HOLME-NEXT-THE-SEA

NEIGHBOURHOOD PLAN 2016-2036

HUN WATER QUALITY: INTERIM RESULTS JUNE – AUGUST, 2017

Evidence Base: Research Report 3, Water Quality

25 August 2016

Hun water quality: Interim report

1.0 BACKGROUND AND SUMMARY OF FINDINGS

1.0.1 Holme-next-the-Sea lies entirely within the North Norfolk Coast AONB and more than 40 per-cent of the Parish is covered by Protected Sites. At the heart of these sites lies the River Hun, one of a small number of rare chalk streams which should provide a unique habitat for wildlife.

1.0.2 The Hun rises in springs to the south-east of Hunstanton and flows north and then eastwards through Holme Dunes National Nature Reserve to reach the sea via a sluice at Thornham Sea Bank. The lower reaches pass through an area of international importance for nature conservation with Ramsar, SAC, SPA and SSSI designations.

1.0.3 By virtue of the habitat which they provide these sites represent a vital hub in the Natura 2000 international network for conservation of migrating birds. In addition they have become an AONB hot spot for visitors looking to experience the unspoiled landscapes and wildlife they support.

1.0.4 The ecosystem services these sites provide are the main pillar of the local economy and both local people and visitors place enormous value on these parish assets. They are however coming under increasing pressure from growth in visitor numbers, associated car traffic and increases in county-wide development.

1.0.5 In response to a questionnaire survey carried out in 2016 in conjunction with work on Holme's Neighbourhood Development Plan (NDP), more than 80% of respondents expressed concern over damage to the local environment from inappropriate development. 85% of respondents supported positive environmental management to improve habitats and the Parish environment

1.0.6 In response to this questionnaire survey and partly in response to reports of pollution and declining observations of wildlife in The Hun, early in 2017 the Neighbourhood Plan Team decided to follow up these concerns. This decision coincided with an approach to the Parish Council by the Norfolk Coast Partnership (NCP) who, working with the Norfolk Rivers Trust (NRT), have been successful in establishing improvement programmes for other chalk streams in Norfolk and wanted to explore likely levels of support for a programme of improvements to the Hun.

1.0.7 The Parish Council (PC) indicated informally that they would support improvements to The Hun, subject to establishing that changes to the river would not impact negatively on the Protected Sites or any risk of flooding .

1.0.8 In spring 2017 sightings of a persistent algal bloom on Broadwater Lagoon gave rise to further concerns about pollution of water bodies in the Parish. Some preliminary monitoring of water quality in both the River and the lagoon was undertaken using test kits supplied by The Freshwater Habitats Trust. The initial results were reviewed with the NRT and in view of the findings it was agreed that it would be important to carry out more detailed investigations via a more extensive project to examine water quality and its likely impact on wildlife/environmental health.

1.0.9 In order to establish priorities for the project and to begin addressing the pollution issues, the NCP, NRT and the Parish Council (via the NDP Team) agreed to work together on a programme of water quality monitoring spanning the period from May through to December. NRT agreed to fund a demonstration / training exercise followed by a further 6 months of structured water sampling based on four sites in the Hun Catchment and one on Broadwater Lagoon.

1.0.10 The work has been carried out on a voluntary basis by members of the NDP team with input from the Warden of the Norfolk Wildlife Trust (NWT) and the cooperation of the Norfolk Ornithologists Association (NOA). Analysis of samples has been carried out at the Environment Agency's National Laboratory.

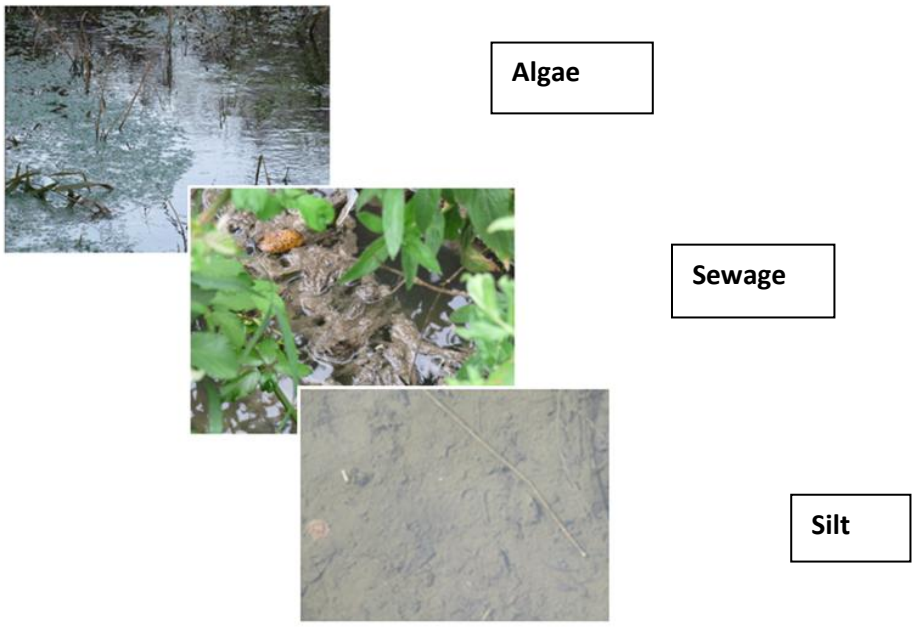
1.0.11 The results of the first three sets of monthly observations have been enlightening:

- At the sampling stations on the River Hun, Nitrate levels are well in excess of Water Framework Directive standards and Nitrite levels are sufficiently high to give cause for concern.
- Pollution from Orthophosphates and Ammonia is a concern in the headwaters of The Hun (i.e. in Hunstanton Park).
- Water quality in Broadwater Lagoon is very poor with extremely high levels of Chlorophyll A and Phosphorus and levels of Ammonium which also give rise to concern.

1.0.12 The concentration and mix of pollutants in the lagoon can be expected to limit aquatic life and impact negatively on the qualifying features of the protected sites – especially birds. Nitrogen levels in the river will have a similar effect especially if they are mirrored in surrounding pools and ditches.

1.0.13 The work to date indicates that the catchment management plan proposals to make improvements to the channel and flow of the Hun (Phase 1 of the Hun Project), combined with a riparian buffer zone would make a major contribution to improving the current situation if carefully implemented. Supporting proposals for improved public access and pathways would at the same time improve visitor experience.

1.0.14 However, until nitrate levels in the river are brought down to acceptable levels 'rewetting' of the lagoon(s) and pools in the lower reaches of the Hun could be extremely damaging because it would add nitrogen-based nutrients to the already heavily polluted lagoon which is mainly affected by phosphorus. This would cause further damage to the Protected Sites and their qualifying features. It is clear that funding will need to be found to continue and expand the programme of water quality monitoring beyond six months and to investigate biological status in addition to water chemistry. This further work will help to improve understanding of the issues facing the river catchment and the Protected Sites and assist with the identification of remedial measures.



2.0 Introduction

2.1.1 The River Hun is a small chalk stream which rises in Hunstanton Park, flows east along the coast through Holme-next-the-Sea before discharging through a tidal sluice into Thornham Harbour. Much of its course has been canalized resulting in a straight channel that is detached from its floodplain. The western part of its course adjoins Old Hunstanton Golf Course to the north and arable farmland to the south. Further to the East in Holme it flows through Holme Dunes NNR and the North Norfolk SSSI, Ramsar, SAC, and SPA Protected Sites.

2.1.2 Its floodplain in Holme consists largely of grazing marshes which support a rich diversity of wildlife – especially birds. Relict oxbow lakes of the river are a feature of the marshes but are now detached from the main channel only being flushed with water from the Hun at times of flood. Broadwater lagoon is one of these lakes and is a qualifying feature of the SAC. It is an important site for several bird species some of which are qualifying SPA features. The lower reaches of the river and the lagoons are brackish (Figure 1).

Figure 1: The course of the River Hun showing its relict meanders and course through Holme Dunes NNR. (Imagery by courtesy of the European Space Agency; Contains modified Copernicus Sentinel data, 2017).

2.1.3 Chalk streams are relatively rare with only about 200 in the world. The Hun is one of several found in Norfolk. In their natural state they have clean, clear, alkaline water filtered by chalk substrate. They typically would support a rich ecology of plants, invertebrates and salmonid fish species including salmon (*Salmo*

salar) and brown trout (*Salmo trutta*). European Otters (*Lutra lutra*) are often found in chalk stream catchments. However, many chalk streams have been seriously damaged by inappropriate management and pollution to the extent that in 2013 some 77% failed to meet the environmental standards required by the EU Water Framwork Directive (WWF, 2014).

2.1.4 Concerns have been expressed about the state of the Hun for some time. Sewage has been reported in both the river and its tributaries, concerns have been expressed about excessive quantities of 'grey sediment' and the lack of fish has been a feature of the river for some years.

2.1.5 The Holme-next-the-Sea Neighbourhood Plan questionnaire survey revealed concerns in the local community about 'inappropriate development' and a strong desire for positive environmental management. One important aspect of this is having policies to ensure that pollution in the Parish does not become intractable.

2.1.6 As part of a broader project aimed at trying to improve Norfolk's chalk streams the Norfolk Coast Partnership in conjunction with the Norfolk Rivers Trust have been seeking Heritage Lottery Funding for the first phase of a project to introduce improvements to the Hun. The broad aims of the project are set out in a catchment plan published by the Norfolk Rivers Trust and the Environment Agency (Blervllet, 2014). Key elements include improvements to channel morphology, riverside planting and reconnection of the river with its floodplain including Broadwater Lagoon. The bid for funding was unsuccessful in the last round due to lack of funds and insufficient evidence of community support.

2.1.7 As part of developing their Neighbourhood Plan Holme-next-the-Sea Parish Council are concerned to ensure an effective management strategy for the Hun and the protected EU sites especially as a significant area within these sites (including much of Home Dunes NNR) is subject to a Shore Line Management Plan policy of Managed Realignment. This policy would ultimately result in the area being open to tidal inundation and reverting to intertidal zone. The policy would, in the words of the Plan's Strategic Environmental Assessment, have a 'major negative' impact on the sites and has permission from the Secretary of State to proceed on the grounds of 'Imperative Reasons of Overriding Public Interest' (IROPI).

2.1.8 The Parish Council is certainly committed to improving the hydrology and ecology of the Hun within the catchment and has agreed to work with interested stakeholders to identify a route forward that best serves the interests of the Parish and at the same time might help with the acquisition of appropriate funding for an agreed programme of work.

2.1.9 In order to progress this aim it was felt important to ensure that reconnecting the Hun with the floodplain and lagoons would not result in any pollutants from the former damaging the latter.

3.0 Water quality testing

3.1.1 Good water quality is a basic requirement for the function and survival of almost all ecosystems and underpins effective management of sites like Holme Dunes. Initial screening of water in the Hun was carried out using simple test kits based on colorimetric methods and a printed colour chart supplied by the Freshwater Habitats Trust. These provided an excellent starting point for general screening of sites and very quickly revealed high levels of nitrates at various points in the river.

3.1.2 Early in 2017 it was noticed that Broadwater Lagoon was exhibiting a strong algal bloom (Figure 2) and this raised further questions about water quality in the catchment.

3.1.3 Whilst lakes of this type are sensitive to nutrient enrichment and growth of algae (JNCC, 2015) and blooms do occur, it is possible that they can become self-perpetuating and lead to eutrophication and damage to the qualifying features of the system. Whilst the lake does appear green in some historical aerial photography, blooms of this strength have not been noticeable in the field during the last ten years.

Figure 2: Broadwater lagoon – exhibiting a strong algal bloom first seen in May 2017. The bloom has persisted to September 1st 2017 and at times is associated with a strong, unpleasant odour.

3.1.4 Against this background, Norfolk Rivers Trust secured funding for some basic water quality monitoring. It was agreed that samples of nitrates and phosphates would be collected by members of the Holme Neighbourhood Plan team on a monthly basis for a period of 6 months. One measurement of Chlorophyll A would also be collected from Broadwater at the start of the period and one at the end.

3.1.5 Arrangements were made to send samples by courier immediately after collection to the EA National Laboratories for analysis. After the second samples were taken, additional measurements of pH and turbidity were added. All samples were collected in clean containers supplied by the laboratory. Care has been taken to avoid cross contamination of samples.

3.1.6 Five sample locations were selected at likely entry points of pollutants to the river identified on the basis of local knowledge and discussions with staff from the Environment Agency with knowledge of the catchment. These are shown in Figure 3. Since starting the programme a possible, additional pollutant entry point has been located upstream of Sample Site S1 in Hunstanton Park.

3.1.7 Water depths in the river were recorded using a measuring stick located at Sample site S2 under Beach Road bridge (Site S2).

3.1.8 An overview of the results for the first three months sampling is shown in Appendix 1.

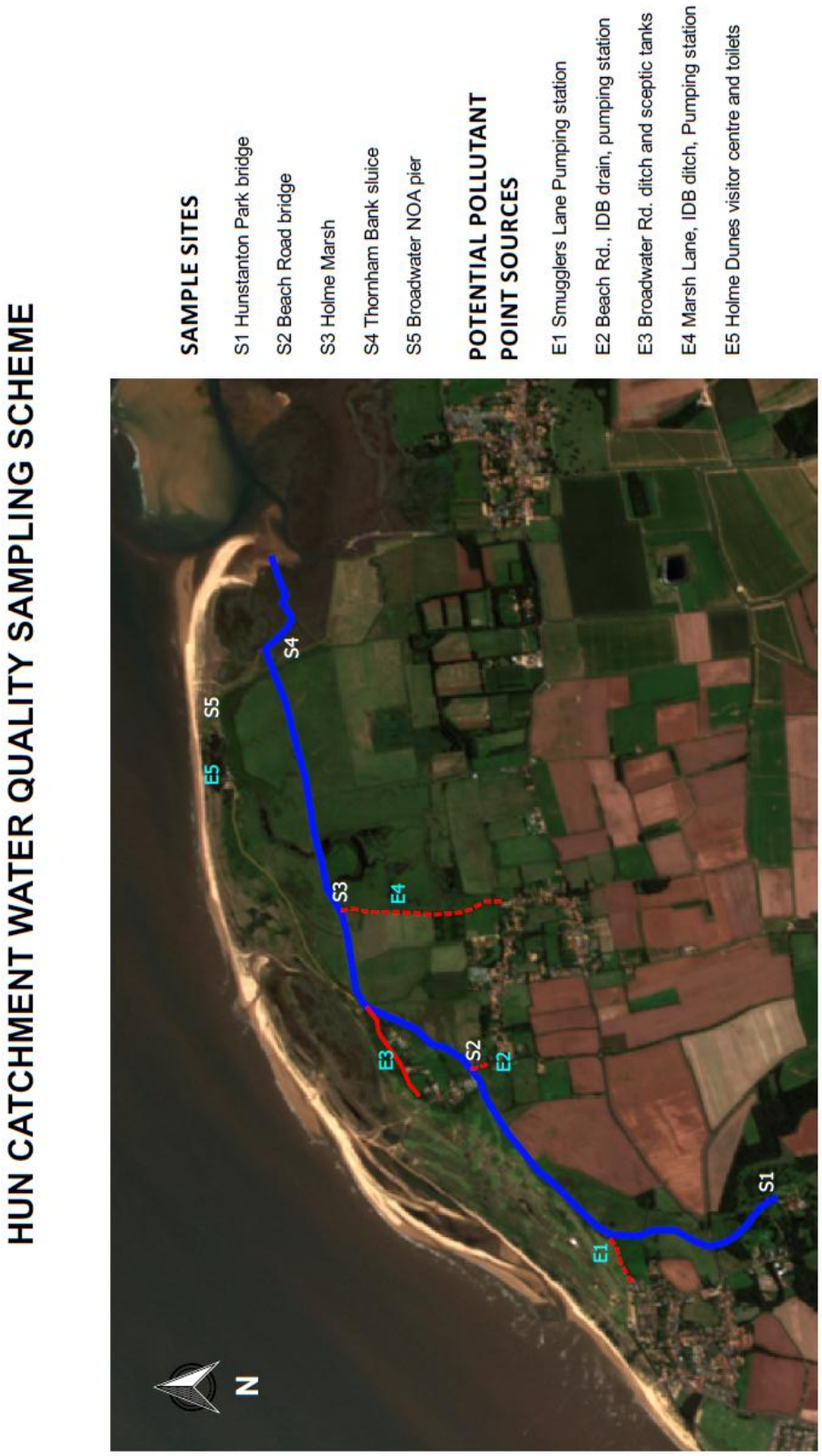


Figure 3: Locations of sample sites and possible sources of pollution (Imagery by courtesy of the European Space Agency; Contains modified Copernicus Sentinel data, 2017).

4.0 Water quality – Summary of First Quarter's results

4.0.1 Water quality standards have been developed for many pollutants by a range of organizations. Growing understanding of pollution impact on human and aquatic populations is developing and changing all the time so there are no magic numbers that prove water is unpolluted or otherwise. A particularly complex issue for the developing science of water quality is that pollutants usually act in combination so isolating the effects of one particular pollutant can be extraordinarily difficult.

4.0.2 Furthermore, three months data is too little to draw firm conclusions about general patterns of water quality of a system but it is sufficient to gain some indication of the likely condition and status of the River Hun and Broadwater Lagoon in the context of supporting wildlife.

4.0.3 The first and most striking feature of the results is that the Lagoon and sample site S1 in Hunstanton Park show very different results to the rest of the River (Sites S2-S4). The Lagoon and site S1 are characterized by very high levels of phosphorous and high levels of Ammonium with minimal/low presence of Nitrates and Nitrite. Sites S2-S4 are characterized by very high levels of Nitrates with minimal levels of Phosphorus and Ammonium.

4.0.4 This suggests that during the sampling period to date, there is no connection between the river and the lagoon. This might change when water levels in the river rise in the autumn/winter or it might suggest that they are actually two separate systems. The results for each will thus be described separately.

Results for the pollutants

Nitrate

4.1.1 Nitrate levels are very low at station S1 in Hunstanton Park (predominantly grassland and woodland surroundings with some settlement). At the remaining stations they are significantly higher than the WFD standard (11.3 mg/l) with a range of 14-16 mg/l and an overall average of 14.97 mg/l. It is possible that the high levels are explained by proximity to arable farmland and the golf course in the section of the Hun between Old Hunstanton and Holme together with IDB drains E2 and E4 which drain arable farmland.

4.1.2 The levels in most of the river are thus worryingly high especially as it flows through a Nitrate Vulnerable Zone over a drinking water aquifer. Camargo *et al.* (2005) present evidence to suggest that even relatively short term exposure to levels this high can be lethal to some invertebrates, damage some amphibians and impact negatively on the fry of sensitive species of fish.

4.1.3 The very low concentrations in Broadwater Lagoon and Hunstanton Park require further explanation (see below).

Nitrite

4.1.4 Nitrite levels are below the resolution of the laboratory measuring equipment for Broadwater Lagoon but rather higher for the stations on the river. The range for these sites is 0.005 to 0.025 and the mean is 0.0176. Opinions seem to differ on acceptable levels from none to 0.01 mg/l N for 'unpolluted water'.

4.1.5 Nitrite occurs as a result of the oxidation of Ammonia to Nitrate. This is a two step process involving oxidation of ammonia to nitrite by Nitrosomonas bacteria and oxidation of nitrite to nitrate by Nitrobacter bacteria. Nitrite is thus usually short lived and as long as these bacteria are present in appropriate conditions for the oxidization process (including availability of dissolved oxygen) it is usually fairly transient.

4.1.6 Its presence is thus linked to that of Ammonia which can frequently be a sign of pollution by sewage and outfalls from waste water treatment plants although there are other sources. Nitrite can thus be taken as an indicator of pollution.

4.1.7 Although it is rapidly oxidized to nitrate its presence at even low concentrations is very damaging to aquatic organisms.

4.1.8 Average levels of Nitrite in Snettisham Lagoons over a 12 month period were between 0.0054 and 0.011 over a twelve month monitoring period (Natural England, 2011) in a study which demonstrated that despite the presence of algae in the lagoons their function as a habitat for birds was not obviously damaged.

4.1.9 The levels recorded here for stations S1 – S4 are rather higher and if average concentrations started to become much higher than 0.02 mg/l N there would be cause for concern.

Ammoniacal nitrogen

4.1.10 Ammoniacal nitrogen levels were at or near the lower limit of laboratory equipment measurement accuracy (<0.03 mg/l) for stations S2 to S5 on the Hun but were much higher for Broadwater Lagoon (Mean of 0.39 mg/l) and showed through time an increasing trend for Hunstanton Park (0.08 mg/l to 0.719 mg/l).

4.1.11 As a comparison, the highest mean level recorded in the Snettisham Lagoons (Natural England 2011) was 0.03 mg/l and more typical levels around 0.015. This suggests that levels at Hunstanton Park in the Hun and in Broadwater Lagoon are substantially higher – possibly by an order of magnitude. Similarly, the UK Environment Agency (2015) recorded levels of around 0.1 mg/l in the R. Thurne and 0.07 mg/l in Martham and Hickling Broads. In the same report, Horsey Mere was deemed to have fallen below acceptable quality standards for Ammonia with a concentration of 0.3 mg/l. (NB Broads observations are average values for 2012-14).

4.1.12 Ammoniacal nitrogen is a combination of Ammonium nitrogen (NH_4) and Ammonia (NH_3). Ammonium is relatively harmless to aquatic life but Ammonia is very damaging. At any time the proportions of Ammoniacal Nitrogen present as NH_4 and NH_3 depends on the pH and temperature of the water. Recording of pH and temperature only began once the rather high levels of ammonium were seen.

4.1.13 It would appear that the lagoon typically has a pH of around 8 and on the one day measurements were taken temperatures were around 17 degrees C but probably reached 20 degrees C later in the day. This would suggest that levels of NH_3 in the lake would have been around 0.017 mg/l but potentially reaching 0.02 mg/l.

4.1.14 Despite substantial research on toxicity of Ammonia to aquatic organisms, standards have been controversial. The Environment Agency (2007) in proposing revised standards note that “The lowest credible concentration of un-ionised ammonia at which long-term effects were found is 0.022 mg NH3-N l-1 when a cumulative mortality of 71 per cent was observed for eggs, larvae and fry of rainbow trout (Oncorhynchus mykiss) over 73 days exposure”. Other Salmonid species, including Brown Trout (Salmo trutta) typical of chalk streams show similar tolerances.

4.1.15 The current WFD, long term exposure standard for salt water is 0.021 mg/l NH_3 and 0.78 mg/l total Ammonium. For fresh water it is 0.015 mg/l. (Environment Agency, 2010). The data collected for Hunstanton Park and Broadwater lagoon suggests that these sites are at best close to these critical levels if not exceeding them.

4.1.16 In the same report the Environment Agency has suggested that rather tighter standards may be appropriate. A significant difficulty in agreeing these standards is that they are dependent on the quality of water in terms of other parameters.

Chlorophyll A

4.1.17 Chlorophyll is vital for photosynthesis and its measurement in water is an indicator of the amount of algae present. It was agreed to take one measurement at the start of the programme from Broadwater Lagoon to learn more about the algal bloom. The sample was taken from a small pier at the edge of the lake. It contained a high level of green solids and returned a concentration of 80.6 ug/l.

4.1.18 By any standards this is a very high concentration. UK Tag (2014) counts the number of times a level of 50 ug/l (dependent on salinity) is exceeded when classifying water quality. On the basis of the colour of the lake and the solids content of subsequent water samples for other pollutants it is not inconceivable that this very high level has been a persistent feature of Broadwater since June 2017 when the sample was collected. On occasions a strong smell comes from the lake.

4.1.19 This level of algal bloom in the lagoon is indicative of high levels of nutrients and is likely to be damaging to aquatic life because it will cause light starvation to organisms in and on the floor of the lake. Certain types of algal bloom (Harmful Algal Blooms or HABS) can pose a threat to public health. These effects are likely to ripple through the food chain and ultimately impact on higher organisms (fish) and birds using the lake. Some of these will be qualifying features for the SPA.

4.1.20 To date no comparators have been found for Chlorophyll A in nearby water features. In the Snettisham lagoons study (*op cit*) Secchi depth was used as a proxy. However, RMB Environmental Laboratories inc. would classify lakes with this level of Chlorophyll A as 'hypereutrophic'.

Phosphorus

4.1.21 For rivers the WFD standard for phosphorus is 0.087 mg/l P. Stations S2-S4 on the Hun are all well within this limit. However, Hunstanton Park (S1) exceeds the limit by a factor of 5 to 7 for the three months in question.

4.1.22 Around 90% of Total P for this location consists of orthophosphate. As there are no arable fields close to the site this suggests that nearby septic tanks may be a source.

4.1.23 Levels for Broadwater lagoon were 0.646 mg/l P, 0.579 mg/l P and 0.374 mg/l P possibly suggesting a decreasing trend. The limit for brackish lakes suggested by the JNCC (2015) is 0.035 mg/l so levels in the lagoon exceeded this by a maximum factor of 18 and a minimum of 10.

4.1.24 The orthophosphate component of these concentrations is below the measurable limit suggesting that the Phosphorus is mainly organic and bound up in the high levels of algae.

4.1.25 These levels in the Lagoon are very high and are almost certainly the cause of the prominent algal bloom seen on the lake. Furthermore, Phosphorus readily attaches itself to sediments and other solids and so can be a very persistent form of pollution.

4.1.26 The very high levels of phosphorus and Chlorophyll A linked to the algal bloom are likely to lead to very low levels of dissolved oxygen in the water. Oxygen is needed for the support of Nitrobactor and Nitrosomonas to break down ammonia into nitrites and nitrates. It was noted above that levels of both nitrite and nitrate are very low in the lake and this is one possible explanation.

4.1.27 No dissolved oxygen levels have yet been measured for the lagoon but this is now seen as a priority.

4.1.28 Chlorophyll A levels were very high suggesting the lagoon could be described as 'hypereutrophic'.

Combined effects of pollutants

4.1.29 As far as the Lagoon is concerned the combined levels of ammonium, phosphate and chlorophyll A (algae) would seem to provide a toxic combination that could not support acceptable levels of aquatic life. Whilst birdlife is not absent from the lake, the relatively small number of birds present seems to be in contrast to other lagoons in the vicinity. Collection of some dissolved oxygen concentrations has to be a priority to get a clearer picture of the lake's status.

4.1.30 As far as the River is concerned the levels of Nitrate and Nitrite would also prove hostile for aquatic species so it is little surprise that fish are rarely seen in the river.

4.1.31 From three months observations it would seem that the river and the lake are separate functional systems given the pattern of pollutants in each. However, with increasing flood levels in the winter and the possibility of flood water from the river entering the lagoon this may change.

4.1.32 The Norfolk Rivers Trust Catchment Plan for the Hun (Blervlett, *op cit*) could make a major contribution to improving water quality in the river based on channel improvements and riparian buffer zones/planting. It is less clear at this point how the problems affecting the lagoon could be addressed. However, re-connecting the river with its floodplain and the lagoons could make matters considerably worse given the rather different patterns of pollutants in each.

4.1.33 Overall, the water quality in both the river and the lagoon needs improvement to be consistent with the conservation objectives of the Protected Sites in terms of their qualifying features. It is also important to maintain ecosystem services and tourist income linked to the sites. Continued monitoring is important in this respect with additional focus on biology. Funding for the first phase of the Catchment Plan could make a major impact and give greater clarity as to if and how the other aspects of the plan might proceed.

5.0 Conclusions

5.0.1 The first three months of water quality measurements for the Hun catchment have been reviewed. This is not a sufficiently long time series to draw firm conclusions about patterns in the catchment. However, it is sufficiently long to detect high pollutant concentrations that would be damaging to aquatic life.

5.0.2 Of the four recording stations on the Hun: Beach Road Bridge, Holme Marsh and Thornham Sluice (stations S2-S4) had very similar results while Hunstanton Park (S1) was quite different.

5.0.3 The former exhibited levels of Nitrate well over the Water Framework Directive limit. Scientific evidence suggests that these levels would be lethal to some invertebrates, damaging to amphibians and prevent long term survival of sensitive fish populations – including Salmo Trutta (Brown Trout). The catchment is in a Nitrate Vulnerable Zone.

5.04 All of the stations on the river showed rather high nitrite concentrations with some reaching levels that would be damaging in the short term to aquatic life.

5.0.4 Hunstanton Park exhibited very low levels of Nitrate but substantially exceeded the Water Framework Directive limit for Phosphorus in the form of orthophosphate. As the site is some distance from arable fields and Ammonium is also present it is possible that sewage from septic tanks may be the source. Water samples from this location appeared more turbid than those from the rest of the river. At the time of recording pH and temperature levels were low for this site but the levels of ammonium in the third month were worryingly high for the safety of aquatic organisms.

5.0.5 Broadwater Lagoon showed a very different picture to the river. Nitrate and Nitrite concentrations were below the measurable limit. Notable concentrations of ammonium were present and these could easily reach a level where they would be lethal to sensitive fish and other organisms if there was a small increase in lake pH or a larger increase in water temperature.

5.0.6 Phosphorous levels were between 10 and 18 times above the JNCC recommended limits and this obviously is the driving factor for the algal bloom. However, orthophosphate levels were below the measurable limit suggesting that most of this phosphorus was tied up in the algae itself. The persistent algal bloom is damaging to aquatic life.

6.0 References

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7.0 Appendix 1: Water quality measurements for June to August 2017

Site	Location	Date	Phosphorus: Total as P	Orthophosphate, reactive as P	Organic Phosphate (Total P - reactive P)	Ammoniacal Nitrogen as N	Ammonia est	Nitrogen : Total Oxidised as N	Nitrite as N	Nitrate as N	Chlorophyll, Acetone Extract	ph
			mg/l	mg/l		mg/l	mg/l	mg/l	mg/l	mg/l	ug/l	
S1	Hunstanton Park	8-Jun-17	0.428	0.384	0.044	0.080		0.440	0.025	0.415		
S2	Beach Road Bridge	8-Jun-17	0.035	0.013	0.022	<0.0300		16.000	0.016	16.000		
S3	Holme Marsh	8-Jun-17	0.025	0.011	0.014	<0.0300		15.400	0.018	15.400		
S4	Thornham Bank Sluice	8-Jun-17	0.019	<0.0100		<0.0300		14.500	0.020	14.500		
S5	Broadwater Lagoon	8-Jun-17	0.646	<0.0100	~0.646	0.310		<0.200	<0.00400	<0.200	80.6	
S1	Hunstanton Park	6-Jul-17	0.550	0.490	0.060	0.337		<0.200	0.019	<0.181		
S2	Beach Road Bridge	6-Jul-17	0.027	0.020	0.007	0.030		15.200	0.015	15.200		
S3	Holme Marsh	6-Jul-17	0.031	0.017	0.014	0.030		15.000	0.018	15.000		
S4	Thornham Bank Sluice	6-Jul-17	0.030	0.017	0.013	0.030		14.000	0.020	14.000		
S5	Broadwater Lagoon	6-Jul-17	0.579	<0.0100	~0.579	0.432		<0.200	<0.00400	<0.200		
S1	Hunstanton Park	3-Aug-17	0.662	0.608	0.054	0.719	0.010	<0.02	0.005	<0.195		7.65
S2	Beach Road Bridge	3-Aug-17	0.019	0.013	0.006	0.030	0.000	15.800	0.017	15.800		7.76
S3	Holme Marsh	3-Aug-17	0.026	0.012	0.014	0.030	0.000	14.800	0.020	14.800		7.88
S4	Thornham Bank Sluice	3-Aug-17	0.046	<0.01	~0.046	0.030	0.000	14.100	0.020	14.100		7.95
S5	Broadwater Lagoon	3-Aug-17	0.374	<0.01	~0.374	0.426	0.019	<0.2	<0.004	<0.2		8.16

Fail — No fill = Pass

Caution

8.0 Appendix 2: Contributors

The support of the Norfolk Rivers Trust in funding and supporting this work is gratefully acknowledged. In particular we would like to thank Ursula Juta for her help in making all the necessary arrangements and carrying out the initial set of field tests. The support of Estelle Hook at the Norfolk Coast Partnership and the Freshwater Habitats Trust (Laura Quinlan, People, Ponds and Water Project, funded by the HLF) is also acknowledged. Last but not least, the cooperation of the Norfolk Wildlife Trust and the Norfolk Ornithologists Association is acknowledged.

Field support and assistance has been provided by the following:

Bernard Devereux (Neighbourhood Plan Team)

Lynn Devereux (Holme-next-the-Sea Parish Council and Neighnourhood Plan Team)

Garry Hibberd (Warden at Holme Dunes, Norfolk Wildlife Trust)

Christina Jones (Neighbourhood Plan Team, Project Coordinator)

Ursula Juta (Education & Catchment Support Officer, Norfolk Rivers Trust)