A Appendix - Water Quality Assessment

A.1 Introduction

The increased discharge of effluent due to a growth in population served by a Waste Water Treatment Works (WwTW) may impact 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 the development is such that a deterioration is predicted, a new Environmental Permit (EP) may be required for the WwTW to improve the quality of the final effluent so that the extra pollution load will not result in a deterioration of the quality of the final effluent. This is known as a "no deterioration" or "load standstill".

It is the objective of the WFD that all water bodies achieve Good Ecological Status (GES), or where they have been highly modified achieve Good Ecological Potential (GEP). It is therefore also necessary to assess whether the proposed increase in effluent load could prevent a watercourse from achieving GES or GEP. The water cycle study only requires analysis of the physico-chemical elements Biological Oxygen Demand, Ammonia and Phosphate.

A.2 Rye Meads WwTW

Rye Meads WwTW was identified as the only WwTW likely to receive flows from proposed growth in the Harlow-Gilston Garden Town. This treatment works was built in the 1960s to serve the new towns of Stevenage and Harlow and currently serves a population of approximately 400,000. It is currently in the process of being upgraded with the objective of extending treatment capacity and improving discharge quality to enable it to treat an increased volume of flow. This work is due to complete in 2018 and will increase the population equivalent served up to 447,000.

A high-level assessment by Thames Water indicated that from a final effluent stream standpoint, the site would have capacity up to 2036. Some upgrades to sludge and storm streams may be required during AMP7.

The receiving watercourse for this treatment works is Toll House Stream, an ordinary watercourse not monitored for water quality as part of the Water Framework Directive. The stream flows through a Siphon under the River Stort before discharging into the River Lee just south of Fieldes Weir. It was agreed with the Environment Agency that as Toll House Stream is not monitored for water quality and is primarily a conduit for effluent discharge to enter the River Lee, the water quality assessment would focus in the River Lee itself. **Error! Reference source not found.** shows the point of discharge in the Lee.

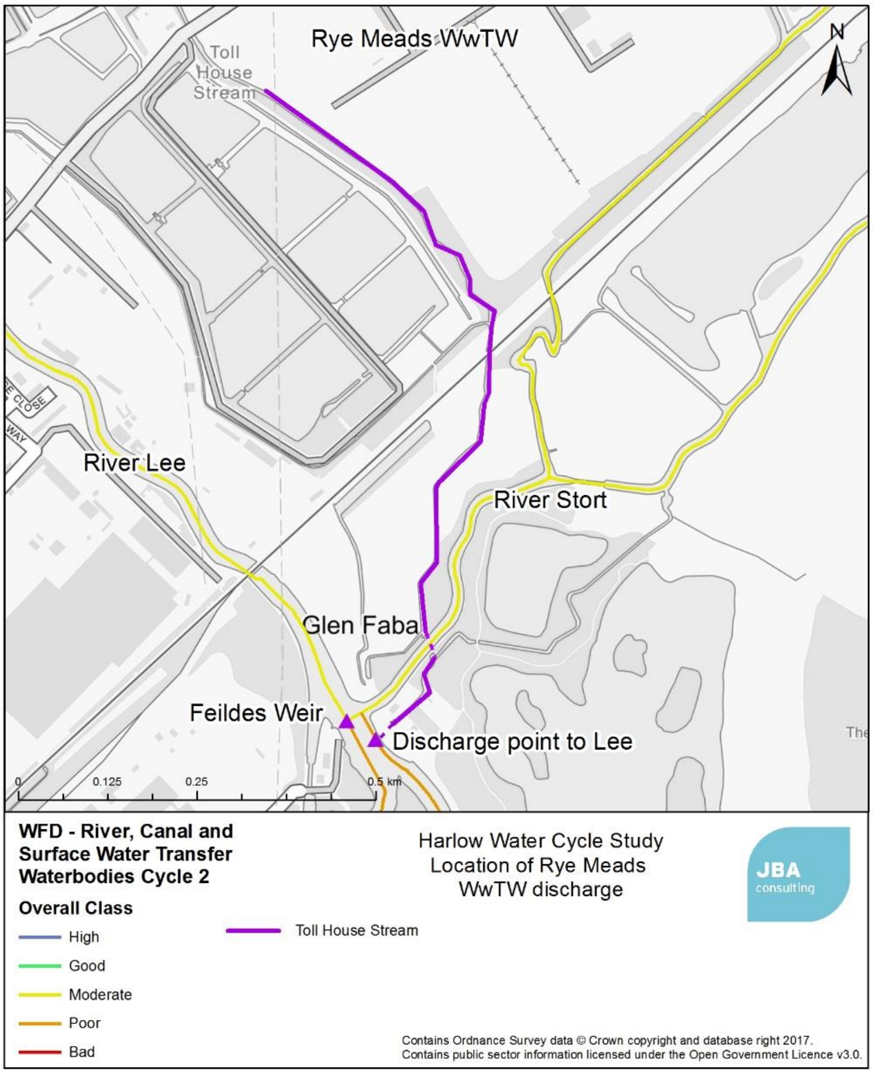


Figure A.1 Discharge point for Rye Meads STW

A monitoring station is present at Feildes Weir (38001) immediately downstream of the confluence of the Lee and Stort. Flow measurement at this station includes the Stort, but does not include the discharge from Rye Meads WwTW or lockage from the navigation channel. Flows of up to 4.7 cumecs discharge over the weir with higher flows enter a flood channel. Flood flows have been known to cause reverse flows on the Stort.

Both the Lee upstream of the Weir, and the Stort were given a Moderate Ecological status in 2016 WFD Cycle 2, this was primarily due to the status for Phosphate. Downstream of the weir, this status has deteriorated to "Poor".

A.3 Study Objectives

This report assesses the potential water quality impacts on the receiving watercourses due to future growth in effluent flows. The aims of this assessment are to:

- Identify whether the increase in wastewater effluent discharged as a result of the proposed growth would lead to a deterioration of the water quality in the receiving watercourse.
- Where deterioration is predicted, test whether this could be prevented by treatment at technically achievable limits (TAL) and a tighter permit condition.
- Where the watercourse is not currently meeting the physico-chemical requirements of the Water Framework Directive Good Ecological Status or Potential, test whether the proposed growth would prevent that from being achieved in the future.

A.4 Methodology

A.4.1 Growth Scenarios

In order to undertake this assessment, flow at the WwTW has been estimated using the number of housing units proposed, an occupancy rate of 2.73 persons per dwelling, and a consumption of 122 l/p/d as outlined in the Affinity Water Resource Management Plan (WRMP)[1]. An assumption was then made that 95 per cent of the water demand is translated into a wastewater demand flowing to the WwTW. The wastewater demand for employment sites was calculated based on 100 l/employee per day. The number of employees was calculated on average employee density by land use type[2].

Planned growth in neighbouring councils adjacent to the Harlow boundary was included where it is expected to drain to Rye Meads WwTW. Refer to section 2 of the main report for details.

A.4.2 Determinands

The determinands assessed were Biological Oxygen Demand (BOD), Ammonia (NH_4) and Phosphate (P).

A.4.3 Upstream Flow

Flow data for the River Lee and River Stort was downloaded from the National River Flow Archive[3,4,5] for the period October 2013 to October 2016, representing the latest three full years of data available. Graphs of this data are shown in Figure A.2 Figure A.4 and summarised in Table A.1 which shows the relative size of the Lee and Stort.

Table A.1 Flow data from gauging stations close to Rye Meads WwTW

Gauging station	Station number	3yr - Mean daily flow (Ml/d)	Standard deviation	3yr - Q95
Lee at Rye House	38027	336.19	346.72	102.816
Stort at Roydon	38031	149.85	197.04	36.37
Lee at Feildes Weir	38001	486.03	534.05	141.48

1 Final Water Resources Management Plan 2015-2020, Affinity Water (2014). Accessed online at: https://stakeholder.affinitywater.co.uk/docs/FINAL-WRMP-Jun-2014.pdf on: 11/04/2018

2 Employment Density Guide 3rd Edition, Homes & Communities Agency (2015). Accessed online at: https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/484133/employment_density_guide_3rd_edition.pdf on: 11/04/2018.

3 38001 - Lee at Feildes Weir, CEH (2018). Accessed online at: http://nrfa.ceh.ac.uk/data/station/info/38001 on: 11/04/2018

4 38031 - Lee at Rye Bridge, CEH (2018). Accessed online at: http://nrfa.ceh.ac.uk/data/station/info/38031 on: 11/04/2018

5 38027 Stort at Glen Faba, CEH (2018). Accessed online at: http://nrfa.ceh.ac.uk/data/station/info/38027 on: 11/04/2018

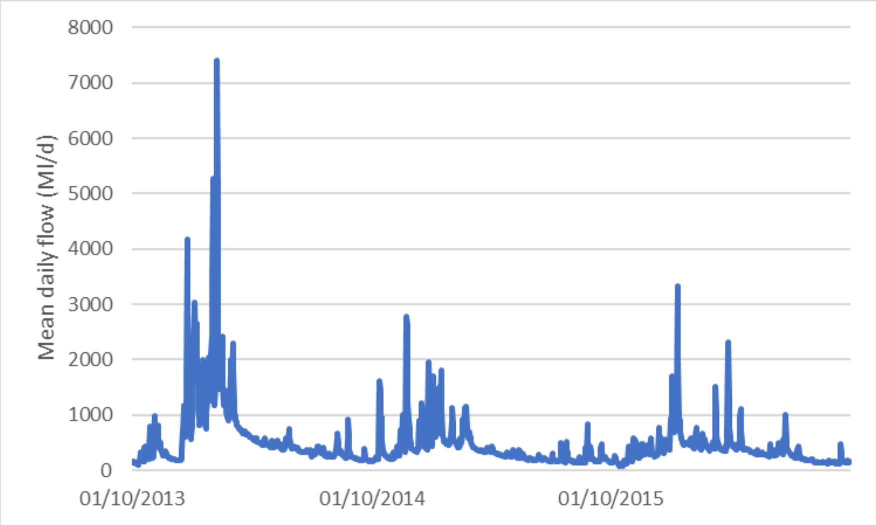


Figure A.2 Mean daily flow at the Lee at Feildes Weir gauging station

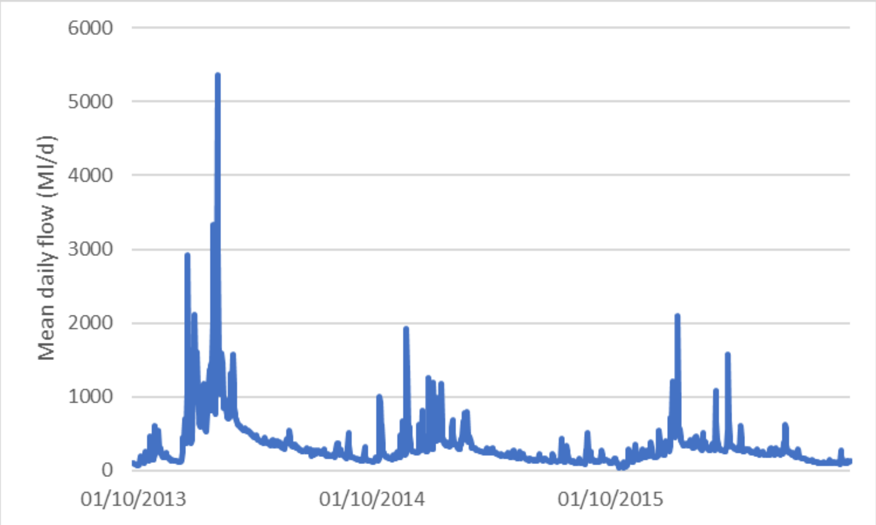


Figure A.3 Mean daily flow at the Lee at Rye Bridge gauging station

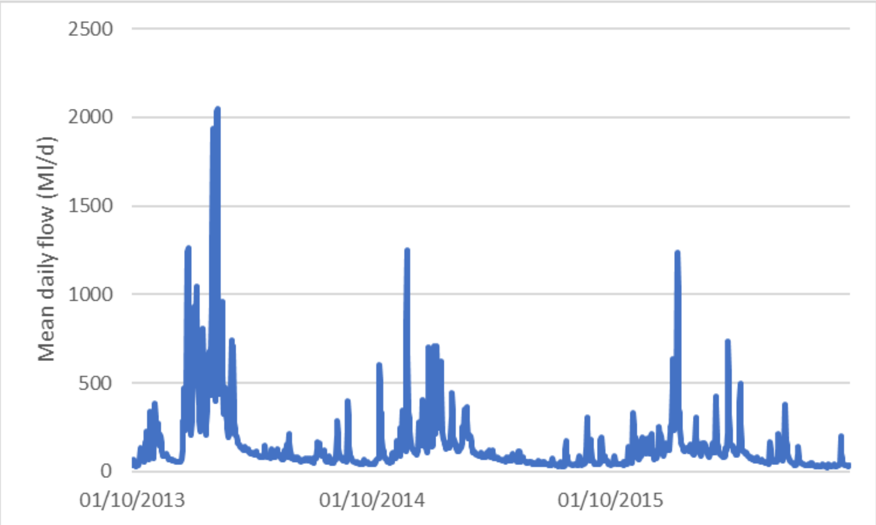


Figure A.4 Mean daily flow at the Stort at Roydon gauging station

A.4.4 Upstream Water Quality

Figure A.5 shows key locations for water quality monitoring in relation to the Rye Meads WwTW discharge.

The waterbody immediately upstream of the WwTW discharge point is the Lee Navigation (Hertford to Fieldes Weir). The nearest water quality monitoring point is 800m upstream at Rye House. Water quality data for the period 2011 to 2018 was downloaded for this point from the EA Water Quality Archive. Graphs of this data are shown in Figure A.6 and Figure A.7. As there were no recorded measurements for BOD, a mid-class figure was taken following guidance from the EA[6,7].

This was compared to data further upstream on the Lee (Lee above Ware Lock sampling point) and the two tributaries, the River Ash and River Stort and found to be comparible.

Where outliers were present in the raw data, they were investigated to ascertain the reason, for example if they related to a pollution incident. In all cases the data points were routine monitoring samples and so were not excluded from the statistics.

Where a qualifier (e.g. <0.3mg/l) was present in the data, the face value of that measurement was taken following guidance received from the EA[7] for a single side limited value.

Table A.2 Determinand concentrations at WQ sample points

WQ Sampling point	Ref.	BOD Mean (SD) (mg/l)	Ammonia Mean (SD) (mg/l)	Phosphorus Mean (SD) (mg/l)
Lee at Rye House	TH-PLER 0073	-	0.040 (0.01)	0.130* (0.039)
Lee above Ware Lock	TH-PLER 0053	1.477 (0.759)	0.045 (0.034)	0.152 (0.046)
Ash at Easneye	TH-PLER 0005	-	0.034 (0.018)	0.278* (0.153)
Stort at Roydon	TH-PLER 0149	1.675 (1.382)	0.051 (0.053)	0.485* (0.414)

* Orthophosphate reactive as P

6 Data code of Practice v3, Environment Agency (2012), Doc No 111_7_SD02 P67.
7 Conference call with EA, 18/05/2018

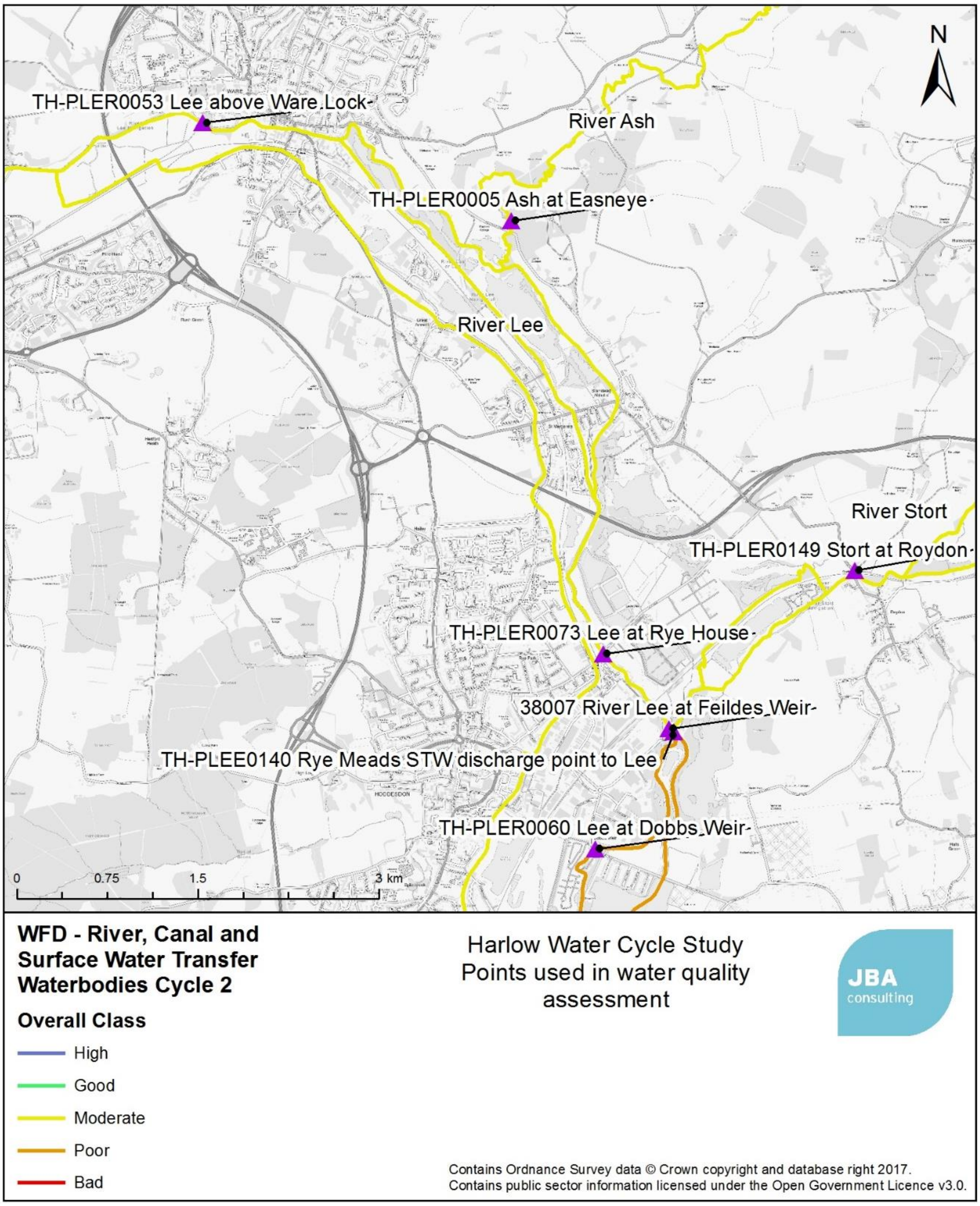


Figure A.5 Location of water quality sampling points

River Lee

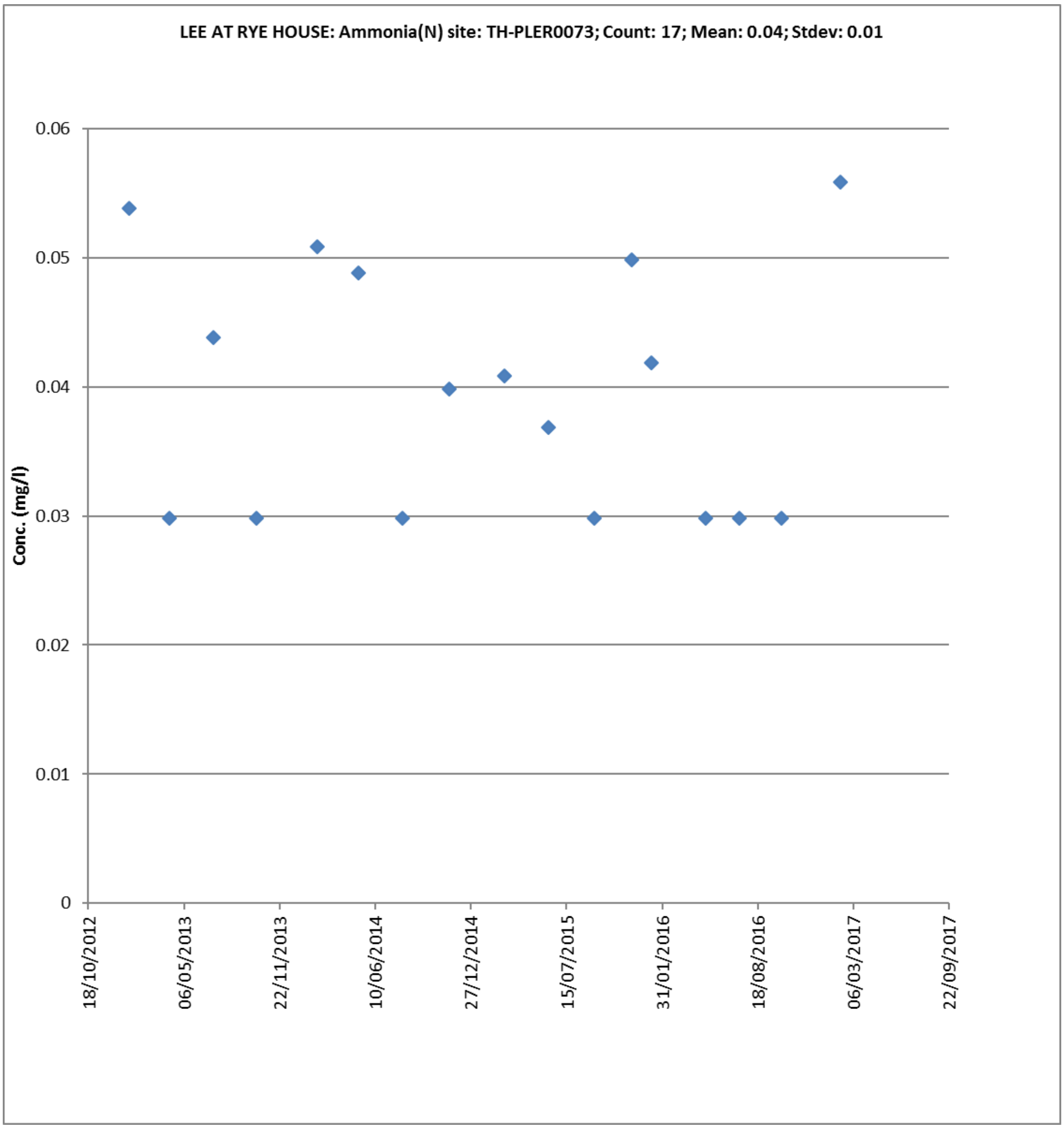


Figure A.6 Graph of Ammonia concentration at the Lee at Rye House sampling point

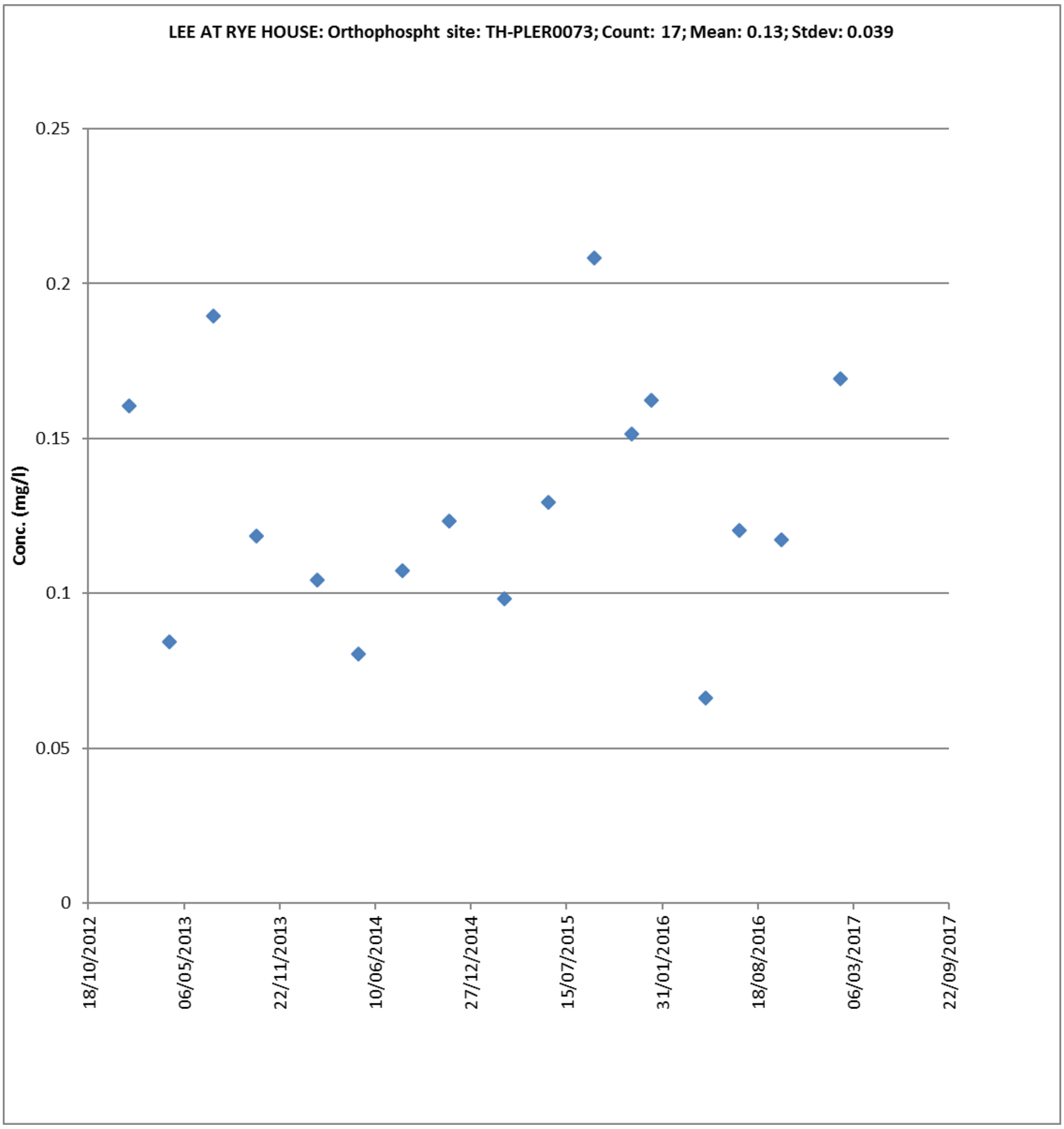


Figure A.7 Graph of Orthophosphate concentration at the Lee at Rye House sampling point

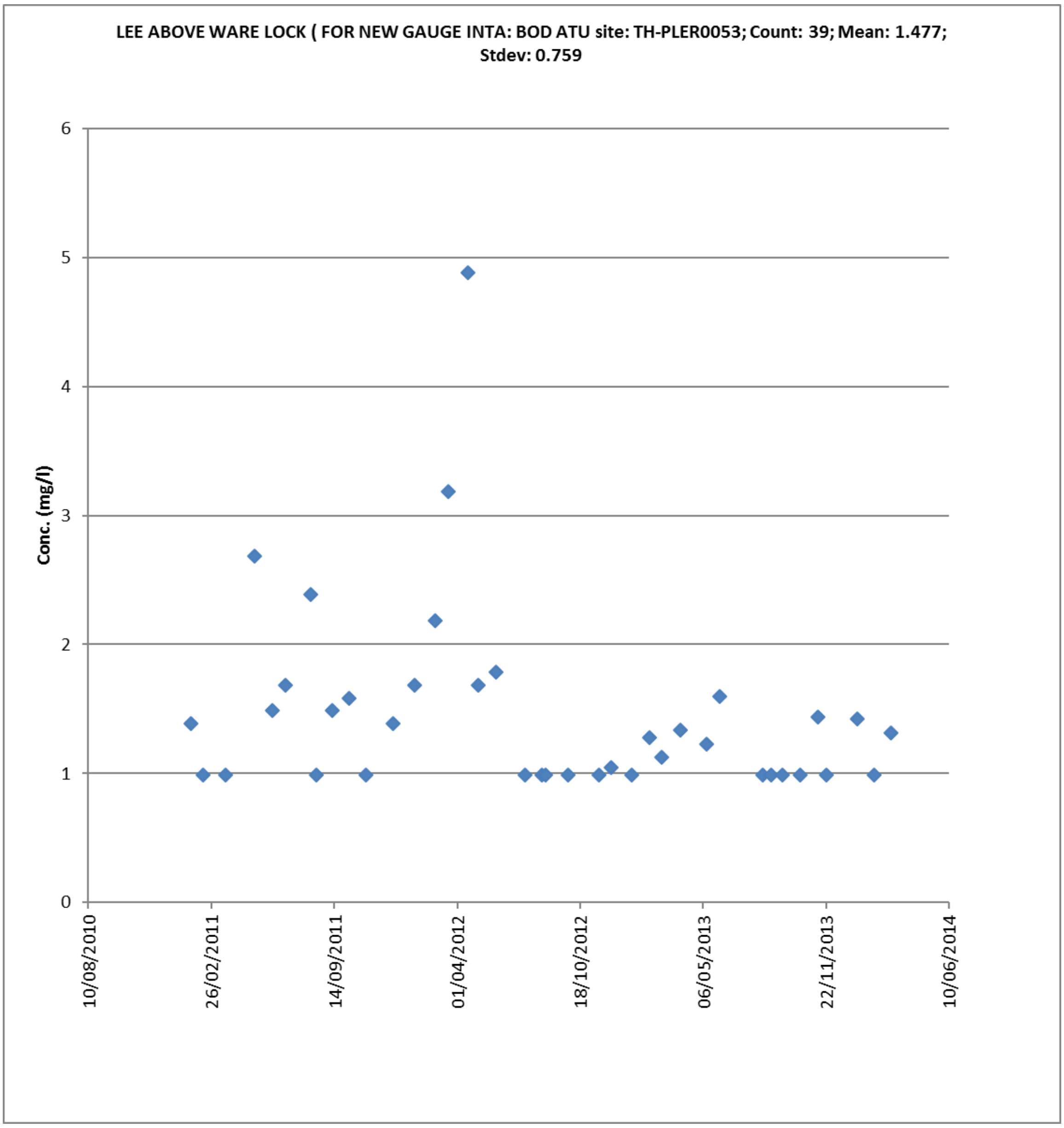


Figure A.8 Graph of BOD concentration at the Lee above Ware Lock sampling point

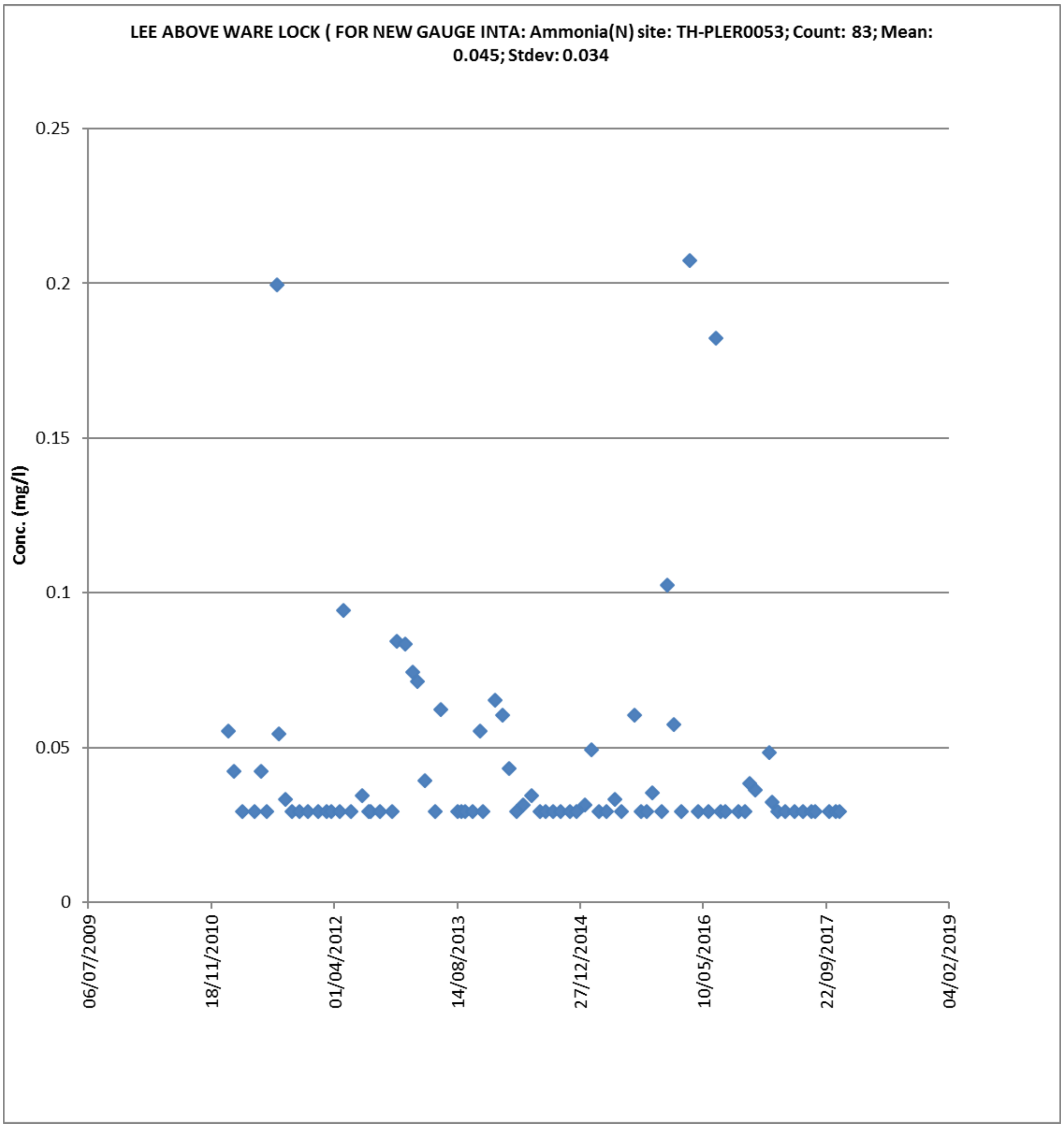


Figure A.9 Graph of Ammonia concentration at the Lee above Ware Lock sampling point

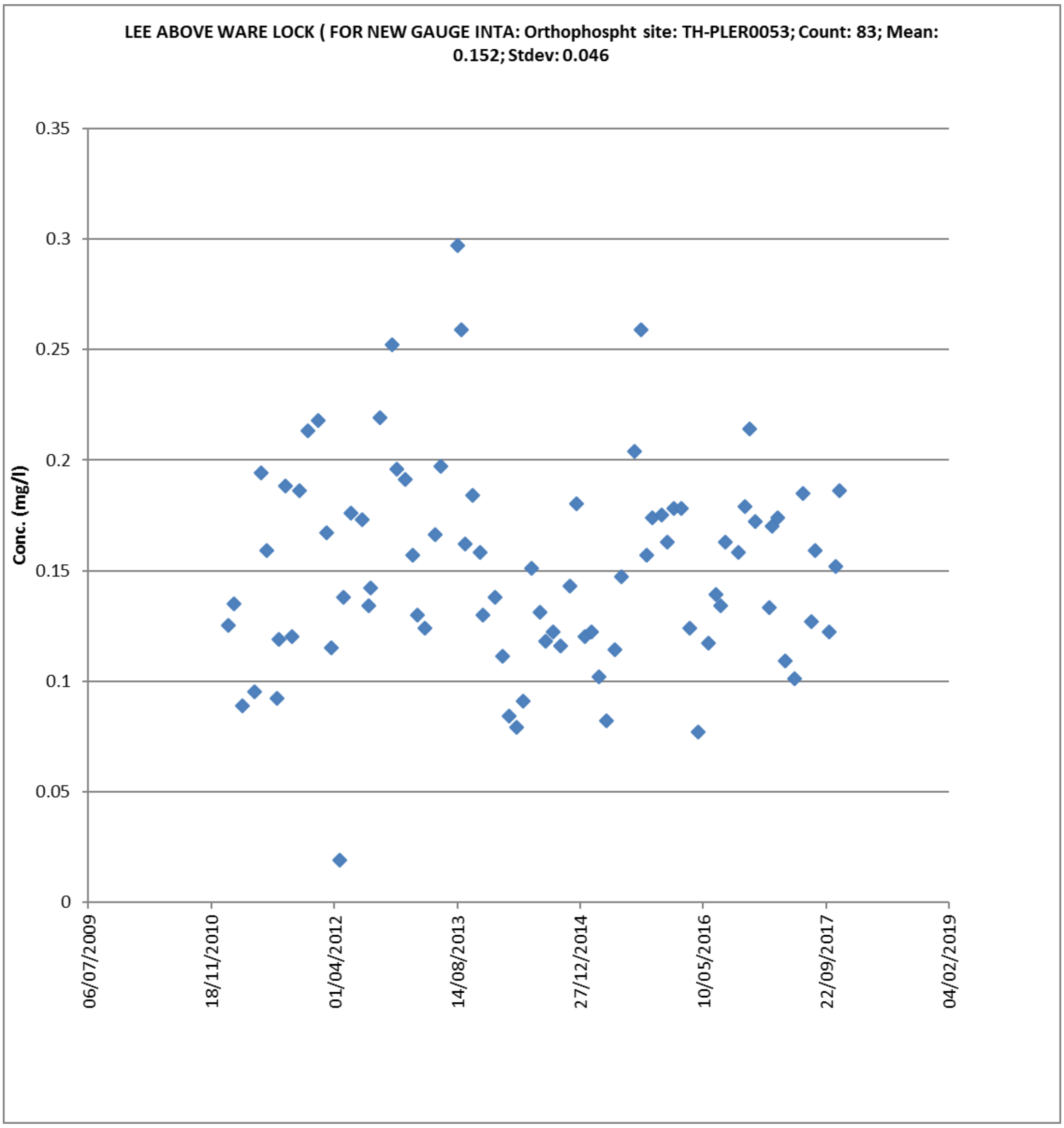


Figure A.10 Graph of Orthophosphate concentration at the Lee above Ware Lock sampling point

River Stort

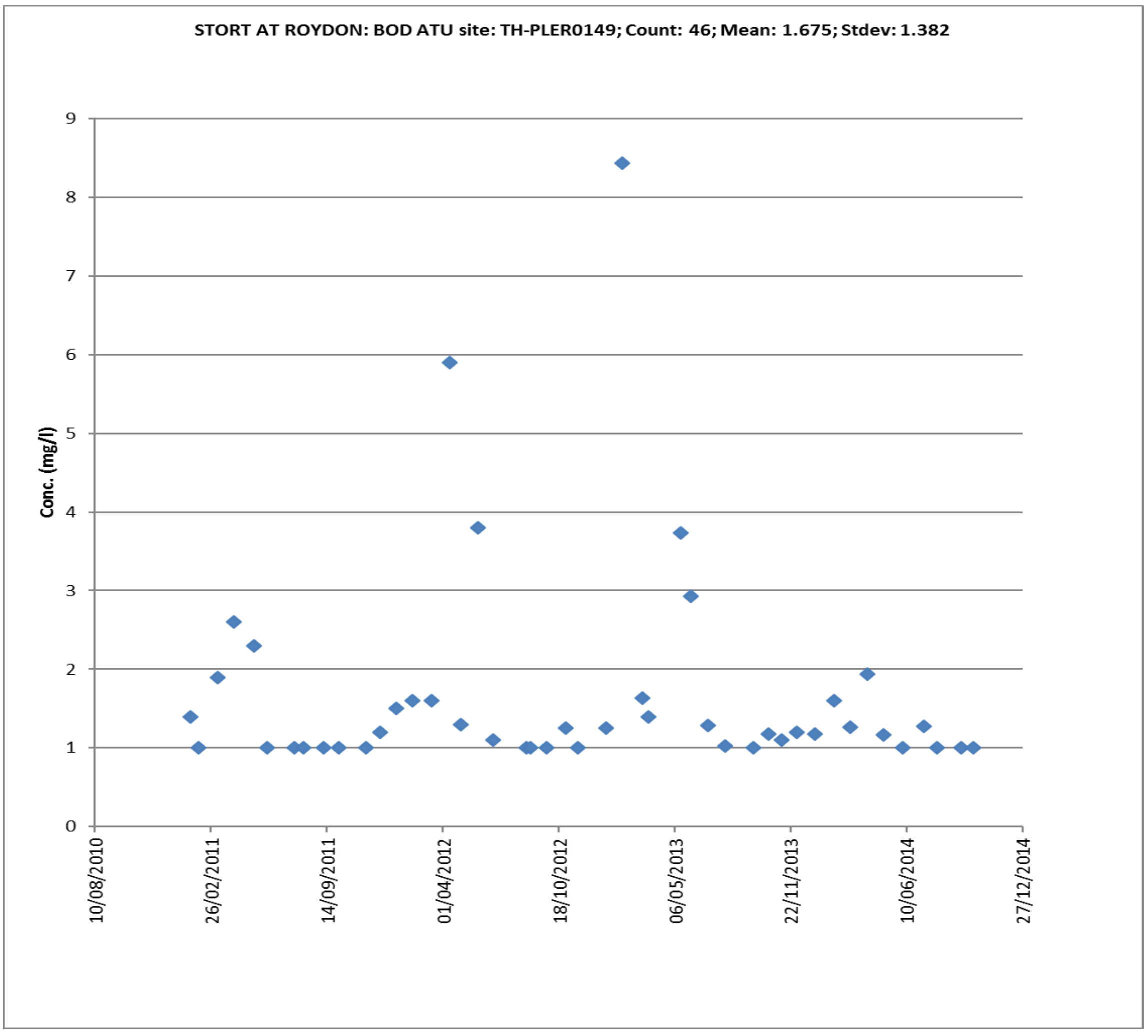


Figure A.11 Graph of BOD concentration for Stort at Roydon sampling point

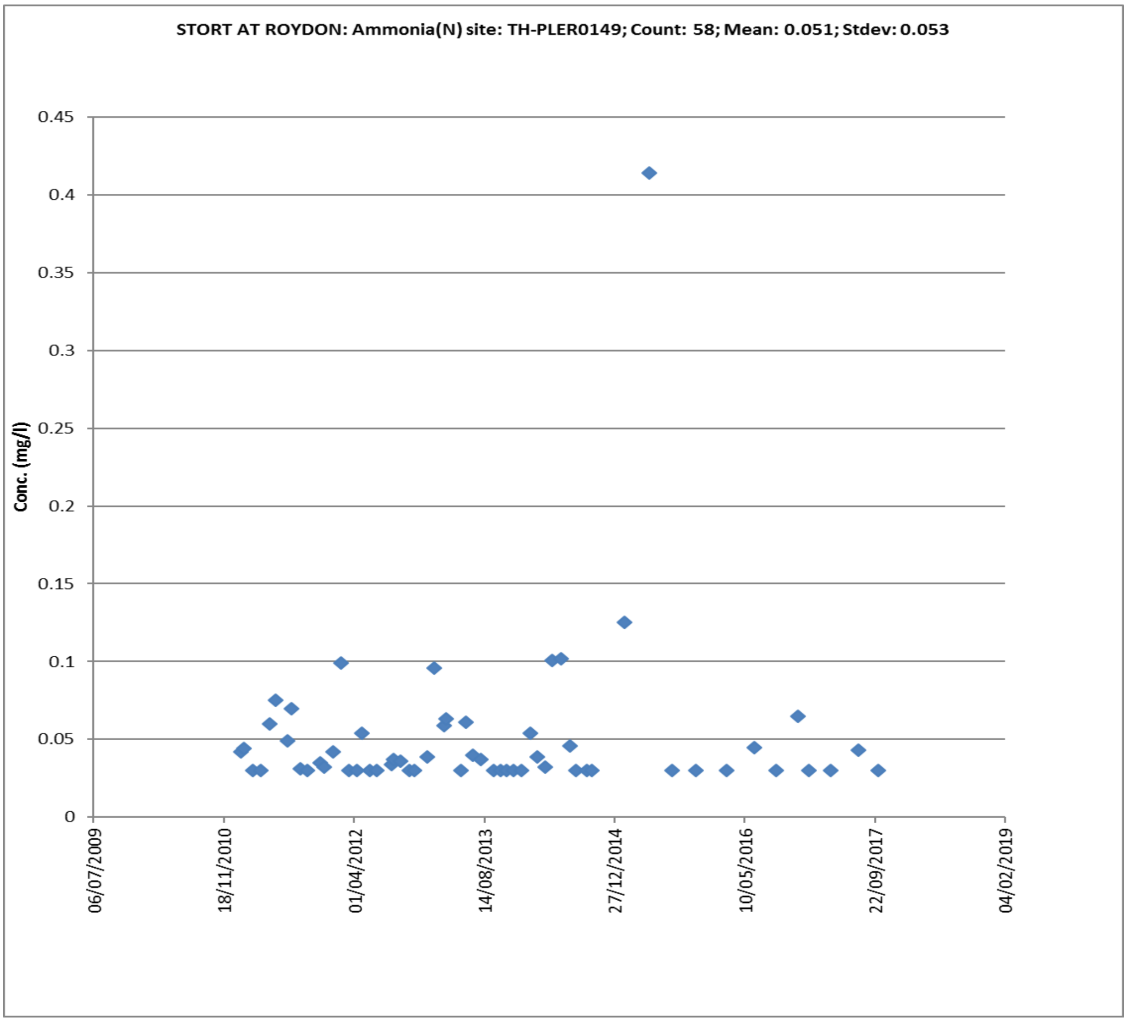


Figure A.12 Graph of Ammonia concentration for Stort at Roydon sampling point

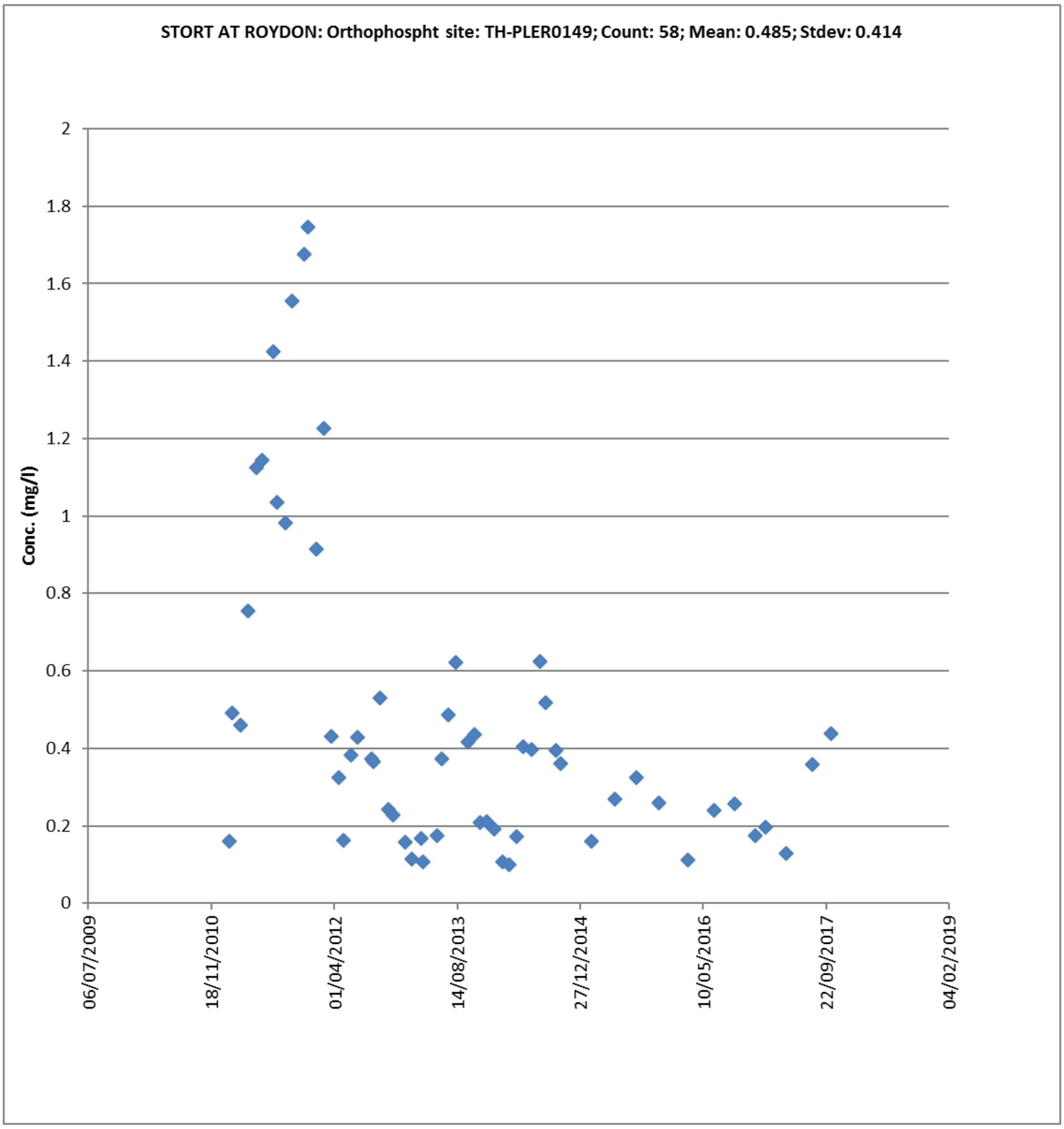


Figure A.13 Graph of Orthophosphate concentration at the Stort at Roydon sampling point

River Ash

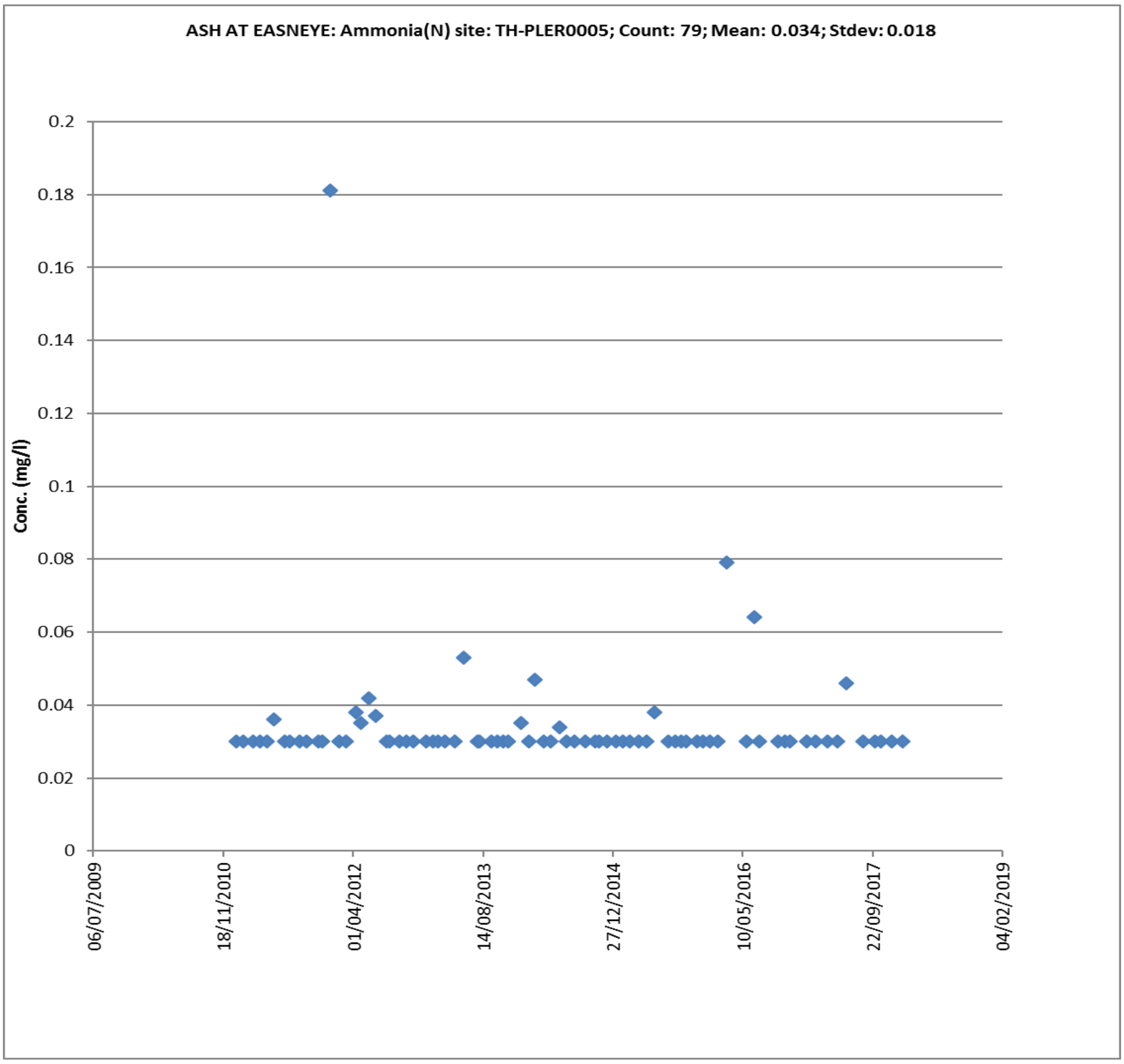

ASH AT EASNEYE: Ammonia(N) site: TH-PLER0005; Count: 79; Mean: 0.034; Stdev: 0.018
Conc. (mg/l)
0.2
0.18
0.16
0.14
0.12
0.1
0.08
0.06
0.04
0.02
0
06/07/2009
18/11/2010
01/04/2012
14/08/2013
27/12/2014
10/05/2016
22/09/2017
04/02/2019

Figure A.14 Graph of Ammonia concentration at Ash at Easneye sampling point

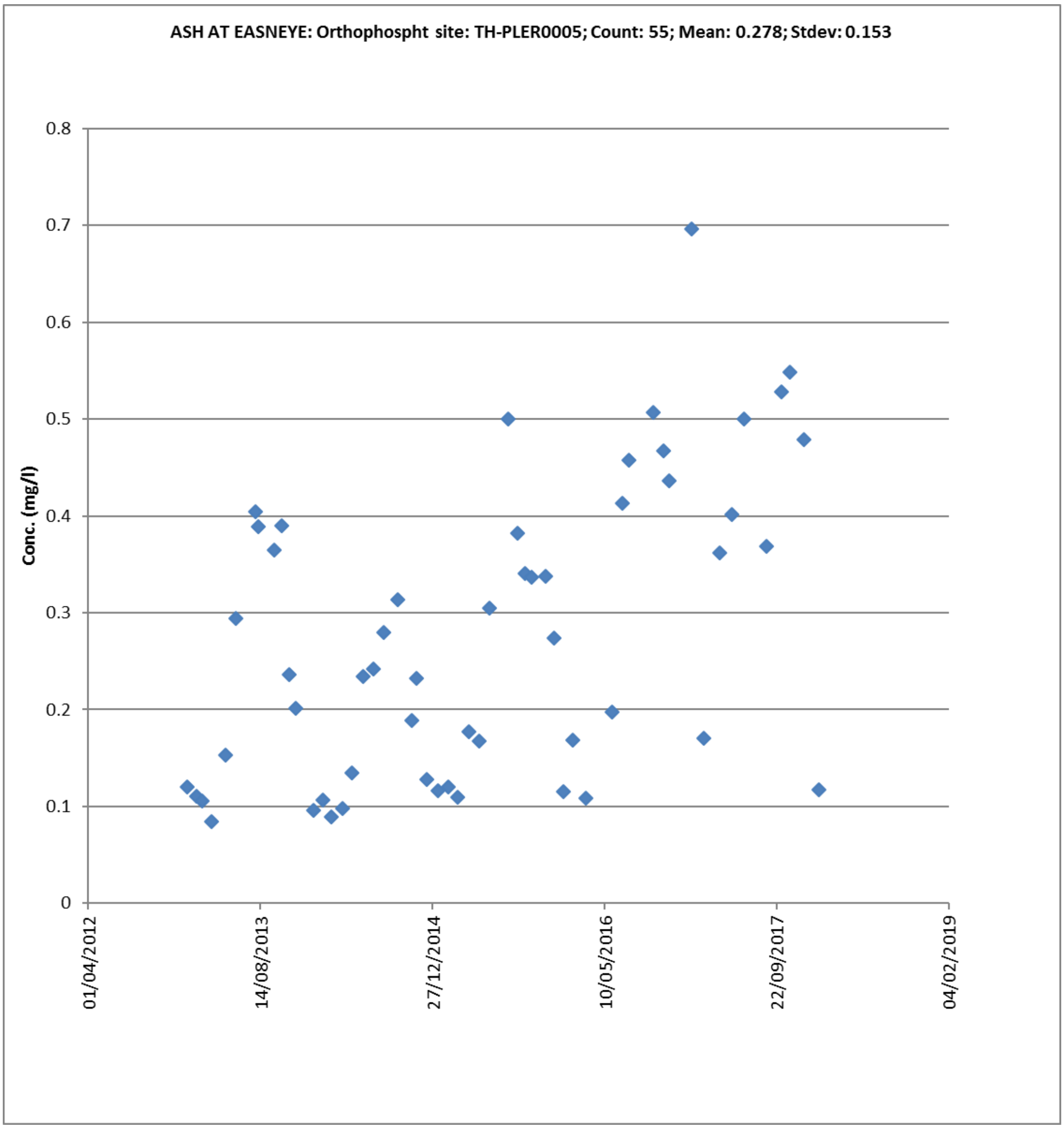


Figure A.15 Graph of Orthophosphate concentration at Ash at Easneye sampling point

A.4.5 Assessment of Deterioration

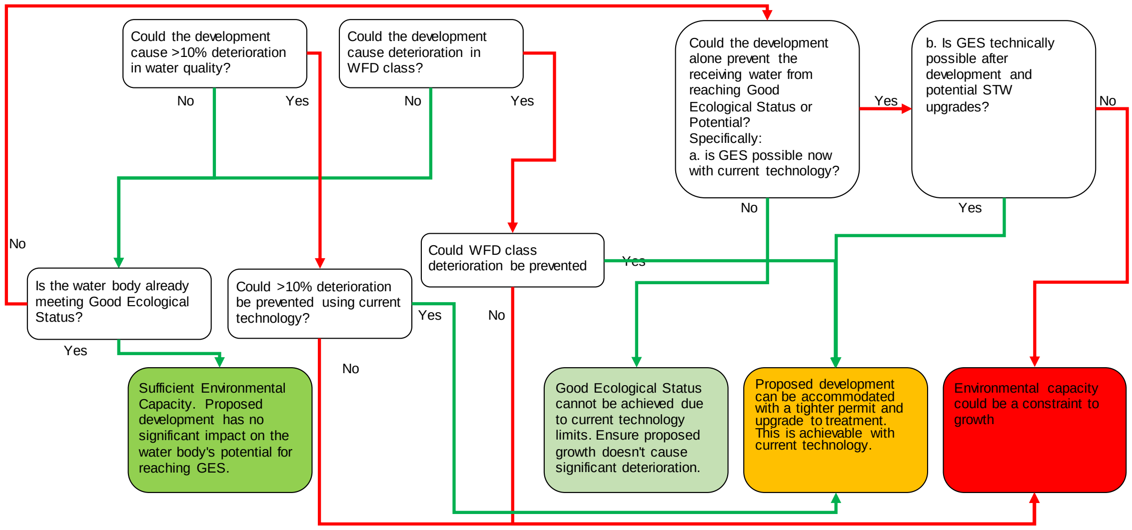
The study was required to assess the impact of increased effluent flows as a result of the proposed development in order to evaluate the impact of the increased pollutant load on the receiving watercourses. An increase in pollutant load being discharged from a WwTW has the potential to cause a deterioration in water quality and the EA set the following criteria to define significant deterioration, at which point a review of the EP may be triggered:

- A class deterioration. For example, if an increased load of ammonia from a WwTW led to a waterbody currently defined as "Moderate" ecological status dropping to "Poor" status.
- A deterioration of more than 10% in any determinand. For example, if the present day 95-percentile BOD downstream of a WwTW is 2.0mg/l, but as a result of an increased WwTW discharge this rose to 2.3mg/l, this would be a deterioration of 15%.
- Any deterioration of a waterbody classed as "Bad". Where a water body is currently of "Bad" ecological status (the lowest WFD status), then no further deterioration is permitted. In practice, deterioration should be limited in such cases to less than 3%.

Where increased discharged from a WwTW is predicted to lead to a failure in one or more of these targets, it is necessary to determine a possible future permit value which would prevent this from occurring.

A.4.6 Technically achievable limit (TAL) assessment

Where river target failures were predicted, the models were re-run to test whether treatment at the Technically Achievable Limit (previously referred to as "Best Available Technology" or BAT) could prevent deterioration and enable the receiving watercourse to meet the physico-chemical requirements to achieve Good Ecological Status or Potential. This assessment process has recently been set out in a guidance document by the Environment Agency's West Thames Area. Whilst this document has no national status, it provides a useful summary of how to interpret the results of the water quality assessment. This guidance is summarised in the flow chart below:



The EA advised the following technically achievable limits, and that these values should be used for modelling all WwTW potential capacity irrespective of the existing treatment technology and size of works:

- BOD (95%ile) = 5mg/l
- Ammonia (95%ile) = 1mg/l
- Phosphate (mean) = 0.25mg/l

Note that phosphate removal has been the subject of ongoing national trials investigating novel techniques and the optimisation of existing methods. The previous TAL of 0.5mg/l was therefore reduced to 0.25mg/l on the recommendation of the Environment Agency[8].

This assessment did not take into consideration the feasibility of upgrading each WwTW to such technology after constraints of costs, timing, space etc are applied.

A.4.7 River Quality Planning Tool

The Environment Agency's River Quality Planning (RQP) tool was the selected approach for this assessment in conjunction with the EA's recommended guidance documents[9,10]. The tool uses a Monte Carlo mass balance approach which allows the user to calculate permit values needed to achieve a particular river quality standard. The tool can also predict the discharge quality required to achieve a downstream water quality target.

The RQP tool was set up and run for the Rye Meads WwTW to determine the current impact of the works as well as the future impact.

8 Environment Agency (2017) PR19: New approaches for permitting phosphorus. Unpublished note.

9 Environment Agency (2014) H1 Annex D2. Assessment of sanitary and other pollutants within Surface Water Discharges. Accessed online at: https://www.gov.uk/government/publications/h1-annex-d2-assessment-of-sanitary-and-other-pollutants-in-surface-water-discharges on: 22/11/2017.

10 Environment Agency (2012) Water Quality Planning: no deterioration and the Water Framework Directive. Accessed online at: http://www.fwr.org/WQreg/Appendices/No_deterioration_and_the_WFD_50_12.pdf on: 22/11/2017

Where failure was predicted in any of the scenarios, and the upstream river quality did not achieve "good status" the model was re-run assuming that the upstream river had "good status". This allows the actual impact of the future effluent discharge to be assessed if upstream point and/or diffuse sources were to be resolved.

A.5 Impact of Climate Change

A.5.8 Background

The Thames River Basin Management Plan (RBMP) recognises that the climate is changing as a result of human activity, and that rising global temperatures are expected to lead to increased winter rainfall and more rain falling in intense storms. It acknowledges that the impacts on river flow, water quality and ecosystems are less clear, but that studies are underway to investigate these impacts. Potential risks which could adversely impact water quality include:

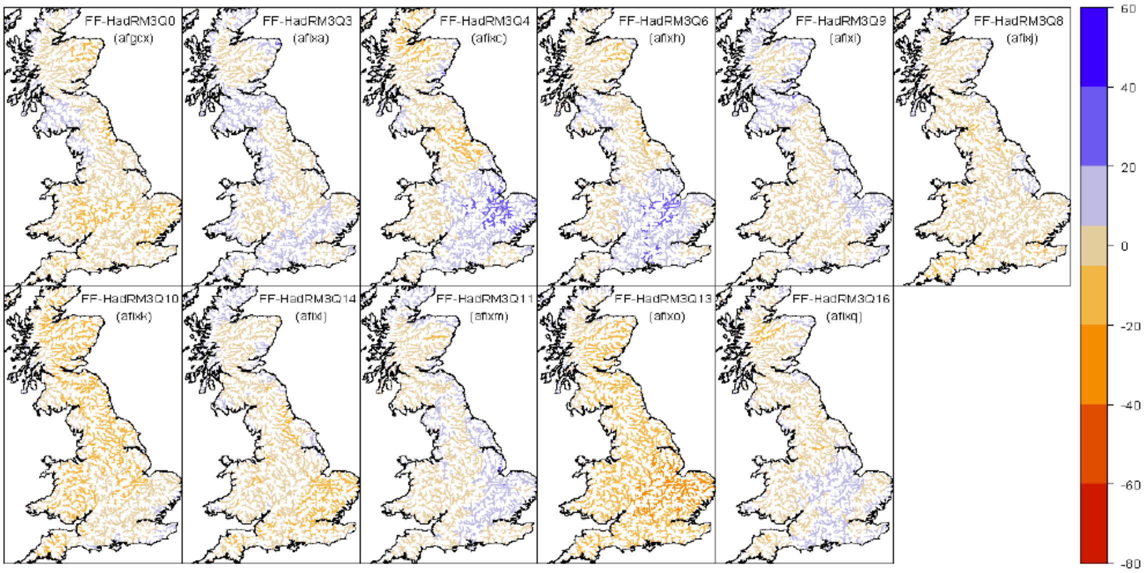
- lower summer river flows leading to reduced dilution of wastewater effluents, and
- increased river water temperatures, leading to reduced dissolved oxygen being available for fish.
- higher concentrations of faecal indicators.

The risk assessment forecast period used in the RBMP (2027), and the future scenario used in this WCS (to 2035, the end of the Local Plan period) are relatively near, and therefore the amount of environmental change as a result of climate change will be relatively limited compared to the longer-term scenarios considered in flood risk management (for example the SFRA considers climate impacts for the period 2070 to 2115). The RBMP has not considered summer flow and water temperatures in its risk assessment for 2027.

A.5.9 Developing a Climate Change Scenario

Analysis by CEH under the Future Flows project[11] considered changes to future river flow and groundwater levels. This work used an 11 member "ensemble" of Hadley climate model runs, using a medium emissions scenario of climate change gases. This was used to drive hydrological models to assess the impact on river flows up to 2098. The detailed model outputs are not licensed for commercial use and therefore could not be considered in this study. However, the project reports contain national maps showing the possible impacts on river flow for the 11 members. The examples below show the outputs for mean flow and the 95-percentile exceedance flow (Q95) for the 2050s. These are the flow statistics used to define upstream river flows used within RQP.

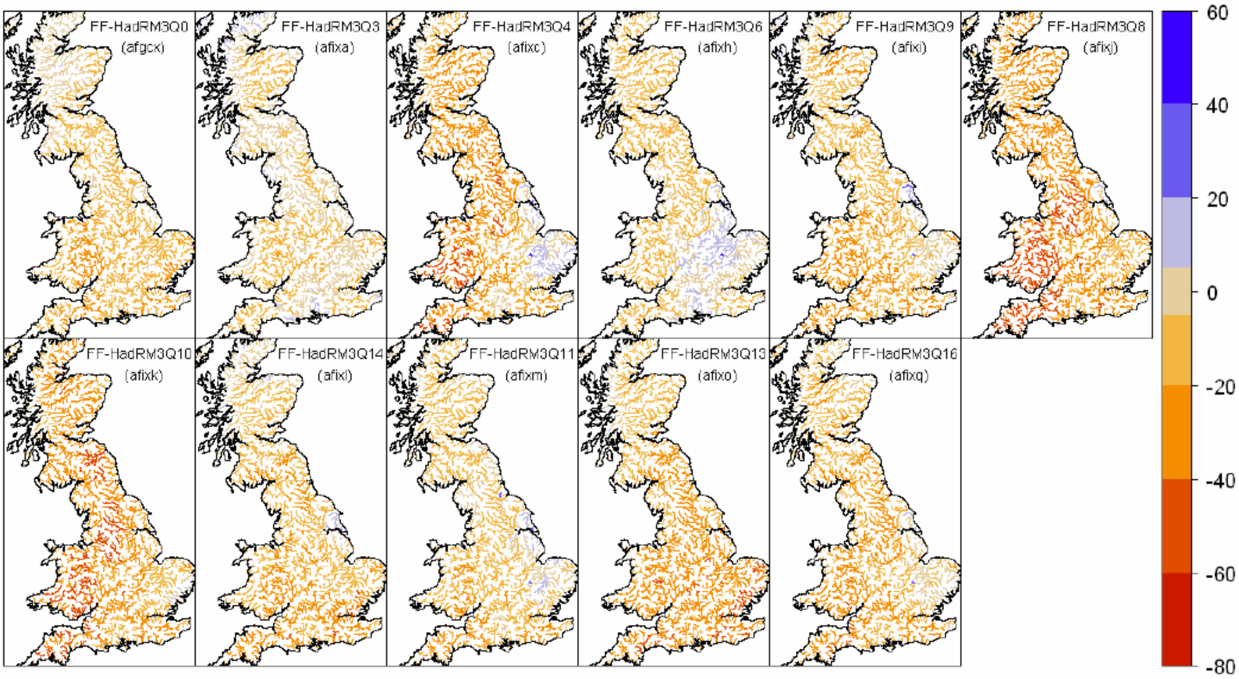
Figure A.16: Future flow assessment of the impact of climate change, mean flows, 2050s



11 CEH (2012) Future flows and groundwater levels SC090016. Final Technical Report. Accessed online at http://webarchive.nationalarchives.gov.uk/20130301204241/http://www.ceh.ac.uk//sci_programmes/Water/Future%20Flows/FFGWLReportsandPublications.html on 11/01/2018

Mean annual flows in the study area are predicted to slightly increase in 5 members, remain stable in four and to decrease in two.

Figure A.17: Future flow assessment of the impact of climate change, Q95 flows, 2050s



The Q95 flow is predicted to increase in the study area in all but two members.

The results, which only represent one future emissions scenario, illustrate the significant levels of uncertainty around the impacts of climate change on river flows in the study area. In order that an assessment of possible climate impacts on water quality was made, it was decided to simulate one alternative future scenario, with planned growth to 2036 and with a 10% reduction in mean river flow and 20% reduction in Q95 flow on a sample of WwTWs.

A.6 Results - Impact of growth

Tables showing the data used in the RQP assessment, the detailed results, and map showing the location and water quality sampling points can be found in Annex A to this report. Table A.3 below summarises the outcomes of each assessment. Deterioration in Ammonia was predicted to be greater than 10%, and the analysis showed that this could not be completely prevented with treatment at TAL. However, the permit level required to prevent deterioration was 0.96 mg/l compared with a TAL of 1mg/l so it may be possible to keep deterioration to an insigificant level.

An additional analysis was carried out to assess the point in the growth scenario where deterioration could no longer be prevented, i.e. when the required discharge quality exceeded the technically achievable limit. This was found to be during the early part of AMP8 (2030-2035).

Table A.3 Outcome of RQP assessment for Rye Meads WwTW

Watercourse (WwTW)	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	No infrastructure upgrade required to achieve		No infrastructure upgrade required to achieve
	Infrastructure upgrade likely to be required, but achievable with treatment at TAL		Infrastructure upgrade likely to be required, but achievable with treatment at TAL, or not achievable due to current technology limits.
	Cannot be achieved with treatment at TAL. Environmental capacity could be a constraint on growth.		Cannot be achieved with treatment at TAL. Environmental capacity could be a constraint on growth.
Rye Meads	Cannot be achieved with treatment at TAL. Environmental capacity could be a constraint on growth.	No class deterioration is predicted.	Good Ecological Status cannot be achieved for P due to current technology limits. The proposed growth should not prevent the waterbody achieving moderate status for P in the future. Ensure proposed growth doesn't cause significant deterioration.

A.7 Results - Impact of climate change

The impact of climate change was assessed by repeating the RQP analysis using reduced upstream river flows on a selection of treatment works. The results are summarised in Table A.4 and Table A.5 below.

Table A.4 Climate change impact on "No deterioration" assessment

		WFD Deterioration Assessment				
		Present day flows			Climate change scenario	
WwTW	Determinand	Baseline Conc.	Future Conc.	% Deterioration	Future Conc.	% Deterioration
Rye Meads	BOD	2.16	2.17	**0%**	2.21	**2%**
	Ammonia	0.19	0.21	**11%**	0.24	**26%**
	Phosphate	0.25	0.27	**8%**	0.29	**16%**

Table A.5 Climate change impact on GES assessment

		Effluent Quality Required for GES					
			Present day flows		Achievable with treatment at TAL?	Climate change scenario	Achievable with treatment at TAL?
WwTW	Determinand	GES Target	Present	Future			
Rye Meads	BOD	Achieves target	N/A	N/A	N/A	N/A	N/A
	Ammonia	Achieves target	N/A	N/A	N/A	N/A	N/A
	Phosphate	0.093	0.18	0.16	No	0.15	No

Climate change was predicted to lead to a deterioration in water quality for all determinands. For BOD this is unlikely to change the conclusions of the RQP assessment. In the case of phosphate, this may lead to a deterioration of 16%, but this could be prevented with treatment at TAL. In the case of ammonia, the deterioration is predicted to be 26%, and deterioration could not be prevented with treatment at TAL. No class deterioration is predicted, ammonia remains at "High" status.

As the deterioration in ammonia cannot be prevented by treatment at TAL, further measures may need to be considered to mitigate the impact of climate change such as a catchment-based approach to managing water quality in the River Lee catchment. For example, reducing the volume of runoff from agricultural land (in particular from the high proportion of arable farmland in the catchment) could help to reduce the concentration of ammonia from fertilizers reaching the River Lee.

A.8 Results - Initial feedback from Environment Agency

The EA responded to a draft of this document with a number of comments on the methodology, and advised that low river flows had been observed recently which should be taken into account[12]. The latest data available from the National River Flow Archive was used in this study, and more recent data covering the last 2 years is not yet available. A teleconference with the Environment Agency was held on 18 May 2018, during which the water quality analysis was discussed and a methdology was agreed[13].

The analysis was repeated using the lowest annual mean flow from the previous 30 years (1986 and 2016). This provided a mean river flow of 140Ml/d compared to 486Ml/d (the mean of 2014 to 2016) increasing the baseline concentration of all determinands. The result was a minor increase in the percentage deterioration of BOD post growth to 1%, and P to 5%, but a decrease in the percentage deterioration in NH_4 from 11 to 5%. No class deterioration was predicted.

As this additonal analysis did not not significantly change the conclusions (excepting Ammonia, the result had improved) the original analysis was retained.

12 K. Murphy. Email Correspondence: Harlow Council Water Cycle Study - EA draft comments. 3 May 2018.

13 Teleconference held at 15:00 on 18 May 208. Present: S. Spinks (Environmnet Agency); R. Pardoe, P. Eccleston, F. Hartland (JBA Consulting)

A.9 Conclusions

- Proposed growth in the Harlow-Gilston Garden Town study area is predicted to lead to a deterioration of 11% in Ammonia at Rye Meads WwTW. This cannot be completely prevented with treatment at TAL, but could be reduced to close to zero.
- BOD and Phosphate are predicted to deteriorate by less than 10%.
- WFD "High" ecological status is already being achieved by the receiving water body for the determinands BOD and Ammonia. This is unlikely to be affected by the proposed growth.
- Good ecological status for the determinand Phosphate cannot be achieved due to current technology limits. The proposed growth is unlikely to prevent the waterbody achieving "Moderate" status for this determinand in the future.
- Climate change during the plan period could lead to deterioration of the water quality as a result of decreased river flows and hence less dilution. This is not, however, sufficient to lead to a class deterioration for any determinand, but the deterioration in ammonia and phosphate is predicted to be greater than 10%. In the case of ammonia this could not be prevented with treatment at TAL.
- Using a reduced river flow to reflect recent low flows does not significantly change the results.