Norwich Western Link

Environmental Statement

Chapter 10: Biodiversity

Appendix 10.34 – Air Quality Ecological Impact Assessment

Sub Appendix B: River Wensum Nutrient Analysis

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Glossary of Abbreviations and Defined Terms

Term	Definition
APIS	UK Air Pollution Information System
Autotroph	An organism capable of producing its own food from inorganic materials.
DCO	Development Consent Order
EA	Environment Agency
N	Nitrogen
NH_4-N	Ammonium concentration as N
NO_2-N	Nitrite concentration as N
NO_3-N	Nitrite concentration as N
P	Phosphorus
PO_4-P	Orthophosphate concentration as P
SAC	Special Area of Conservation
SSSI	Site of Special Scientific Interest
TIN-N	Total Inorganic Nitrogen as N
TON-N	Total Oxidised Nitrogen as N

1 Introduction

1.1 Overview of the scheme

1.1.1 The Proposed Scheme is a highway scheme linking the A1270 Broadland Northway from its junction with the A1067 Fakenham Road to the A47 trunk road near Honingham. The Proposed Scheme will comprise the following listed below:

- A dualling upgrade of the A1067 Fakenham Road westwards from its existing junction with the A1270 to a new roundabout located approximately 400m to the north-west;
- Construction of a new roundabout; and
- Construction of a dual carriageway link from the new roundabout to a new junction with the A47 near Honingham.

1.1.2 As part of a separate planned scheme, National Highways are promoting a scheme to upgrade the A47 from the existing roundabout at Easton to join the existing dual carriageway section at North Tuddenham ('A47 DCO'). The A47 DCO received planning approval to proceed in August 2022, and it is expected that National Highways would construct the Honingham junction, and the Proposed Scheme would connect to the north-eastern side of that junction.

1.1.3 The Proposed Scheme would cross the River Wensum and its floodplain by a viaduct bridge and would also cross four minor roads by overpass or underpass bridges. The Proposed Scheme would also include works for cyclists and walkers, including necessary changes of the local road network and allowing for environmental improvement measures.

1.2 Purpose of the technical note

1.2.1 The **Chapter 10: Biodiversity Appendix 10.34 Air Quality Ecological Impact Assessment** (Document Reference: 3.10.34) identified potential effects of air quality changes at the River Wensum Special Area of Conservation (SAC) and River Wensum Site of Special Scientific Interest (SSSI) resulting from the operation of the Proposed Scheme. The Air Quality Assessment also identified significant changes in nitrogen deposition, ammonia, and nitrous oxides as a result of the Proposed Scheme.

1.2.2 Lowland rivers such as the River Wensum are typically nutrient poor, with the availability of phosphorus (rather than nitrogen) within the ecosystem limiting the growth of *Ranunculion fluitantis* and *Callitricho-Batrachion* vegetation as well as other macrophyte species and algae. Phosphorus is not released by vehicle exhausts and therefore would not contribute to current phosphorus levels within the River Wensum. However, given the current agricultural use surrounding the River Wensum, there is a possibility that phosphorus may not be a limiting factor to impacts arising from increasing nitrogen levels as a result of the Proposed Scheme. It should be noted however that the River Wensum SAC is subject to Natural England's nutrient neutrality requirement which focuses on phosphorus (P) only.

1.2.3 This technical note will determine whether deposition impacts are likely to cause adverse impacts on the integrity and key characteristics of the River Wensum SAC / SSSI.

1.2.4 We have included a summary of key information shown in this document in an accessible format. However, some users may not be able to access all technical details. If you require this document in a more accessible format please contact norwichwesternlink@norfolk.gov.uk

2 Methodology

2.1 Site-specific assessment

2.1.1 The UK Air Pollution Information System (APIS) provides guidance on how to assess whether a river is phosphorus (P), or nitrogen (N) limited. More details about this guidance can be found on APIS Website (**Ref 1**). This requires the calculation of the N:P ratio, for which a molar ratio of around 16:1 (7:1 weight ratio) being the threshold between N- and P- limitation.

2.1.2 The weight ratio will be used in this study, which will be calculated using the total inorganic nitrogen as N (TIN-N) and orthophosphate, reactive as P (PO_4-P) concentrations in milligrams per litres (mg/l). Orthophosphate was used over total inorganic phosphate, orthophosphate being the only form that autotrophs can assimilate. TIN-N concentrations were calculated using the equations below, based on data availability. The equations below are to be used in this order of preference.

$$TIN - N = Total\ oxidised\ nitrogen\ as\ N\ (TON - N) + Ammonium\ as\ N\ (NH4 - N) \quad (1)$$

$$TIN - N = Nitrate\ as\ N\ (NO3 - N) + Nitrite\ as\ N\ (NO2 - N) + Ammonium\ as\ N\ (NH4 - N) \quad (2)$$

2.2 Water quality data

2.2.1 Data from three EA monitoring sites were abstracted from the Environment Agency's (EA) water quality data archive (**Table 2.1**). The EA water quality data archive can be accessed on the UK Government Water Quality Website (**Ref 2**). The geospatial locations of the EA monitoring sites for which the assessment was conducted are illustrated in **Figure 2.1**. The distance between Site 1 and Site 4 is about seven kilometres.

2.2.2 As shown in **Figure 2.1**, three monitoring sites (Site 1, 2 and 3 as per Table 1) were identified for a site-specific assessment upstream of the crossing, Site 1 being the only site with sufficient and recent data. Site 4 was the only site

downstream of the crossing with sufficient and recent data for which the site-specific assessment was carried out. The site-specific assessment was conducted on Sites 2 and 3 for the period for which data are available and compared to the site-specific assessment for Site 1 and 4 to understand if similar trends were observed over the same period.

Table 2.1 EA Monitoring sites information (information obtained from Ref 2)

Number	Monitoring point	Grid reference	Data availabilities	Web link
1	River Wensum Great Witchingham Bridge	TG1073518724	January 2013 to May 2023 (Weekly sampling apart in 2020)	River Wensum Great Witchingham Bridge - Water quality
2	Old Rail Br. Alderford	TG1220017800	February 2013 to February 2020 (3 to 4 times a year	Old Rail Br. Alderford - Water quality
3	River Wensum D/S Attlebridge	TG1291816355	Monthly sampling between January 2021 and June 2021	River Wensum D/S Attlebridge - Water quality
4	River Wensum Taverham bridge	TG1600013649	January 2013 to May 2023 (3 to 5 times a year, ten times in 2019)	River Wensum Taverham bridge - Water quality

Figure 2.1 Geospatial of EA monitoring points compared to the location where the scheme crosses the River Wensum

3 Site specific assessment

3.1 Site 1: River Wensum at Great Witchingham Bridge

3.1.1 Inorganic nitrogen species and orthophosphate concentration trends for the period between 2013 and 2023 are illustrated in **Table 3.1**, **Table 3.2**, **Figure 3.1,** and **Figure 3.2**. N:P ratio trends are illustrated in **Table 3.1**, **Table 3.2,** and **Figure 3.3**.

3.1.2 It has to be noted that the concentration for ammoniacal nitrogen as N was used as a surrogate for the concentration of ammonium as N; the dataset analysed did not include data for the concentration of ammonium. The concentration of ammoniacal nitrogen as N is the sum of the concentration as N of ammonia and ammonium. The dataset didn't provide a consistent monitoring of ammonia as N as represented in **Figure 3.1**, which didn't allow derivation of the concentration of ammonium as N for all ammoniacal nitrogen data points. Furthermore, 64.6% of the results for ammonia as N were below the limit of detection. When concentration of ammonia was above the limit of detection, ammonia as N concentration constitutes 2 to 4 % of the ammoniacal nitrogen as N.

3.1.3 Seasonal variation is observed with higher level of TIN-N between December and March (the average for this period varies between 7 and 7.5 mg/l over 10 years) and lower level between July and September (the average for this period varies between 5 and 5.21 mg/l over 10 years). The seasonal variation and levels of concentration observed for all inorganic nitrogen species remain consistent over the last 10 years. It has to be noted that NO_3-N concentration constitutes on all data points more than 98.9% of TON-N concentration and 95% of TIN-N.

3.1.4 Seasonal variations were observed with higher levels of PO_4-P between June and January (the average for this period varies between 0.065 and 0.071 mg/l over 10 years) and lower between February and May (the average for this period varies between 0.028 and 0.045 mg/l over 10 years). The seasonal variation and levels of concentration observed for orthophosphate remain consistent over the last 10 years.

3.1.5 Consequently, lower N:P ratios are observed between June and October when lower TIN-N concentrations and higher PO_4-P concentrations are observed. Nevertheless, the N:P ratio remain above the 7:1 ratio, with a minimum ratio of 33.4:1. In conclusion, this indicates that the River Wensum at Great Witchingham Bridge is P-limited.

Table 3.1 Minimum, average and maximum concentration for parameter of interest between 2013 and 2023

Parameters	Units	Minimum	Average	Maximum
Orthophosphate, reactive as P	mg/l	0.010	0.058	0.168
Ammoniacal nitrogen as N	mg/l	0.030	0.039	1.30
Nitrogen, Total Oxidised as N	mg/l	3.47	6.14	8.70
Total Inorganic nitrogen as N	mg/l	3.52	6.18	8.74
Ratio N:P	Not applicable	33.4:1	130:1	626:1

Table 3.2 Average concentration in mg/l as a function of the month for the period 2013-2023

Parameters	TIN-N (mg/l)	PO4-P (mg/l)	N:P Ratio
January	7.441	0.066	116.9
February	7.317	0.052	148.2
March	7.053	0.041	180.8
April	6.610	0.027	295.6
May	5.945	0.045	176.5
June	5.458	0.071	80.4
July	5.010	0.070	75.3
August	4.827	0.065	76.1
September	5.219	0.070	78.6
October	5.661	0.070	84.4
November	6.422	0.066	100.6
December	7.141	0.065	113.2

Figure 3.1 Concentration of inorganic nitrogen species in the River Wensum at Witchingham bridge

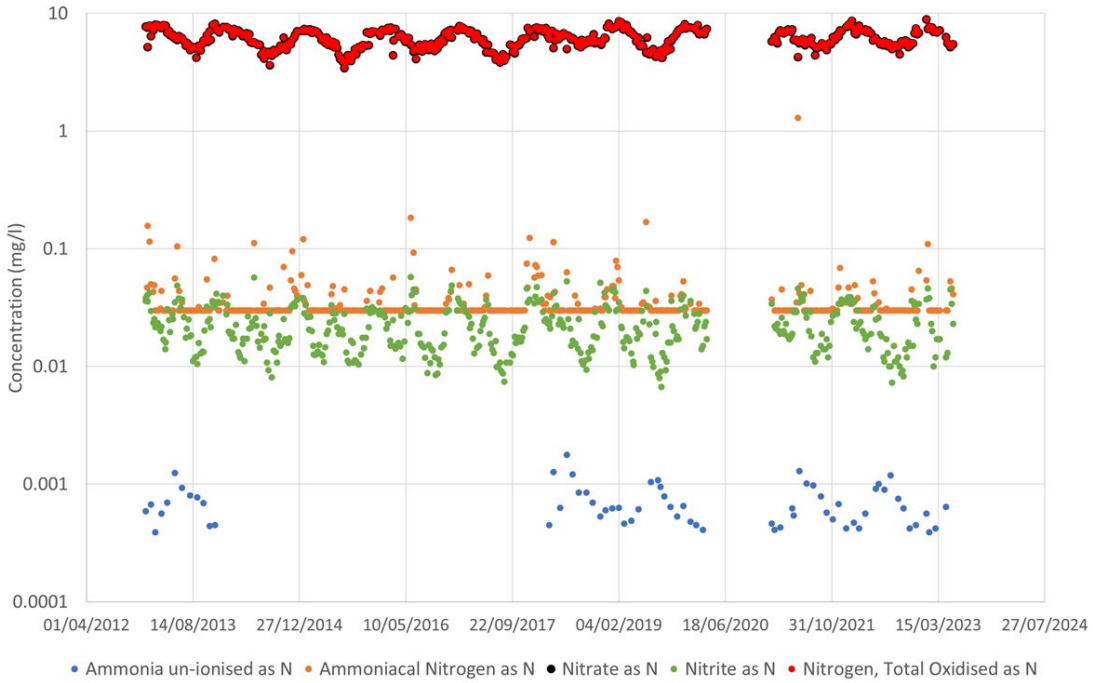


Figure 3.2 Concentration of orthophosphate in the River Wensum at Witchingham bridge

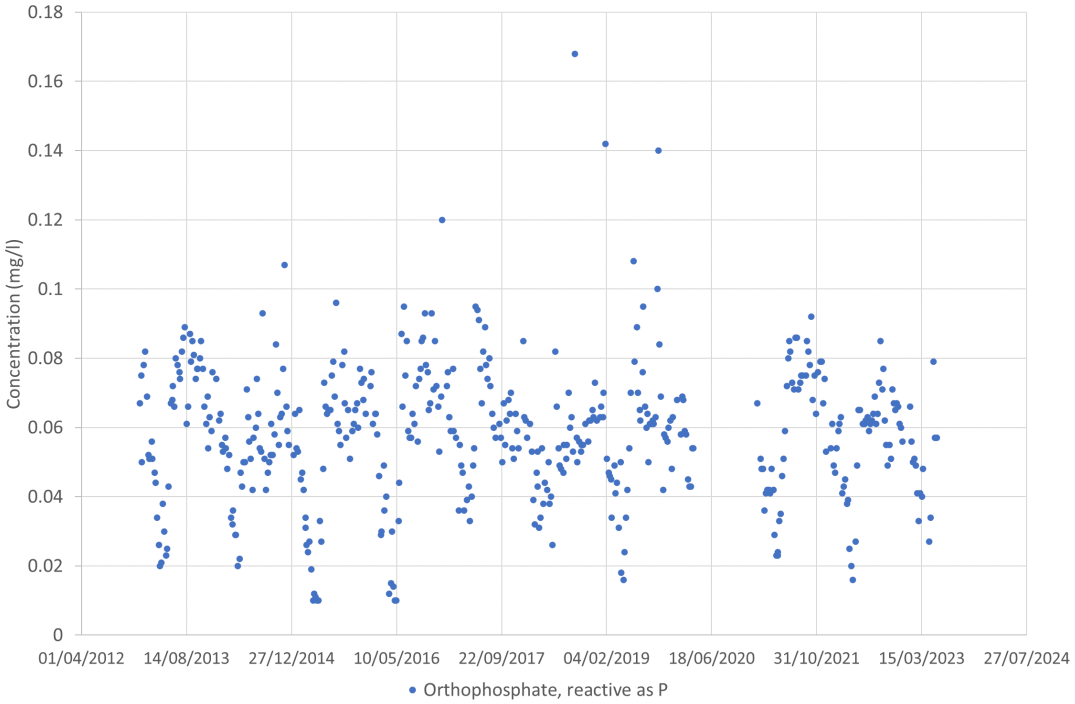
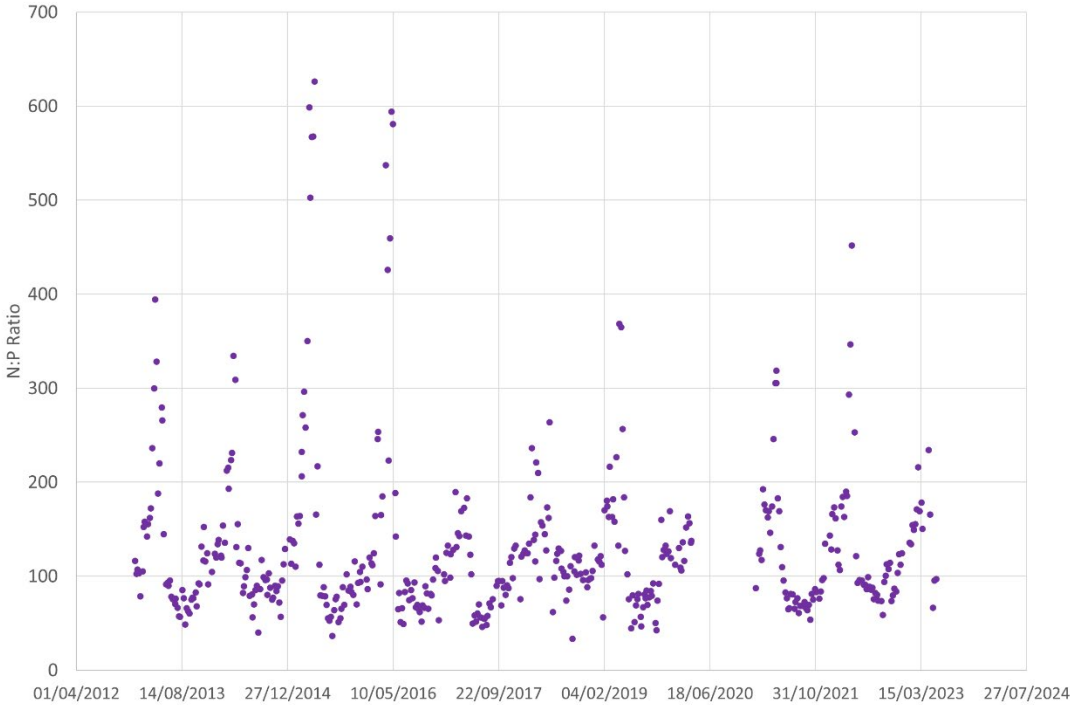


Figure 3.3 N:P ratio for the River Wensum at Witchingham bridge



3.2 Site 2: River Wensum at Old Rail Br. Alderford

3.2.1 Inorganic nitrogen species and orthophosphate concentration trends for the period between 2013 and 2020 are illustrated in **Table 3.3**, **Table 3.4**, **Figure 3.4,** and **Figure 3.5**. N:P ratio trends are illustrated in **Table 3.3**, **Table 3.4,** and **Figure 3.6**.

3.2.2 As per Site 1, ammoniacal nitrogen as N was used as a surrogate for the concentration of ammonium as N for approach consistency; the dataset analysed did not include data for the concentration of ammonium. When concentration of ammonia was above the limit of detection, ammonia as N concentration constitutes 1 to 4 % of the ammoniacal nitrogen as N.

3.2.3 Seasonal variation is observed with higher levels of TIN-N between January and March (the average for this period varies between 6.06 and 6.63 mg/l over 7 years) and lower level between May and June and September and October (the average for this period varies between 4.80 and 5.34 mg/l over 7 years). The seasonal variation and levels of concentration observed for all inorganic nitrogen species remain consistent over the 7 years. It has to be noted that NO_3-N concentration constitutes, over all data points, more than 99.2% of TON-N concentration and 98.0% of TIN-N.

3.2.4 Seasonal variation is observed with higher levels of PO_4-P between June and October, and January (the average for this period varies between 0.043 and 0.068 mg/l over 7 years) and lower between February and May (and November) (the average for this period varies between 0.023 and 0.035 mg/l over 7 years). However the concentration seems to differ from one year to another with higher concentrations observed from 2017. It should be kept in mind that those concentrations are minimal, the yearly average varying from 0.036 to 0.057 mg/l between 2013 and 2019.

3.2.5 Consequently, lower N:P ratios are observed between June and October when lower TIN-N concentrations and higher PO_4-P concentrations are observed. Nevertheless, the N:P ratio remain above the 7:1 ratio, with a minimum ratio of 51.5:1. In conclusion, this indicates that the River Wensum at Old Rail Br Alderford is P-limited.

Table 3.3 Minimum, average and maximum concentration for parameter of interest between 2013 and 2020

Parameters	Units	Minimum	Average	Maximum
Orthophosphate, reactive as P	mg/l	0.018	0.043	0.088
Ammoniacal nitrogen as N	mg/l	0.030	0.042	0.092
Nitrogen, Total Oxidised as N	mg/l	4.22	5.57	7.27
Total Inorganic nitrogen as N	mg/l	4.26	5.61	7.34
Ratio N:P	Not applicable	51.5:1	154:1	333:1

Table 3.4 Average concentration in mg/l as a function of the month for the period 2013-2020

Parameters	TIN-N (mg/l)	PO4-P (mg/l)	N:P Ratio
January	6.637	0.053	133
February	6.368	0.035	205
March	6.063	0.023	276
April	5.775	0.031	215
May	5.118	0.033	166
June	4.932	0.064	94
July	5.747	0.054	106
August	5.938	0.068	87
September	5.157	0.049	107
October	5.335	0.043	126
November	4.797	0.032	153

Figure 3.4 Concentration of inorganic nitrogen species in the River Wensum at Old Rail Br. Alderford

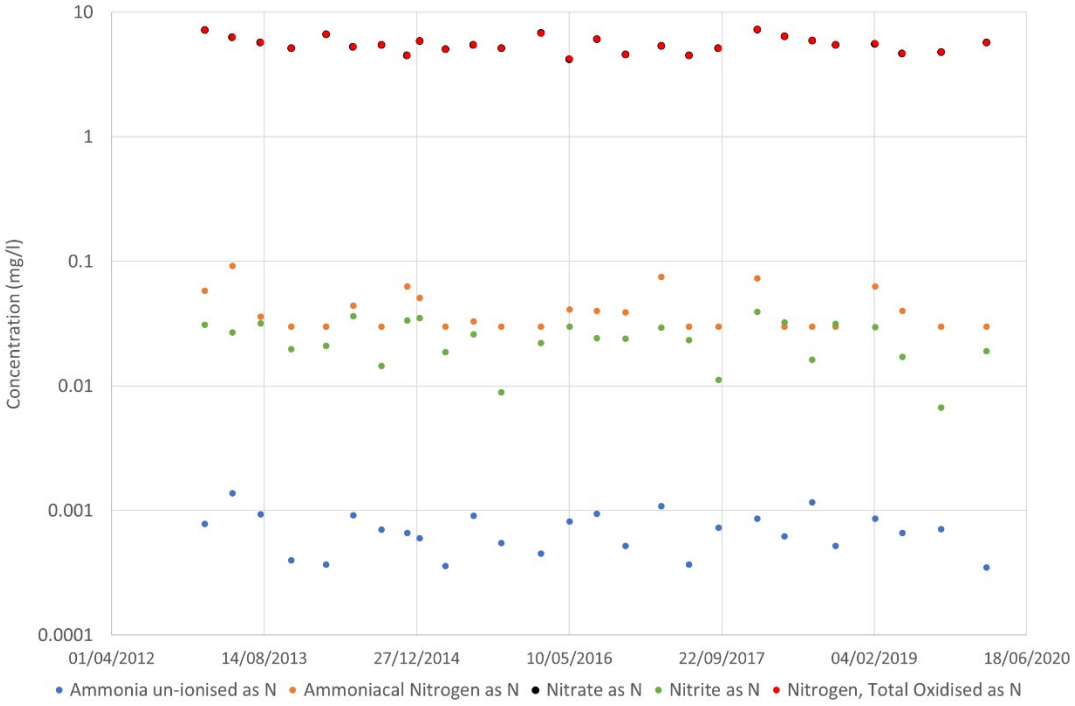


Figure 3.5 Concentration of orthophosphate in the River Wensum at Old Rail Br. Alderford

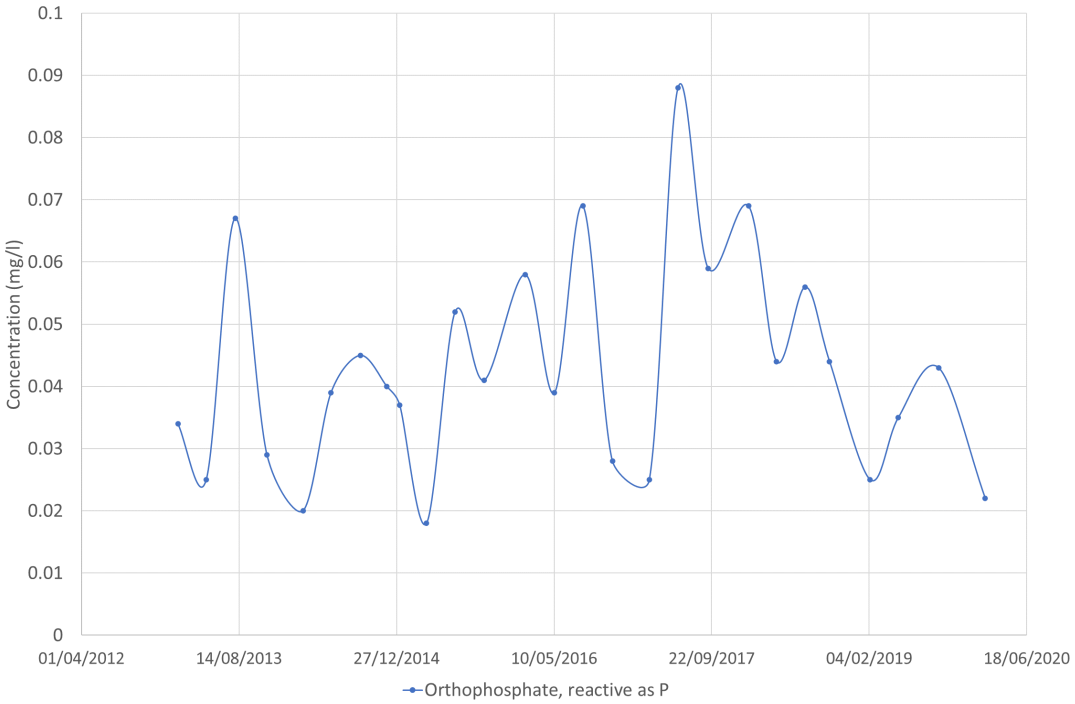
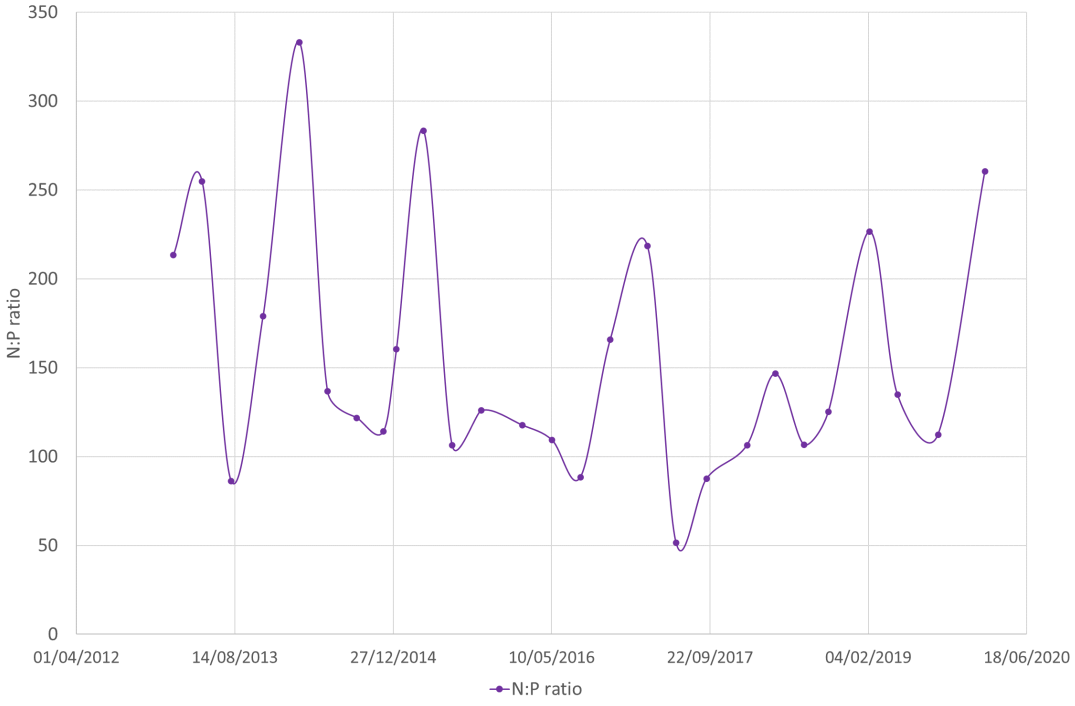


Figure 3.6 N:P ratio for the River Wensum at Old Rail Br. Alderford



3.3 Site 3: River Wensum D/S Attlebridge

3.3.1 Inorganic nitrogen species concentrations, orthophosphate concentrations and N:P ratio trends for the period between January 2021 and June 2021 are illustrated in **Table 3.5** and **Table 3.6**.

3.3.2 As per Site 1, ammoniacal nitrogen as N was used as a surrogate for the concentration of ammonium as N for approach consistency; the dataset analysed did not include data for the concentration of ammonium. When concentration of ammonia was above the limit of detection, ammonia as N concentration constitutes 1.4% to 3.2 % of the ammoniacal nitrogen as N. Due to the small amount of data available (six data points), seasonal variation graphs were not produced.

3.3.3 TIN-N concentrations were higher between February and May. Seasonal variation is observed with higher levels of TIN-N between December and March (6.21 to 6.92 mg/l) and lower in January and June, (respectively 5.26 and 5.63 mg/l). In contrast, PO_4-P concentrations were higher in January, both at 0.05 mg/l and lower between February and May (0.02 to 0.04 mg/l). As per previous sites, NO_3-N concentration constitutes the largest proportion of TON-N (>99.2%) and TIN-N (>98.0%).

3.3.4 Consequently, lower N:P ratios are observed in January and June when lower TIN-N concentrations and higher PO4-P concentrations are observed. Nevertheless, the N:P ratio remains above the 7:1 ratio, with a minimum ratio of 97.4:1. In conclusion, this indicates that the River Wensum downstream of Attlebridge is P-limited.

Table 3.5 Minimum, average and maximum concentration for parameter of interest between January and June 2021

Parameters	Units	Minimum	Average	Maximum
Orthophosphate, reactive as P	mg/l	0.019	0.037	0.054
Ammoniacal nitrogen	mg/l	0.001	0.034	0.064
Nitrogen, Total Oxidised as N	mg/l	5.200	6.117	6.900
Total Inorganic nitrogen as N	mg/l	5.264	6.151	6.917
Ratio N:P	Not applicable	97.4:1	201:1	334:1

Table 3.6 Average concentration in mg/l as a function of the month in 2021

Parameters	TIN-N (mg/l)	PO4-P (mg/l)	N:P Ratio
January	5.264	0.054	97.5
February	6.206	0.032	193.9
March	6.537	0.04	163.4
April	6.917	0.022	314.4
May	6.353	0.019	334.4
June	5.629	0.054	104.2

3.4 Site 4: River Wensum at Taverham Bridge

3.4.1 Inorganic nitrogen species and orthophosphate concentration trends for the period between 2013 and 2023 are illustrated in **Table 3.3**, **Table 3.8**, **Figure 3.7,** and **Figure 3.8**. N:P ratio trends are illustrated in **Table 3.7**, **Table 3.8,** and **Figure 3.9**.

3.4.2 As per Site 1, ammoniacal nitrogen as N was used as a surrogate for the concentration of ammonium as N for approach consistency; the dataset analysed did not include data for the concentration of ammonium. When concentration of ammonia was above the limit of detection, ammonia as N concentration constitutes 1 to 4 % of the ammoniacal nitrogen as N.

3.4.3 Seasonal variation is observed with higher levels of TIN-N between December and March (the average for this period varies between 7.11 and 7.43 mg/l over 10 years) and lower levels between July and September (the average for this period varies between 4.58 and 4.96 mg/l over 10 years). The seasonal variation and levels of concentration observed for all inorganic nitrogen species remain consistent over the last 10 years. It has to be noted that NO_3-N concentration constitutes on all data points more than 99% of TON-N concentration and 97% of TIN-N.

3.4.4 Seasonal variation was observed with levels of PO_4-P higher between June and February (the average for this period varies between 0.054 and 0.101 mg/l over 10 years) and lower between March and May (the average for this period varies between 0.023 and 0.043 mg/l over 10 years). The seasonal variation and levels of concentration observed for orthophosphate remain consistent over the last 10 years.

3.4.5 Consequently, lower N:P ratios are observed between June and October when lower TIN-N concentrations and higher PO_4-P concentrations are observed. Nevertheless, the N:P ratio remains above the 7:1 ratio, with a minimum ratio of 17:1. In conclusion, this indicates that the River Wensum at Taversham Bridge is P-limited.

Table 3.7 Minimum, average and maximum concentration for parameter of interest between 2013 and 2023

Parameters	Units	Minimum	Average	Maximum
Orthophosphate, reactive as P	mg/l	0.010	0.056	0.240
Ammoniacal nitrogen	mg/l	0.030	0.036	0.128
Nitrogen, Total Oxidised as N	mg/l	4.10	6.08	7.71
Total Inorganic nitrogen as N	mg/l	4.13	6.12	7.74
Ratio N:P	n/a	17.2:1	151:1	590:1

Table 3.8 Average concentration in mg/l as a function of the month for the period 2013-2023

Parameters	TIN-N (mg/l)	PO4-P (mg/l)	N:P Ratio
January	7.429	0.067	110.9
February	7.189	0.054	136.1
March	7.198	0.043	178.6
April	6.662	0.025	302.1
May	6.240	0.023	375.5
June	5.816	0.067	92.1
July	4.537	0.062	76.2
August	4.658	0.101	71.8
September	4.960	0.066	75.9
October	5.488	0.063	96.8
November	5.895	0.059	101.9
December	7.114	0.054	132.2

Figure 3.7 Concentration of inorganic nitrogen species in the River Wensum at Taverham bridge

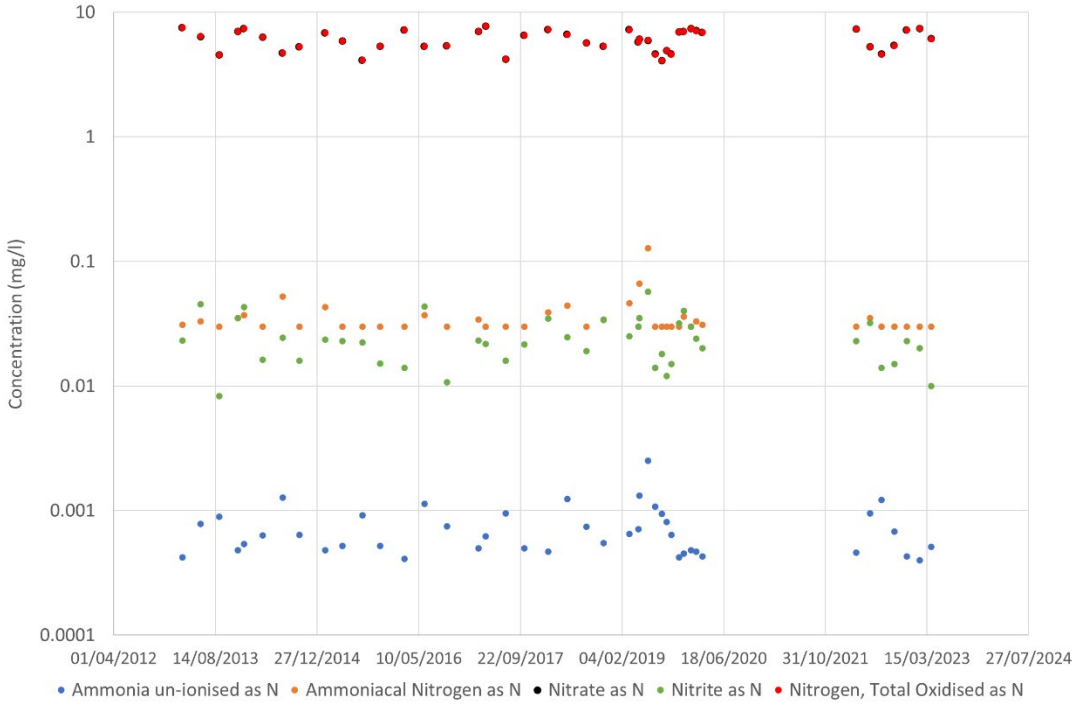


Figure 3.8 Concentration of orthophosphate in the River Wensum at Taverham Bridge

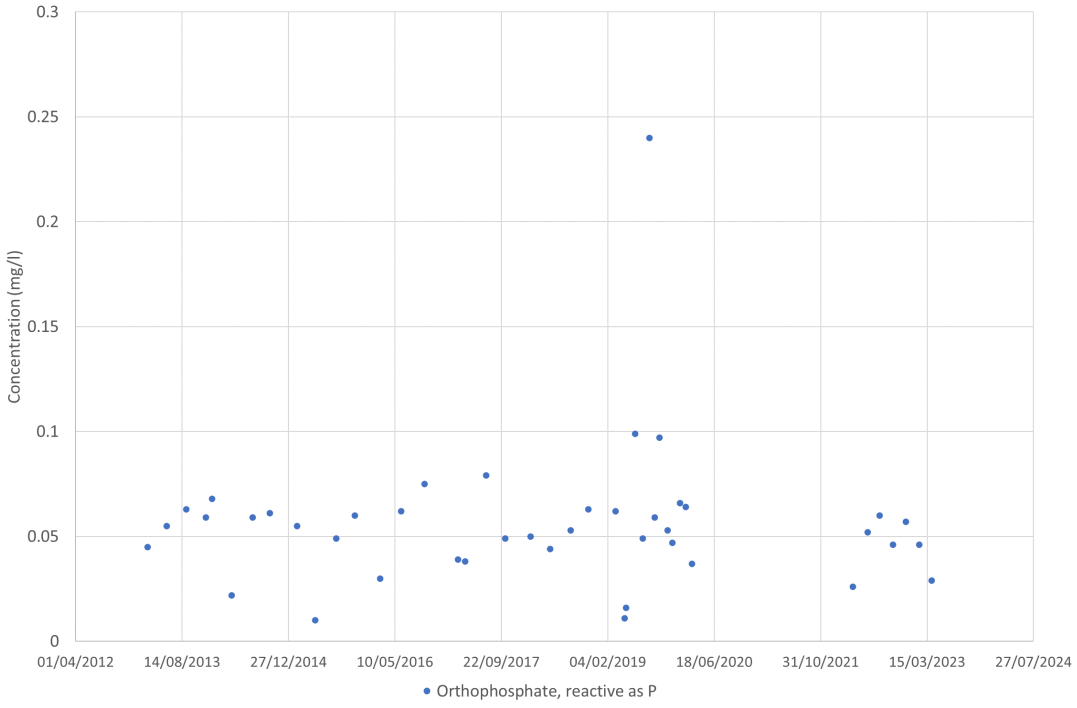
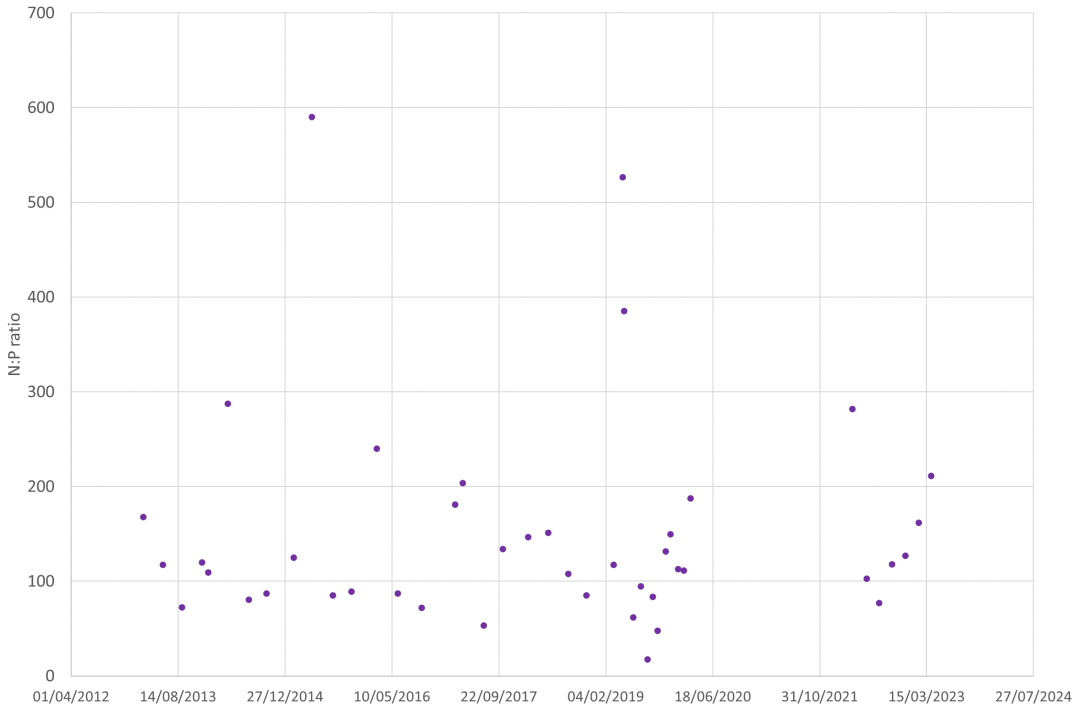


Figure 3.9 N:P ratio for the River Wensum at Taverham Bridge



4 Conclusion

4.1.1 This study determined the N:P ratio for each of the assessed sites. Findings are summarised below:

- The N:P ratio remains above the 7:1 ratio at all times between Site 1 and Site 4, indicating that the River Wensum is P-limited between Witchingham bridge and Taverham bridge. As such any increase in inorganic nitrogen associated with the Proposed Scheme should not have an impact on macrophytes and algae populations.
- Seasonal variations were observed with lower N:P ratios observed between June and October.

5 References

Ref 1 Foy et al. (no date) Nitrogen deposition :: Rivers and streams, Nitrogen deposition : Rivers and Streams | Air Pollution Information System. (Accessed: June 2023).

Ref 2 *Water Quality Data Archive* (no date) *Open WIMS data.* (Accessed: June 2023).