not detect any step change (see Figure 19).

Figure 18: Aardvark summary for NH4 for Louth WRC.

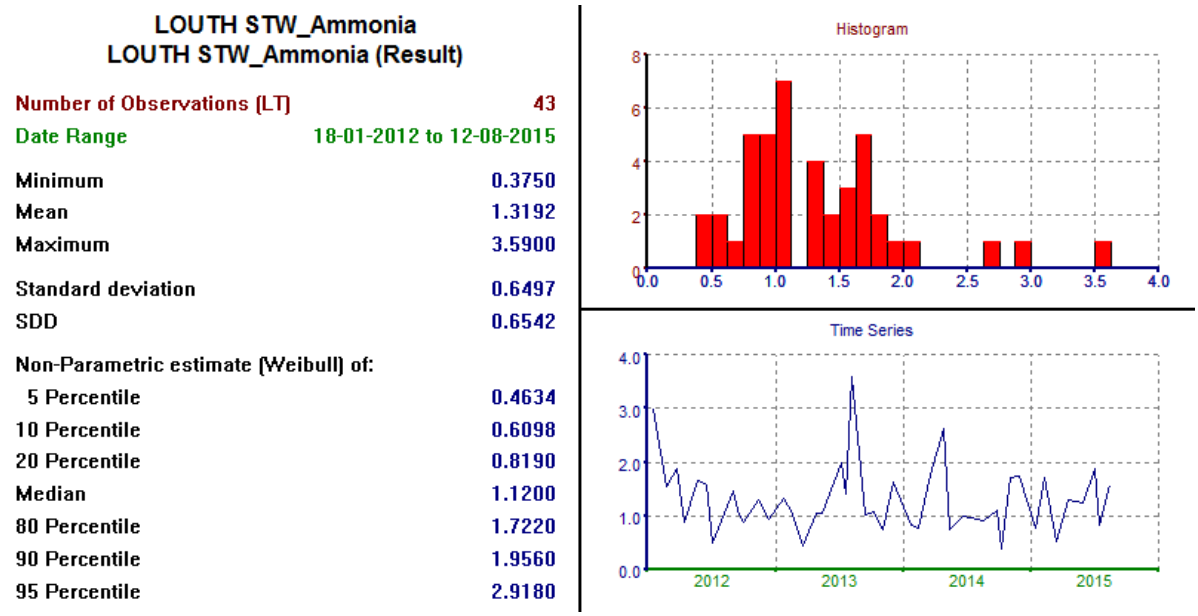
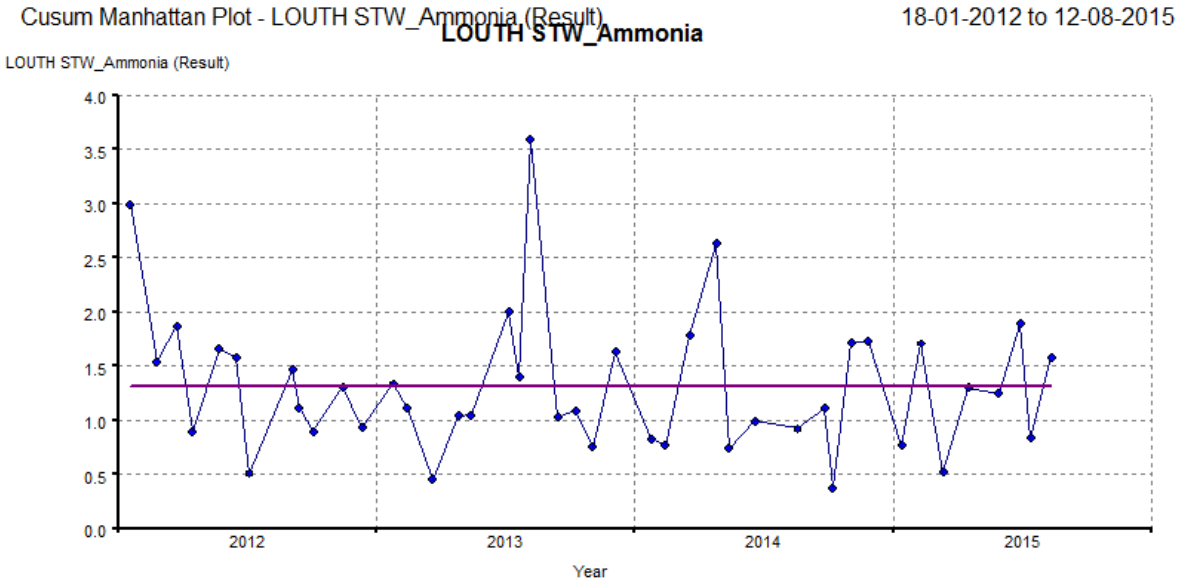


Figure 19: Aardvark cumulative analysis for NH4 for Louth WRC.



A.7.5 Manby

Legbourne WRC discharges into an unnamed drain as shown in Figure 20. The status of the river Long Eau that is the nearest watercourse with WFD classification is summarised in Table 19 below:

Table 19: Long Eau status.

	Overall	BOD	Ammonia	Phosphorus
2015 status	Moderate	High	High	Poor
Objective	Good by 2027	High	High	Good

Figure 20: Manby WRC and discharge location.

Table 20 shows the input data and RQP results for Manby. The works has permitted values for DWF, NH4 and BOD and is currently operating within these limits for all of them. Future scenarios predict that the WRC will be working within its current permits for NH4 and BOD. It was no possible with the data available to assess future DWF consent.

The model results indicate that for BOD and NH4 there is no class or deterioration target failure. For P all the scenarios cause the good status failure

The RQP function was used to calculate the required discharge quality for P to meet the river target. The model results in Table 21Table 9 indicate that the targets cannot be achieved for any scenario using BAT even assuming good class upstream of the work.

Table 20: Input data and RQP results for Manby WRC.

Parameter	Statistic	River	Source	Present day			S4			S2, S3, S5			S1		
				WRC	Source	RQP Result	WRC	Source	RQP Result	WRC	Source	RQP Result	WRC	Source	RQP Result
Flow (Ml/d)	Mean	18.00	EA data 2012	1.40	EA data 2014		1.46	calculated using AW parameters		1.45	calculated using AW parameters		1.44	calculated using AW parameters	
	SD			0.47			0.49			0.49			0.48		
	5%ile	1.56													
BOD (mg/l)	Mean	1.15	Mid class high	3.49	Measured data	2.48	3.49	Measured data	2.49						
	SD	0.69		1.46			1.46								
	Target 90%ile	4.00	2015 WFD												
NH4 (mg/l)	Mean	0.09	Mid class high	0.19	Measured data	0.18	0.19	Measured data	0.18						
	SD	0.05		0.32			0.32								
	Target 90%ile	0.30	2015 WFD												
P (mg/l)	Mean	1.57	Mid class poor	5	EA suggested value	2.14	5	EA suggested value	2.15	5	EA suggested value	2.15	5	EA suggested value	2.15
	SD	1.57		3			3			3			3		
	Target Mean	0.10	2015 WFD												
P (mg/l)	Mean	0.08	Assumed mid class good	5	EA suggested value	0.87	5	EA suggested value		5	EA suggested value		5	EA suggested value	0.89
	SD	0.08		3			3			3			3		
	Target Mean	0.10	0.00												

Table 21: discharge quality required to meet good WFD targets for P at Manby.

Pollutant	Target	Upstream river quality	Scenario	Mean	SD	95%ile
P	0.097 - good	Assumed mid class good	S4	**0.18**	0.10	0.38
P	0.097 - good	Assumed mid class good	S1	**0.18**	0.11	0.39
P	0.097 - good	Assumed mid class good	Present day	**0.19**	0.11	0.39

A.1 Aardvark analysis for Manby discharge data

BOD and NH4 observed data are available for Manby WRC discharge flow.

BOD

There are 43 samples for BOD from 2012 till 2015. Figure 21 shows the summary statistic for Manby WRC.

There were not outlier and Aardvark did not detect any step change (see Figure 22).

Figure 21: Aardvark summary for BOD for Manby WRC.

MANBY STW_BOD 5
MANBY STW_BOD 5 (Result)

Number of Observations (LT)	43
Date Range	18-01-2012 to 12-08-2015
Minimum	1.02
Mean	3.49
Maximum	8.91
Standard deviation	1.460
SDD	1.315
Non-Parametric estimate (Weibull) of:	
5 Percentile	2.02
10 Percentile	2.25
20 Percentile	2.42
Median	3.07
80 Percentile	4.47
90 Percentile	5.86
95 Percentile	6.28

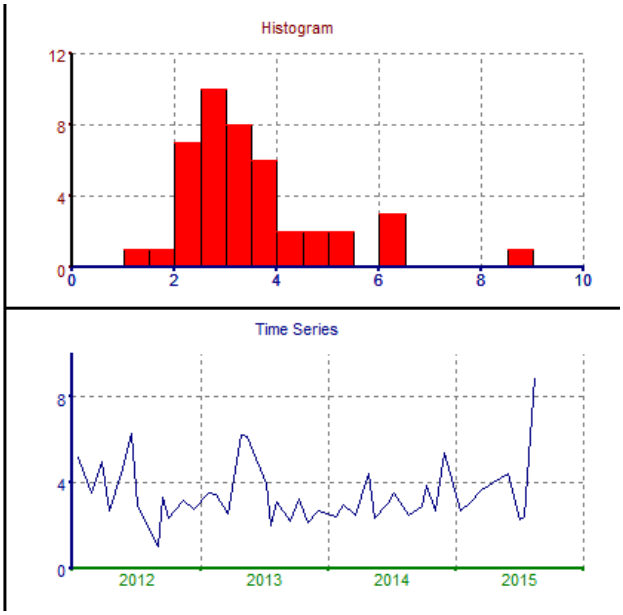
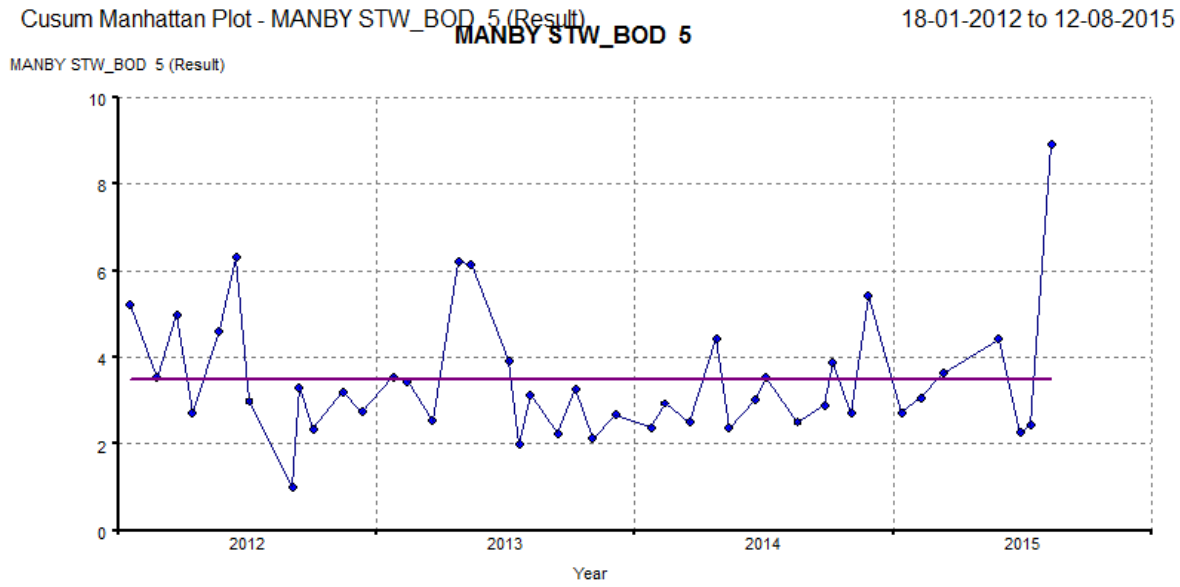


Figure 22: Aardvark cumulative analysis for BOD for Manby WRC.



NH4

There are 43 samples for BOD from 2012 till 2015 of which 21 are "less than". Figure 23Figure 24 shows the summary statistic for Coningsby WRC.

There were not outlier and Aardvark did not detect any significant step change (see Figure 24).

Figure 23: Aardvark summary for NH4 for Manby WRC.

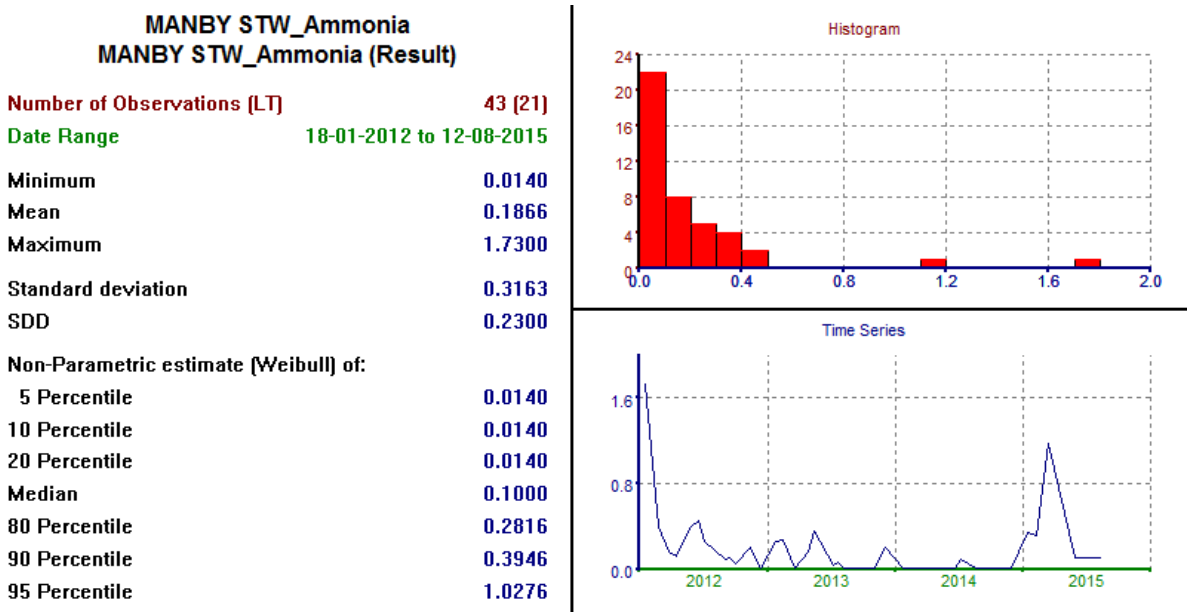
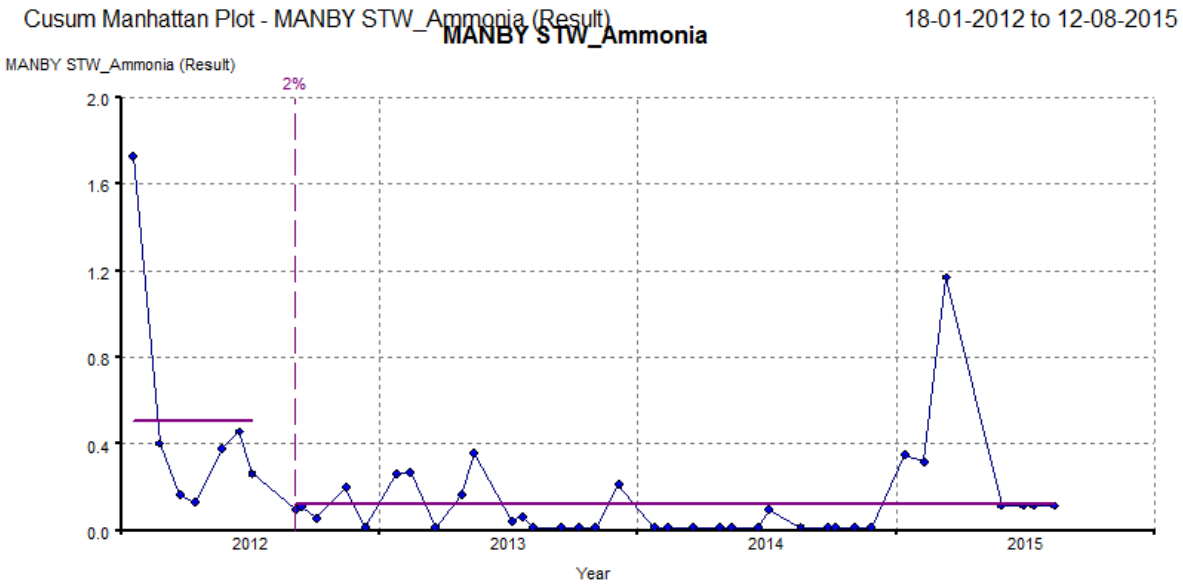


Figure 24: Aardvark cumulative analysis for NH4 for Manby WRC.



A.7.6 Sibsey

Sibsey WRC discharges into an unnamed drain as shown in Figure 25. The status of the Witham Drain that is the nearest watercourse with WFD classification is summarised in Table 22 below:

Table 22: Witham Drain status.

	Overall	BOD	Ammonia	Phosphorus
2015 status	Moderate	Not available	Good	Good
Objective	Good by 2027	Not available	Good	Good

Figure 25: Sibsey WRC and discharge location.

Table 23 shows the input data and RQP results for Manby. The works has permitted values for DWF, NH4 and BOD and is currently operating within these limits but for all of them. Future scenarios predict that the WRC will be working within its current permits for NH4 and BOD. It was no possible with the data available to assess future DWF consent.

The model results indicate that for NH4 there is no class or deterioration target failure. For BOD and P all the scenarios cause a class deterioration. For BOD from good to moderate and for P from good to poor.

The RQP function was used to calculate the required discharge quality for BOD and P to meet the river target. The model results in Table 24 indicate that for BOD the targets can be achieved for any scenario using BAT whilst for P targets cannot be achieved for any scenario using BAT.

Table 23: Input data and RQP results for Sibsey WRC.

Parameter	Statistic	River	Source	Present day			S4			S2, S3, S5			S1		
				WRC	Source	RQP Result	WRC	Source	RQP Result	WRC	Source	RQP Result	WRC	Source	RQP Result
Flow (Ml/d)	Mean	0.92	EA data 2016	0.45	EA data 2014		0.52	calculated using AW parameters		0.51	calculated using AW parameters		0.50	calculated using AW parameters	
	SD			0.27			0.31			0.30			0.30		
	5%ile	0.00													
BOD (mg/l)	Mean	2.58	Assumed Mid class good	4.95	Measured data	6.96	4.95	Measured data	7.00	4.95	Measured data	7.00	4.95	Measured data	6.99
	SD	1.55		2.92			2.92			2.92			2.92		
	Target 90%ile	5.00	2015 WFD												
NH4 (mg/l)	Mean	0.26	Mid class good	0.20	Measured data	0.43	0.20	Measured data	0.43						
	SD	0.15		0.27			0.27								
	Target 90%ile	0.60	2015 WFD												
P (mg/l)	Mean	0.08	Mid class good	5.00	EA suggested value	3.27	5.00	EA suggested value	3.39	5.00	EA suggested value	3.38	5.00	EA suggested value	3.36
	SD	0.08		3.00			3.00			3.00			3.00		
	Target Mean	0.10	2015 WFD												

Table 24: discharge quality required to meet good WFD targets for BOD and P at Sibsey.

Pollutant	Target	Upstream river quality	Scenario	Mean	SD	95%ile
BOD	5 - good	Assumed mid class good	S4	3.24	1.83	**6.77**
P	0.101 - good	Mid class good	S4	**0.11**	0.06	0.23
P	0.101 - good	Mid class good	S1	**0.11**	0.06	0.24
P	0.101 - good	Mid class good	Present Day	**0.11**	0.06	0.24

A.1 Aardvark analysis for Sibsey discharge data

BOD and NH4 observed data are available for Sibsey WRC discharge flow.

BOD

There are 30 samples for BOD from 2012 till 2015. Figure 26 shows the summary statistic for Sibsey WRC.

There were not outlier and Aardvark did not detect any step change (see Figure 27).

Figure 26: Aardvark summary for BOD for Sibsey WRC.

SIBSEY STW_BOD 5
SIBSEY STW_BOD 5 (Result)

Number of Observations [LT]	30
Date Range	13-01-2012 to 08-07-2015
Minimum	1.92
Mean	4.95
Maximum	16.50
Standard deviation	2.916
SDD	2.933
Non-Parametric estimate (Weibull) of:	
5 Percentile	2.12
10 Percentile	2.35
20 Percentile	2.68
Median	4.22
80 Percentile	6.80
90 Percentile	8.76
95 Percentile	12.42

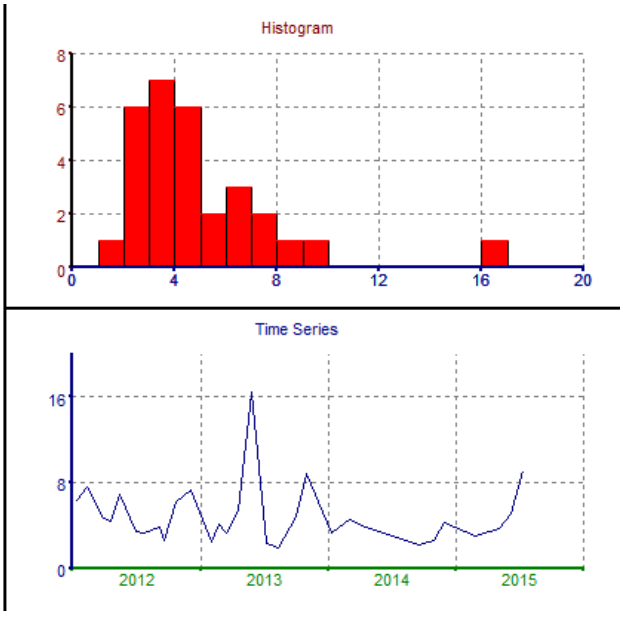
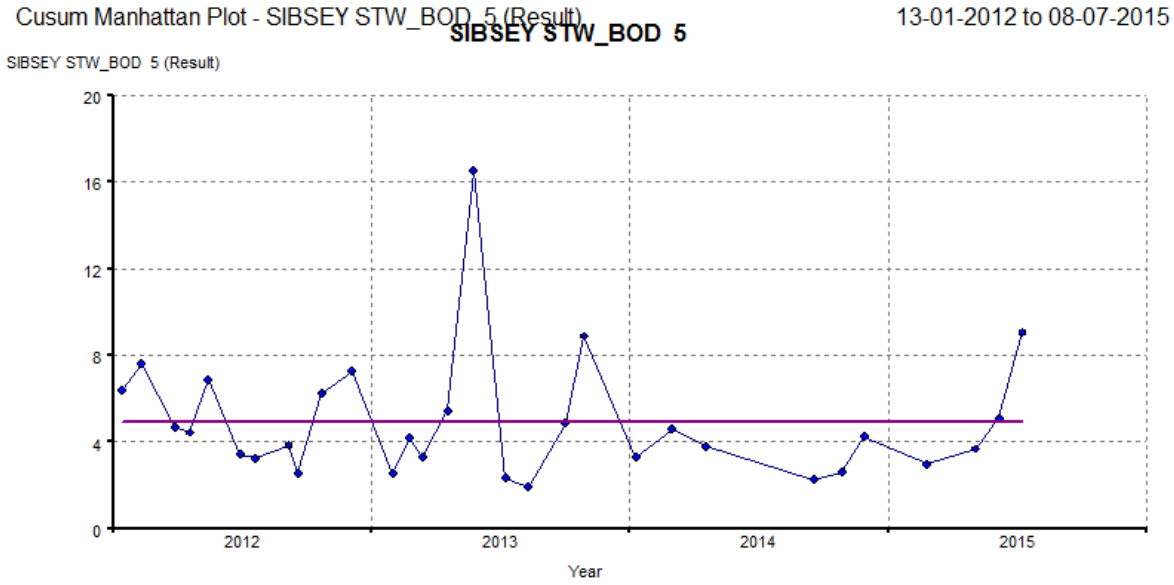


Figure 27: Aardvark cumulative analysis for BOD for Sibsey WRC.



NH4

There are 30 samples for BOD from 2012 till 2015 of which 5 are "less than". Figure 28 shows the summary statistic for Sibsey WRC.

There was one outlier and Aardvark did not detect any significant step change (see Figure 29). Figure 30 shows the summary statistic without outlier and Figure 33 shows that the cumulative analysis does not report any step changes.

Figure 28: Aardvark summary for NH4 for Sibsey WRC.

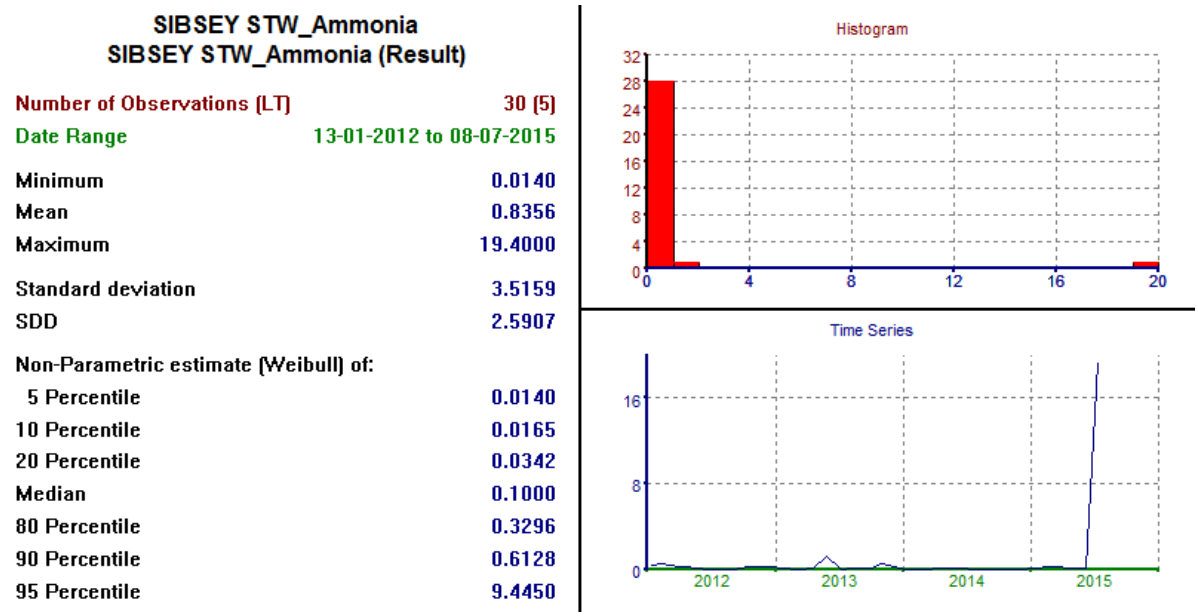


Figure 29: Aardvark cumulative analysis for NH4 for Sibsey WRC.

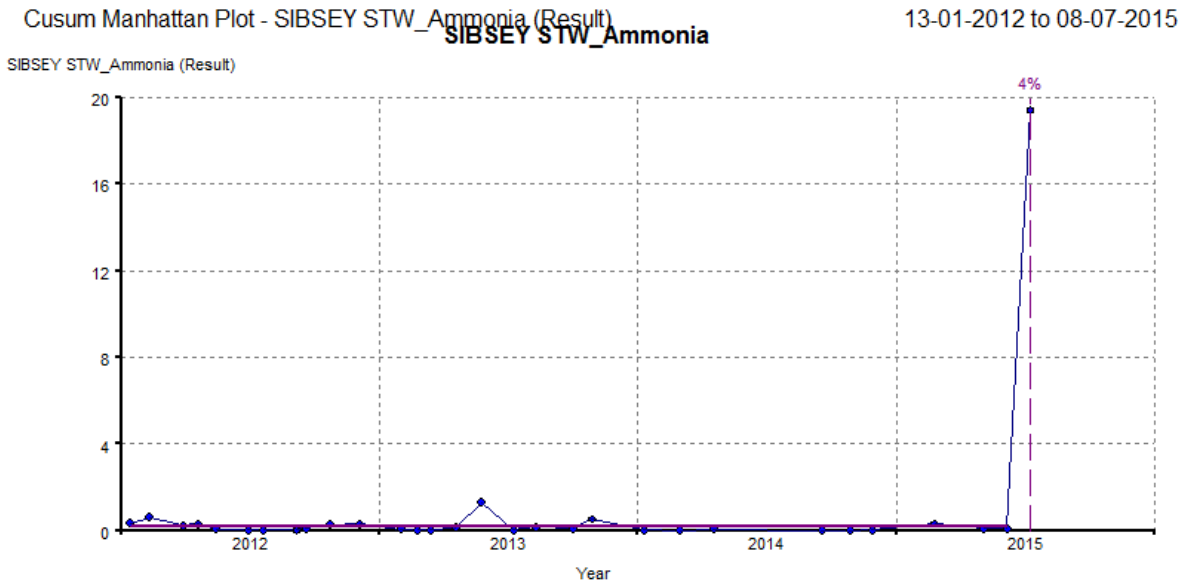


Figure 30: Aardvark summary for NH4 for Sibsey WRC without outlier.

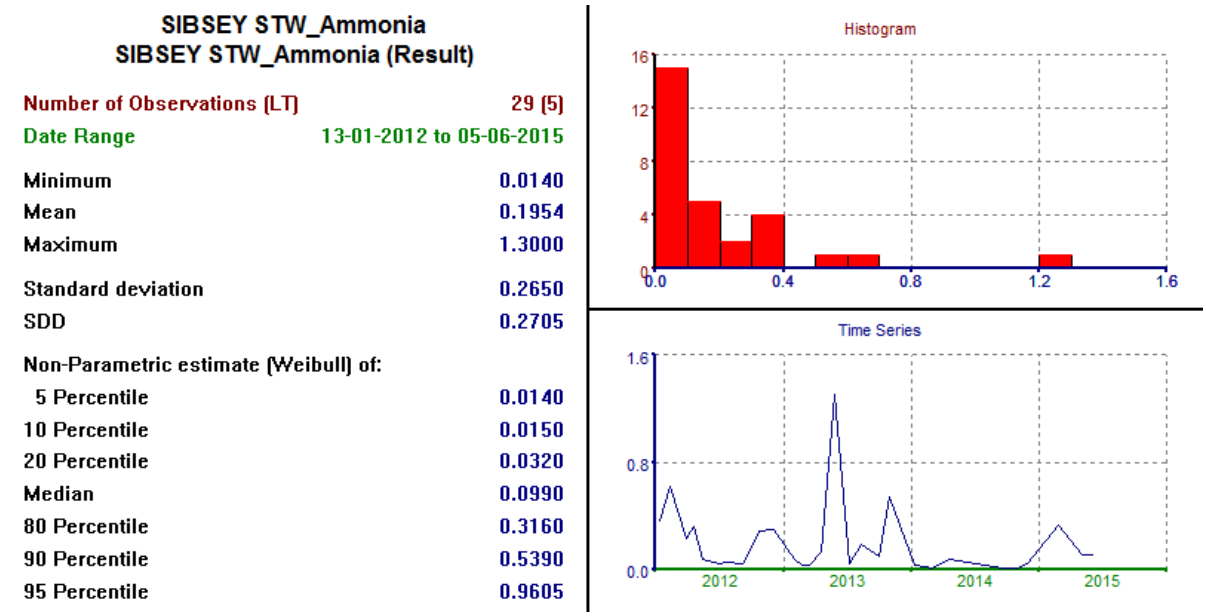
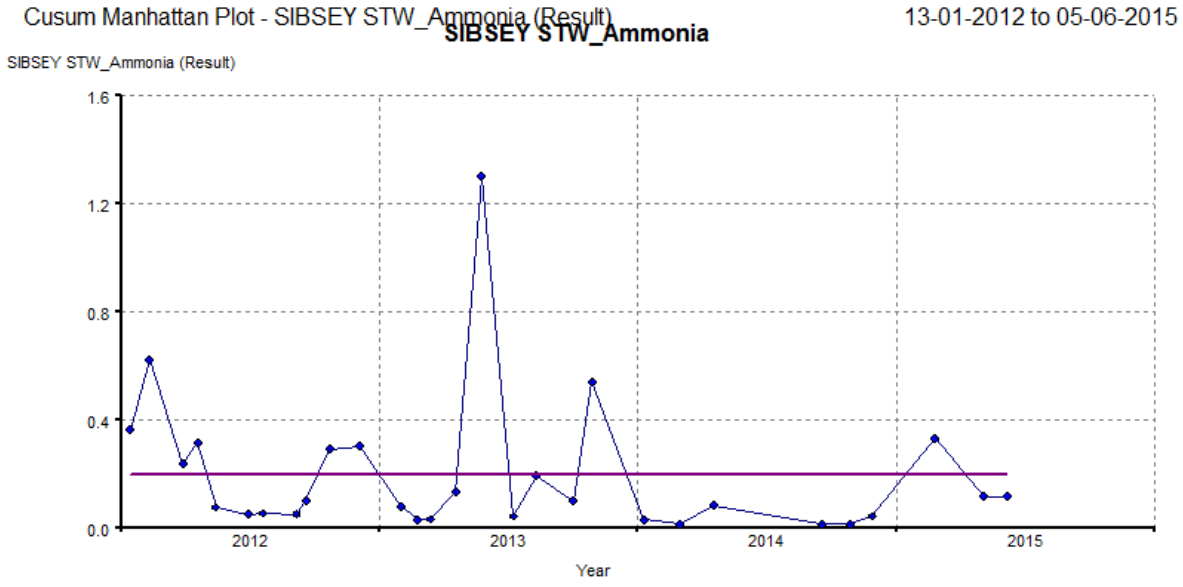


Figure 31: Aardvark cumulative analysis for NH4 for Sibsey WRC without outlier.



A.7.7 Woodhall Spa

WRC discharges into an unnamed drain as shown in Figure 32. The status of the Lower Witham that is the nearest watercourse with WFD classification is summarised in Table 25 below:

Table 25: Lower Witham status.

	Overall	BOD	Ammonia	Phosphorus
2015 status	Moderate	High	Good	Moderate
Objective	Moderate by 2015	High	Good	

Figure 32: Woodhall Spa WRC and discharge location.

Table 26 shows the input data and RQP results for Woodhall Spa. The works has permitted values for DWF, NH4 and BOD and is currently operating within these limits but for all of them. Future scenarios predict that the WRC will be working within its current permits for NH4 and BOD. It was no possible with the data available to assess future DWF consent.

The model results indicate that for BOD and NH4 there is no class or deterioration target failure. For P all the scenarios cause a failure of the class target from moderate to poor even assuming good class upstream of the work.

The RQP function was used to calculate the required discharge quality for P to meet the river targets. The model results in Table 27 indicate that the target can be achieved for any scenario using BAT if good class upstream of the works is assumed. With moderate class upstream of the works the target cannot be achieved even using BAT for any scenario.

Table 26: Input data and RQP results for Woodhall WRC.

Parameter	Statistic	River	Source	Present day			S4			S2			S3, S5			S1		
				WRC	Source	RQP Result	WRC	Source	RQP Result	WRC	Source	RQP Result	WRC	Source	RQP Result	WRC	Source	RQP Result
Flow (Ml/d)	Mean	803.00	EA data 2014	1.64	EA data 2014		1.77	calculated using AW parameters		1.76	calculated using AW parameters		1.75	calculated using AW parameters		1.74	calculated using AW parameters	
	SD			0.56			0.60			0.60			0.60			0.59		
	5%ile	34.40																
BOD (mg/l)	Mean	1.15	Mid class high	6.63	Measured data	2.04	6.63	Measured data	2.04									
	SD	0.69		2.76			2.76											
	Target 90%ile	4.00	2015 WFD															
NH4 (mg/l)	Mean	0.26	Mid class good	0.69	Measured data	0.45	0.69	Measured data	0.45									
	SD	0.15		0.61			0.61											
	Target 90%ile	0.60	2015 WFD															
P (mg/l)	Mean	0.16	Mid class moderate	5.00	EA suggested value	0.21	5.00	EA suggested value	0.21	5.00		0.21	5.00		0.21	5.00		0.21
	SD	0.16		3.00			3.00			3.00			3.00			3.00		
	Target Mean	0.09	2015 WFD															
P (mg/l)	Mean	0.07	Assumed mid class good	5.00	EA suggested value	0.12	5.00	EA suggested value	0.12	5.00		0.12	5.00		0.12	5.00		0.12
	SD	0.07		3.00			3.00			3.00			3.00			3.00		
	Target Mean	0.09	0.00															

Table 27: discharge quality required to meet good WFD targets for P at Woodhall.

Pollutant	Target	Upstream river quality	Scenario	Mean	SD	95%ile
P	0.093 - good	Mid class moderate	S4	**not achivable**		
	0.093 - good	Mid class moderate	Present day	**not achivable**		
P	0.093 - good	Assumed mid class good	S4	**2.23**	1.28	4.71

A.1 Aardvark analysis for Woodhall discharge data

BOD and NH4 observed data are available for Woodhall WRC discharge flow.

BOD

There are 44 samples for BOD from 2012 till 2015 of which 1 is "less than". Figure 33 shows the summary statistic for Woodhall WRC.

There were not outlier and Aardvark did not detect any step change (see Figure 34).

Figure 33: Aardvark summary for BOD for Woodhall WRC.

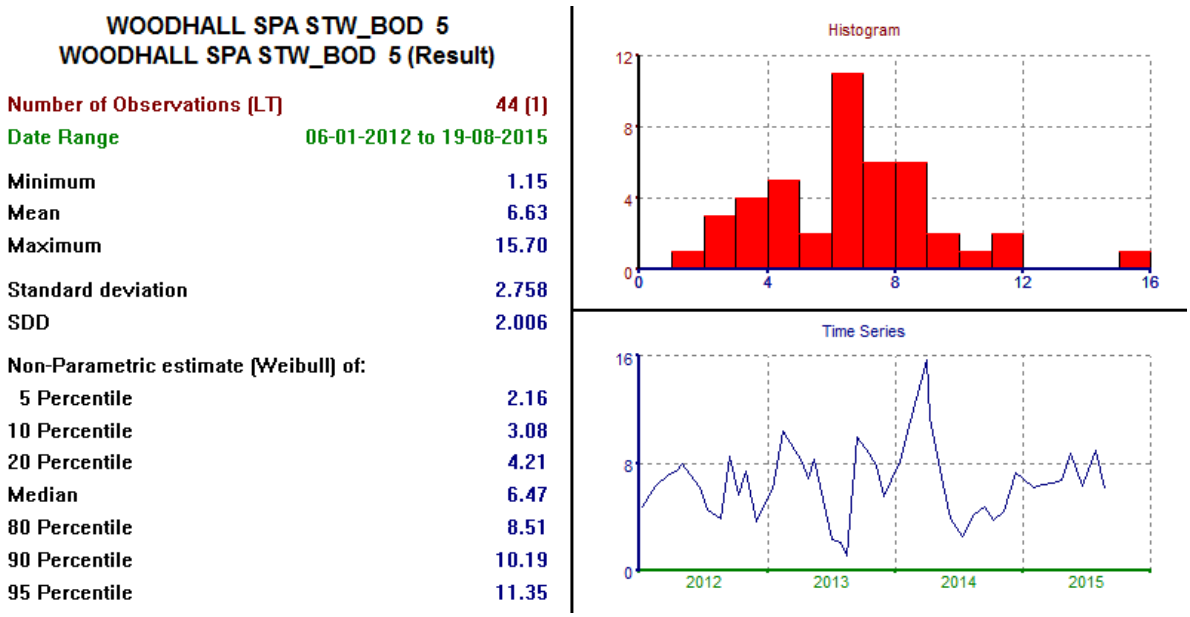
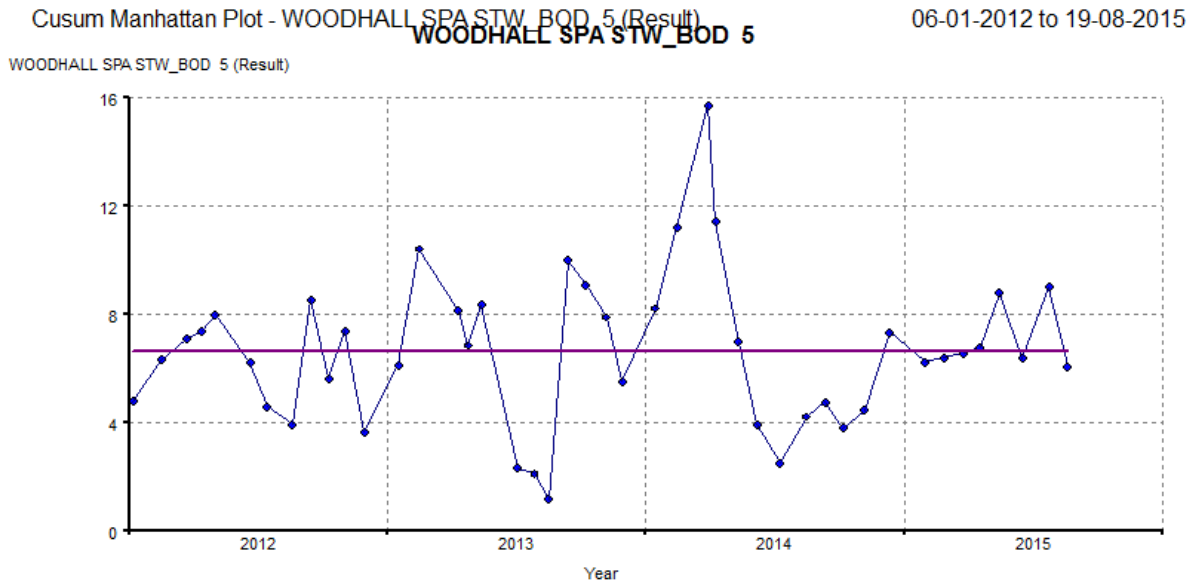


Figure 34: Aardvark cumulative analysis for BOD for Woodhall WRC.



NH4

There are 44 samples for NH4 from 2012 till 2015 of which 3 are "less than". Figure 35 shows the summary statistic for Woodhall WRC.

There were not outlier and Aardvark did not detect any significant step change (see Figure 36).

Figure 35: Aardvark summary for NH4 for Woodhall WRC.

WOODHALL SPA STW_Ammonia
WOODHALL SPA STW_Ammonia (Result)

Number of Observations (LT)	44 (3)
Date Range	06-01-2012 to 19-08-2015
Minimum	0.0700
Mean	0.6882
Maximum	2.2700
Standard deviation	0.6101
SDD	0.5221
Non-Parametric estimate (Weibull) of:	
5 Percentile	0.1043
10 Percentile	0.1155
20 Percentile	0.1450
Median	0.4060
80 Percentile	1.1500
90 Percentile	1.7250
95 Percentile	2.1175

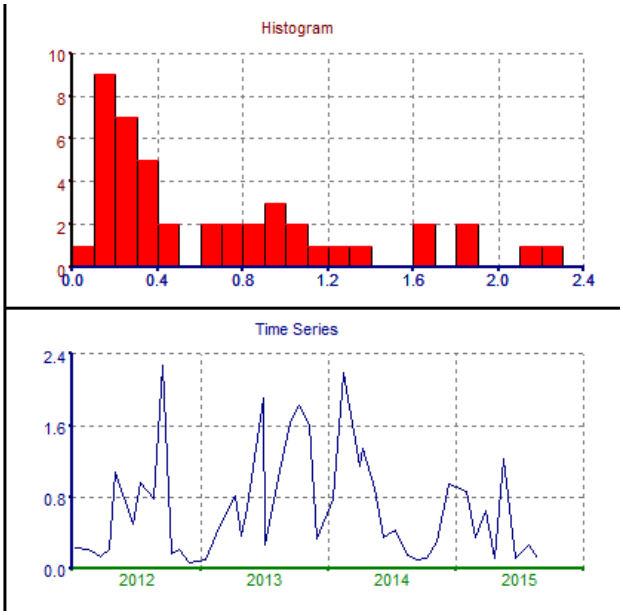
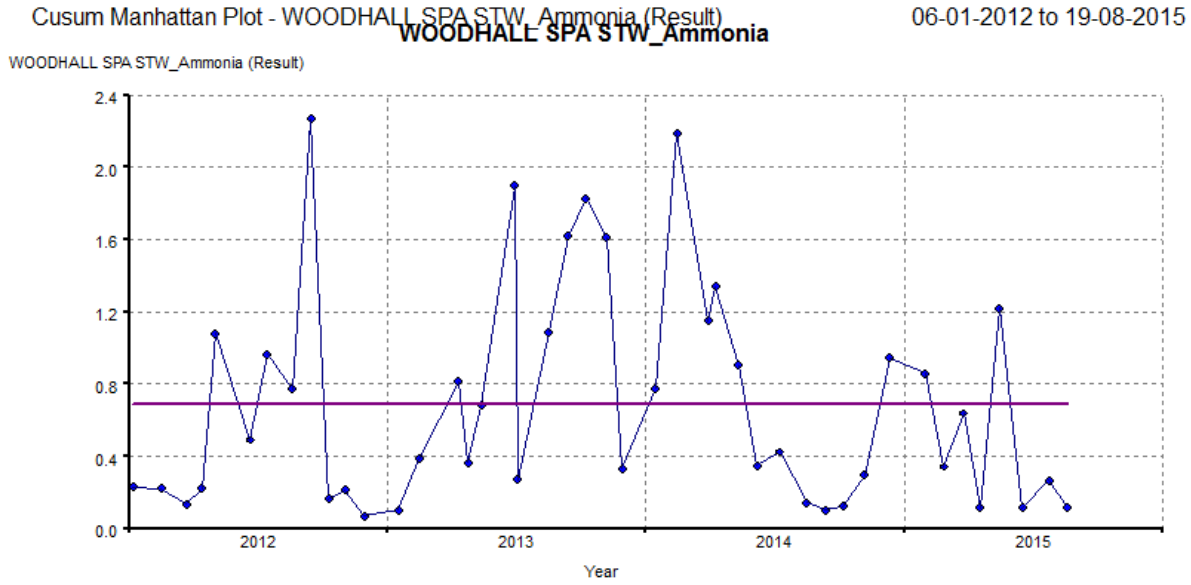


Figure 36: Aardvark cumulative analysis for NH4 for Woodhall WRC



A.8 Summary and conclusion

A.8.8 Method

The increased discharge of effluent due to an increase in the population served by a Water Recycle Centre (WRC) may impact on the quality of the receiving water. The Water Framework Directive (WFD) does not allow a watercourse to deteriorate from its current class (either water body or element class).

It is Environment Agency policy to model the impact of increasing effluent volumes on the receiving watercourse. Where the scale of development is such that a deterioration is predicted, a new permit may be required for the WRC to improve the quality of the final effluent, so that the extra pollution load will not result in a deterioration in the water quality of the watercourse. This is known as a “no deterioration” or “load standstill".

During the preparation of this Water Cycle Study (WCS) East Lindsey District Council advised that it would be necessary to undertake an assessment of the water quality impact of development in the 7 WRCs catchments which present some potential issues in the District according to the Anglian Water assessment.

The assessment was undertaken using the EA's River Quality Planning (RQP) tool which enables a Monte-Carlo analysis to be undertaken at a single point of discharge to a watercourse.

RQP models were initially set up and run, for each WRC, for the present-day situation first. Where failure of any of the targets was predicted for the present-day scenario, no future scenarios were assessed. Where the present-day scenario did not predict any failures, the worst-case future scenario was assessed next. Where this worst-case scenario did not predict failure of any target no further modelling was required. Otherwise, the next worse scenario was modelled, until a scenario was arrived at where no failure of any target was predicted, or until all future scenarios were modelled.

Where failure was predicted for any of the scenarios, and the upstream river quality did not achieve ‘good status’, the model was run by assuming that the river had ‘good status’. The reason of this approach is to assess the actual impact of the effluent if upstream point and/or diffuse sources were to be resolved.

A.8.9 Results

Table 28 summaries the modelling results for passing or failing of the following targets:

- 'Good status';
- 'No 10% deterioration';
- 'No class deterioration'.

Table 28: RQP results summaries for passing or failing targets of: 'Good Status', 'No >10% Deterioration' and 'No Class Deterioration'.

Watercourse (WRC discharging into it)	Scenario	Achieves 'Good status' target?			Achieves 'No > 10% deterioration' target?			Achieves 'Class deterioration' target?		
		BOD	NH4	P	BOD	NH4	P	BOD	NH4	P
Key		Achieves good status			No deterioration			No class deterioration		
		NA			Up to 10% deterioration			NA		
		Fails good status			More than 10% deterioration			Class deterioration		
River Bain (Coningsby)	Present day	yes	yes	no	N/A	N/A	N/A	N/A	N/A	N/A
	S4	yes	yes	no	-0.4%	7.7%	8.6%	yes	yes	yes
	S2	yes	yes	no	0.0%	< 8%	2.9%	yes	yes	yes
	S1, S3, S5	yes	yes	no	0.0%	< 8%	3.0%	yes	yes	yes
Old River Bain (Horncastle)	Present day	no	yes	no	N/A	N/A	N/A	N/A	N/A	N/A
	S4	no	yes	no	1.9%	5.2%	5.4%	yes	yes	yes
	S2	no	yes	no	0.7%	3.5%	2.9%	yes	yes	yes
	S1, S3, S5	no	yes	no	0.9%	3.5%	2.5%	yes	yes	yes
Unnamed drain (Legbourne)	Present day	yes	yes	no	N/A	N/A	N/A	N/A	N/A	N/A
	S3, S5	yes	yes	no	3.1%	8.1%	1.1%	yes	yes	yes
	S1, S2, S4	yes	yes	no	< 3.1%	5.4%	0.6%	yes	yes	yes
Louth Canal (Louth)	Present day	yes	no	no	N/A	N/A	N/A	N/A	N/A	N/A
	S4	yes	no	no	5.0%	6.4%	8.8%	yes	yes	yes
	S2,S3,S5	yes	no	no	2.7%	3.2%	4.4%	yes	yes	yes
	S1	yes	no	no	2.2%	3.2%	3.5%	yes	yes	yes
Unnamed drain (Manby)	Present day	yes	yes	no	N/A	N/A	N/A	N/A	N/A	N/A
	S4	yes	yes	no	0.4%	0.0%	0.5%	yes	yes	yes
	S2,S3,S5	yes	yes	no	0.4%	0.0%	0.5%	yes	yes	yes
	S1	yes	yes	no	0.4%	0.0%	0.5%	yes	yes	yes
Unnamed drain (Sibsey)	Present day	no	yes	no	N/A	N/A	N/A	N/A	N/A	N/A
	S4	no	yes	no	0.5%	0.0%	3.7%	yes	yes	yes
	S2,S3,S5	no	yes	no	0.5%	0.0%	3.3%	yes	yes	yes
	S1	no	yes	no	0.4%	0.0%	2.8%	yes	yes	yes
Unnamed drain (Woodhall Spa)	Present day	yes	yes	no	N/A	N/A	N/A	N/A	N/A	N/A
	S4	yes	yes	no	0.0%	0.0%	0.0%	yes	yes	yes
	S2	yes	yes	no	0.0%	0.0%	0.0%	yes	yes	yes
	S3, S5	yes	yes	no	0.0%	0.0%	0.0%	yes	yes	yes
	S1	yes	yes	no	0.0%	0.0%	0.0%	yes	yes	yes

A.8.10 Best Available Technology (BAT) assessment

Where river target failures occurred, the modelling results were compared against BAT to assess if improving the works to such level of performance could prevent the failure to occur. Table 29 summarises for each WRC the following questions:

- Will the WRC remain within its existing permit?
- Do any of the determinands experience a 10% deterioration and if so can this be prevented by application of BAT?
- Do any of the determinands experience a class deterioration and if so can this be prevented by application of BAT?
- Do any of the determinands experience a failure in reaching good status and if so can this be prevented by application of BAT?
- Do any of the determinands experience a failure in reaching the actual WFD status and if so can this be prevented by application of BAT?

The EA advised that the following permit values are achievable using best available technology, and that these values should be used for modelling all WRC potential capacity irrespective of the existing treatment technology and size of the works:

- BOD (95%ile) = 5mg/l
- Ammonia (95%ile) = 1mg/l
- Phosphorus (mean) = 0.5mg/l

This does not take in consideration if it is feasible to upgrade each existing WRC to such technology due to constraints of cost, timing, space, carbon cost etc. Table 29 shows a summary of the conclusions using BAT.

Table 29: Summary of results assuming BAT is applied.

Watercourse (WRC discharging into it)	DWF Permit Compliant	Could the development cause a greater than 10% deterioration in WQ?	Could the development cause a deterioration in WFD class of any element?	Could the development prevent the water body from reaching GES?
Key		Passes		
		Fails: target is achievable using BAT or permit capacity is reached		
		Fails: target is not achievable using BAT or permit capacity is exceeded.		
River Bain (Coningsby)	Currently working below DWF permit	Predicted deterioration is less than 10%. No WRC upgrade is required	No class deterioration is predicted. No WRC upgrade is required	Good status is not reached for P. Upgrade to the WRC is needed and it is achievable with BAT assuming GES upstream.
Old River Bain (Horncastle)	Currently working below DWF permit	Predicted deterioration is less than 10%. No WRC upgrade is required	No class deterioration is predicted. No WRC upgrade is required	Good status is not reached for BOD and P. Upgrade to the WRC is needed and it is achievable with BAT only for BOD. For P even assuming GES upstream it is not possible to achieve GES.
Unnamed drain (Legbourne)	Currently working below DWF permit	Predicted deterioration is less than 10%. No WRC upgrade is required	No class deterioration is predicted. No WRC upgrade is required	Good status is not reached for P. Upgrade to the WRC is needed and it is not achievable with BAT even assuming GES upstream. For P even assuming GES upstream it is not possible to achieve GES.
Louth Canal (Louth)	Currently working below DWF permit	Predicted deterioration is less than 10%. No WRC upgrade is required	No class deterioration is predicted. No WRC upgrade is required	Good status is not reached for NH4 and P. Upgrade to the WRC is needed but it is achievable with BAT only for NH4 (the mean requested for S4 scenario is within the 10% model tolerance / variability).
Unnamed drain (Manby)	Currently working below DWF permit	Predicted deterioration is less than 10%. No WRC upgrade is required	No class deterioration is predicted. No WRC upgrade is required	Good status is not reached for P. Upgrade to the WRC is needed and it is not achievable with BAT even assuming GES upstream. For P even assuming GES upstream it is not possible to achieve GES.

Watercourse (WRC discharging into it)	DWF Permit Compliant	Could the development cause a greater than 10% deterioration in WQ?	Could the development cause a deterioration in WFD class of any element?	Could the development prevent the water body from reaching GES?
Key		Passes		
		Fails: target is achievable using BAT or permit capacity is reached		
		Fails: target is not achievable using BAT or permit capacity is exceeded.		
Unnamed drain (Sibsey)	Currently working below DWF permit	Predicted deterioration is less than 10%. No WRC upgrade is required	No class deterioration is predicted. No WRC upgrade is required	Good status is not reached for BOD and P. Upgrade to the WRC is needed but it is achievable with BAT only for BOD.
Unnamed drain (Woodhall Spa)	Currently working below DWF permit	Predicted deterioration is less than 10%. No WRC upgrade is required	No class deterioration is predicted. No WRC upgrade is required	Good status is not reached for P. Upgrade to the WRC is needed and it is achievable with BAT assuming GES upstream.

Table 30 reports information on the runs and the model results used to compare against BAT. Further explanation of column headers are:

- Scenario: specifies the discharge flow and quality scenario data used as input in the RQP run;
- Target: specifies the target to achieve;
- Upstream river quality: specifies if the upstream river condition used for the run is the actual situation or if GES was assumed;
- Mean, SD and 95%ile: these are the RQP tool output representing the discharge value required to meet the specific target. For BOD and ammonia the value to compare with BAT is the 95%ile whilst for P is the mean.

Table 30: runs and the model results used to compare against BAT.

WRC	Pollutant	Target	Upstream river quality	Scenario	Mean	SD	95%ile
Coningsby	P	0.092 - good	Assumed mid class good	S4	**0.54**	0.31	1.14
Coningsby	P	0.092 - good	Mid class moderate	S4	**Not achievable**		
Coningsby	P	0.092 - good	Mid class moderate	Present day	**Not achievable**		
Coningsby	P	0.217 - moderate	Mid class moderate	S4	**1.59**	0.92	3.35
Horncastle	BOD	5 - good	Assumed mid class good	S4	5.02	1.67	**8.12**
Horncastle	NH4	0.3 - high	Mid class high	S4	0.22	0.28	**0.72**
Horncastle	NH4	0.3 - high	Mid class high	S1, S3, S5	0.23	0.28	**0.74**
Horncastle	P	0.092 - good	Assumed mid class good	S4	**0.12**	0.07	0.24
Horncastle	P	0.092 - good	Assumed mid class good	S1, S3, S5	**0.12**	0.07	0.25
Horncastle	P	0.092 - good	Assumed mid class good	Present day	**0.12**	0.07	0.25
Horncastle	P	0.217 - moderate	Mid class moderate	S4	**0.29**	0.17	0.61
Horncastle	P	0.217 - moderate	Mid class moderate	Present day	**0.3**	0.17	0.62
Legbourne	NH4	0.3 - high	Mid class high	S3, S5	1.61	1.69	**4.77**
Legbourne	NH4	0.3 - high	Mid class high	S1, S2, S4	1..69	1.78	**5.02**
Legbourne	P	0.097 - good	Assumed mid class good	S1, S2, S4	**0.42**	0.24	0.89
Legbourne	P	0.097 - good	Assumed mid class good	S3, S5	**0.41**	0.23	0.86
Legbourne	P	0.097 - good	Assumed mid class good	Present day	**0.44**	0.26	0.94
Louth	BOD	4 - high	Mid class high	S4	7.65	1.93	**11.16**
Louth	NH4	0.3 - high	Mid class high	S4	0.51	0.24	**0.98**
Louth	NH4	0.3 - high	Mid class high	S2, S3, S5	0.54	0.26	**1.03**
Louth	P	0.092 - good	Mid class good	S4	**0.16**	0.09	0.34
Louth	P	0.092 - good	Mid class good	S2, S3, S5	**0.17**	0.10	0.35
Louth	P	0.092 - good	Mid class good	S1	**0.17**	0.10	0.35
Louth	P	0.092 - good	Mid class good	Present Day	**0.17**	0.10	0.36
Manby	P	0.097 - good	Assumed mid class good	S4	**0.18**	0.10	0.38
Manby	P	0.097 - good	Assumed mid class good	S1	**0.18**	0.11	0.39
Manby	P	0.097 - good	Assumed mid class good	Present day	**0.19**	0.11	0.39
Woodhall Spa	BOD	5 - good	Assumed mid class good	S4	3.24	1.83	**6.77**
Woodhall Spa	P	0.101 - good	Mid class good	S4	**0.11**	0.06	0.23
Woodhall Spa	P	0.101 - good	Mid class good	S1	**0.11**	0.06	0.24
Woodhall Spa	P	0.101 - good	Mid class good	Present Day	**0.11**	0.06	0.24

A.8.11 Conclusion

The water quality impact assessment has brought the following conclusions:

- All works are currently working below their DWF permits.
- The proposed growth is not predicted to lead to any class deteriorations, or deteriorations of quality of greater than 10% for any determinand.
- For Phosphorus all receiving watercourses at all WRCs fail their targets for the present-day situation:
    - At Coningsby (if BAT for P = 0,5mg/l is considered) and Woodhall, good ecological status could be achieved in the receiving watercourses if these were achieving GES upstream of the works.
    - At Horncastle, Legbourne and Manby even assuming GES upstream, the modelling predicts that it would not be possible to achieve GES in the receiving watercourses.
    - Louth and Sibsey have already GES upstream and it not possible to achieve GES at the receiving watercourses. Note: the reason for the P GES target failure could be due to the fact that by not having any observed data available an assumed discharge value (same for all works) was used.

Note: for phosphorus an average value provided by the EA based on actual data of around 2000 discharges with no P removal was used for all WRCs.

- For BOD only receiving watercourses at Horncastle and Sibsey fail GES but targets can achieved by using BAT.

- For NH4 only receiving watercourse at Louth fails GES but target can achieved by using BAT.