Kingmoor ERF

Appendix D

Ecological interpretation of AQA

Prepared for Fichtner Consulting Engineers

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Contents

1 Introduction

This document provides an ecological interpretation of the Air Quality Assessment (AQA) undertaken by Fichtner Consulting Engineers for Kingmoor Energy Recovery Facility (ERF; 'the Facility'). The AQA was undertaken to inform the Environmental Permit (EP) application for the ERF.

The aim of this document is to provide further ecological interpretation of the results of the AQA, focussing on any effects on sensitive ecological receptors which cannot be screened out as insignificant, in accordance with Environment Agency criteria.

It has not been possible to screen out effects of ammonia levels, nitrogen deposition and acid deposition on habitats within River Eden Special Area of Conservation (SAC) and River Eden and Tributaries Site of Special Scientific Interest (SSSI). Further ecological assessment has therefore been undertaken to:

- Confirm sensitivity of qualifying and notified features with reference to data published by the Air Pollution Information Service (APIS);
- Assess potential effects by comparing dispersion and deposition model plots with the spatial distribution of sensitive habitats;
- To consider existing site condition and additional factors, including catchment-level processes, which could increase or decrease sensitivity to the predicted effects; and
- Provide an informed ecological opinion on the likelihood of significant effects or significant harm.

2 Scope and methodology

2.1 Scope of assessment

The scope of assessment is defined by the following exceedances of Environment Agency screening thresholds at River Eden SAC and River Eden and Tributaries SSSI predicted in the dispersion and deposition modelling set out in the AQA:

- Ammonia levels (at 1µg/m^3 annual mean critical level) to woodland habitats with potentially important bryophyte and lichen communities;
- Nitrogen deposition rates to woodland habitats (at 15kg N/ha/yr critical load);
- Nitrogen deposition rates to grassland habitats (at 15kg N/ha/yr critical load);
- Acid deposition rates to grassland habitats (at acid grassland acidity class critical load); and
- Acid deposition rates to woodland habitats (at unmanaged broadleaved / coniferous woodland acidity class critical load).

2.2 Methodology

Assessment methodology

Sensitivity of qualifying and notified features of designated sites was assessed with reference to the Air Pollution Information Service (APIS) website. Current pressures and the importance of air quality issues affecting the site were assessed with reference to Natural England's Condition Assessments for SSSI units, and the *Supplementary Advice for Conservation Objectives* for the SAC.

The spatial distribution of qualifying and notified features of the relevant designated sites were assessed using a combination of descriptions in the SAC and SSSI Citations, the SSSI Unit information, and interpretation of Google Earth aerial photography with an overlay of the designated site boundaries.

Catchment-level analysis

GIS data for the Eden catchment boundary was downloaded from the National River Flow Archive website[1]. This website also provides information on land cover at 25m scale of resolution, derived from the Land Cover Map 2000 raster data[2].

[1] https://nrfa.ceh.ac.uk/data/search (accessed 19/12/2019)
[2] https://www.ceh.ac.uk/services/land-cover-map-2000 (accessed 19/12/2019)

A literature search was undertaken for relevant studies of factors responsible for effects on water quality on the Eden catchment, in order to contextualise the results of the AQA.

2.3 Personnel

The report has been prepared by Kevin Barry Honour MSc MCIEEM, a Director of Argus Ecology Ltd. who specialises in ecological interpretation of air quality assessments, Habitats Regulations Assessment, Ecological Impact Assessment and habitat surveys (Phase 1 / NVC / EUNIS). He has undertaken numerous interpretations of model outputs for point-source discharges, assessing effects on a wide variety of sites and habitat types.

He was previously a Senior Lecturer in Ecology at the University of Sunderland, with responsibility for teaching air pollution ecology at undergraduate and Masters level.

He has some knowledge of the River Eden in the Carlisle area, having undertaken habitat surveys for the Eden – Caldew section of the Environment Agency's flood defence works in 2006.

3 Sensitive ecological receptors

3.1 River Eden SAC

Qualifying features and Site-relevant Critical Loads

The SAC is designated for the occurrence of the following qualifying features. They are set out in the table below, together with their sensitivity to ammonia levels, nitrogen deposition and acid deposition, as defined by APIS in the Site Relevant Critical Loads web pages[3].

Fig. 3.1: River Eden SAC qualifying features and site-relevant Critical Loads / Levels

Qualifying Feature	NH3 CL	N dep. CL	Acid dep. CL
H3130 Oligotrophic to mesotrophic standing waters	Site-specific advice	3 – 10 kg N/ha/yr	Sensitive but no CL function given
H3260 Water courses of plain to montane levels	Site-specific advice	Sensitive but no comparable CL class	
H91E0 Alluvial forests	1µg/m^3	Not sensitive	Not sensitive
S1092 white-clawed crayfish	3µg/m^3 Site-specific, depending on N or P limitation	Sensitive but no comparable CL class	Broad habitat (rivers and streams) sensitive but no CL function given
S1095 sea lamprey			
S1096 brook lamprey			
S1099 sea lamprey			
S1106 Atlantic salmon			
S1163 bullhead			
S1355 otter			

With respect to the critical load range for nitrogen deposition to oligotrophic to mesotrophic standing waters, APIS advise that the lower end of the range should be used for boreal and Alpine lakes, and the upper end for Atlantic softwaters. They caution that the critical load should only be applied to oligotrophic waters with low alkalinity with no significant agricultural or other human inputs.

With respect to water courses of plain to montane levels and the species which are dependent on this habitat, APIS advise that aquatic systems are often P limited or N/P

[3] http://www.apis.ac.uk/srcl/select-a-feature?site=UK0012643&SiteType=SAC&submit=Next (accessed 20/12/2019)

co-limited (therefore additional N will have less effect, as it is not a limiting nutrient). They also state that '*consideration should also be given to other sources of N, i.e. discharges to water, diffuse agricultural pollution etc.*' This is discussed further below in the context of the deposition modelling results, as it is important to interpret these in terms of published data on other sources of nitrogen and eutrophication issues in the wider Eden catchment.

3.2 River Eden and Tributaries SSSI

Notified Features and Site-relevant Critical Loads

The SSSI is notified for the occurrence of the following features. They are set out in the table below, together with their sensitivity to ammonia levels, nitrogen deposition and acid deposition, as defined by APIS in the Site Relevant Critical Loads web pages[4].

Table 3.2: River Eden and Tributaries SSSI notified features and sensitivity

Notified Feature	**NH3 CL**	**N dep. CL (min – max)**	**Acid dep. CL (min – max CL maxN)**
W5 *Alnus glutinosa – Carex paniculata* woodland	Site-specific advice	10 - 20 kg N/ha/yr	0.605 – 12.041 keq/ha/yr
W6 *Alnus glutinosa – Urtica dioica* woodland			
W8 *Fraxinus excelsior – Acer campestre – Mercurialis perennis* woodland	Site-specific advice	15 - 20 kg N/ha/yr	0.605 – 12.041 keq/ha/yr
W7 *Alnus glutinosa – Fraxinus excelsior – Lysimachia nemorum* woodland	Site-specific advice	Not sensitive	Not sensitive
M23 *Juncus effusus / acutiflorus – Galium palustre* rush-pasture	3µg/m^3	15 - 25 kg N/ha/yr	0.536 – 4.483 keq /ha/yr
S7 *Carex acutiformis* swamp	Site-specific advice	Not sensitive	Not sensitive

[4] http://www.apis.ac.uk/srcl/select-a-feature?site=2000215&SiteType=SSSI&submit=Next (accessed 20/12/2019)

Notified Feature	NH3 CL	N dep. CL (min – max)	Acid dep. CL (min – max CL maxN)
White-clawed crayfish *Austropotamobius pallipes*	3µg/m^3 Site-specific, depending on N or P limitation	Sensitive but no comparable CL class (site-specific)	Insufficient knowledge (site-specific)
Whitefish *Coregonius lavaretus*	No CL assigned	Not assessed	No CL assigned
Bullhead *Cottus gobio*	3µg/m^3 Site-specific, depending on N or P limitation	Sensitive but no comparable CL class (site-specific)	Broad habitat (rivers and streams) sensitive but no CL function given
Whooper swan *Cygnus cygnus*		No critical load assigned, depends on N or P limitation	No expected negative impact
Invertebrate assemblage		Sensitive but no CL class (site-specific)	Insufficient knowledge (site-specific)
River lamprey *Lampetra fluviatilis*		Sensitive but no comparable CL class (site-specific)	Broad habitat (rivers and streams) sensitive but no CL function given
Brook lamprey *Lampetra planeri*			
Sea lamprey *Petromyzon marinus*			
Atlantic salmon *Salmo salar*			
Otter *Lutra lutra*			
Sand martin *Riparia riparia*	No CL assigned	Not assessed	No CL assigned
Upland waters and their margins	No CL assigned	Not assessed	No CL assigned

It should be noted that the SSSI notified features include some of the Habitats Directive Annex I habitats and all of the Annex II species which are qualifying features of the SAC. There are also additional SSSI notified features, including two fen, marsh and swamp habitats (M23 rush-pasture and S7 *Carex acutiformis* swamp); W8 ash woodland; invertebrate assemblage; sand martin; and whooper swan.

Differences in classification system (NVC vs. European Annex I habitats) give rise to some anomalies in the treatment of critical loads and levels by APIS. Alluvial forest habitat includes W5, W6 and W7 NVC communities. However, APIS treat W5 and W6 woodlands as sensitive to nitrogen and acid deposition, whereas W7 and the Annex I Alluvial Woodland habitat are treated as not sensitive. In fact all these wet woodland communities support an alder (*Alnus glutinosa*) canopy, a species which has an associated nitrogen-fixing bacterium (*Frankia alni*). This results in naturally large soil nitrate levels under alderwood communities, with consequent acidification[5]. There is no ecological justification for separating W5 and W6; in fact, as these communities typically occupy alluvial flats subject to additional nutrient inputs from floodwaters, if anything they are likely to be more nutrient-rich than the W7 community, which typically occupies flushed slopes[6].

Conversely, there is some justification for assigning a greater sensitivity to the 'upland waters and their margins' notified feature, as a subset of the 'water courses of plain to montane levels' Annex I habitat, in order to achieve compatibility between treatment of the SSSI and SAC features.

3.3 Distribution of qualifying features in vicinity of emission source

The designated sites cover an extensive area, including the whole of the River Eden and many of its major tributaries such as the Caldew and Irthing. Areas where the model predicts elevated levels or deposition rates (in excess of 1% of the EQS) are shown in the AQA Figures 17 (ammonia), 18 (nitrogen deposition) and 19 (acid deposition). All are confined to a section of the River Eden downstream of Carlisle and upstream of the tidal limit, which falls within component SSSI unit 236 (see Figure 3.1 below). This is the furthest downstream unit of the SSSI (and SAC), extending from the tidal limit up to the confluence with the River Caldew.

Unit 236 is described by Natural England as having a main habitat of Rivers and Streams, and its current Condition Assessment (made in 2010) is Unfavourable Recovering. No reason is given for its current condition in Natural England's published spreadsheets[7].

[5] Bell, N. (*Ed.*) (1994). *The ecological effects of increased aerial deposition of nitrogen*. British Ecological Society Ecological Issues no. 5., Field Studies Council

[6] Rodwell, J.S. (*ed.*) (1991). *British Plant Communities. Volume 1 – Woodlands and scrub.* Cambridge University Press

[7] https://designatedsites.naturalengland.org.uk/ReportUnitCondition.aspx?SiteCode=S2000215&ReportTitle=River%20Eden%20and%20Tributaries%20SSSI (accessed 20/12/2019)

Assessment of aerial photography (overlaying SAC and SSSI boundary on a Google Satellite backdrop layer) indicates that the designated site boundaries here are largely confined to the river and its immediate banks, and do not appear to include any of the associated riparian zone habitats which are designated as SAC or SSSI qualifying / notified features, although sections with trees and woodland may contain riparian alderwood habitat. There are some vegetated / partly vegetated side bars, suggesting the SSSI notified feature 'invertebrate assemblage' could be present, and sand martins may breed on exposed vertical river banks. A more extensive area of braided channels located downstream and to the north of the areas shown on AQA Figures 17-19 may support rush-pasture habitat, but this is outside the area of potential concern.

The main habitat to consider in the assessment is the river channel itself and associated qualifying / notified species. This is the Annex I habitat 'water courses of plain to montane levels', with associated species likely to include lamprey species, salmon, and otter. The SSSI Citation[8] indicates that white-clawed crayfish occur further upstream, in headwater streams, while whitefish occurs in Ullswater and the impounded Haweswater Reservoir.

3.4 Summary of features present and their sensitivity

In summary, the following SAC qualifying features are known to occur, or may occur in the area of potential concern:

- Water courses of plain to montane levels;
- Alluvial forests (fragmentary if present); and
- Qualifying species including river, brook and sea lamprey; Atlantic salmon and otter.

Additional SSSI notified features which may occur include

- invertebrate assemblage; and
- sand martin.

In terms of sensitivity of air quality effects, none of these features has a critical load assigned, although the river is identified by APIS as sensitive to nitrogen deposition, and forms the supporting habitat for species which are also regarded as sensitive.

Fig. 3.1: River Eden SAC and River Eden Tributaries SSSI

[8] https://designatedsites.naturalengland.org.uk/PDFsForWeb/Citation/2000215.pdf (accessed 21/12/2019)

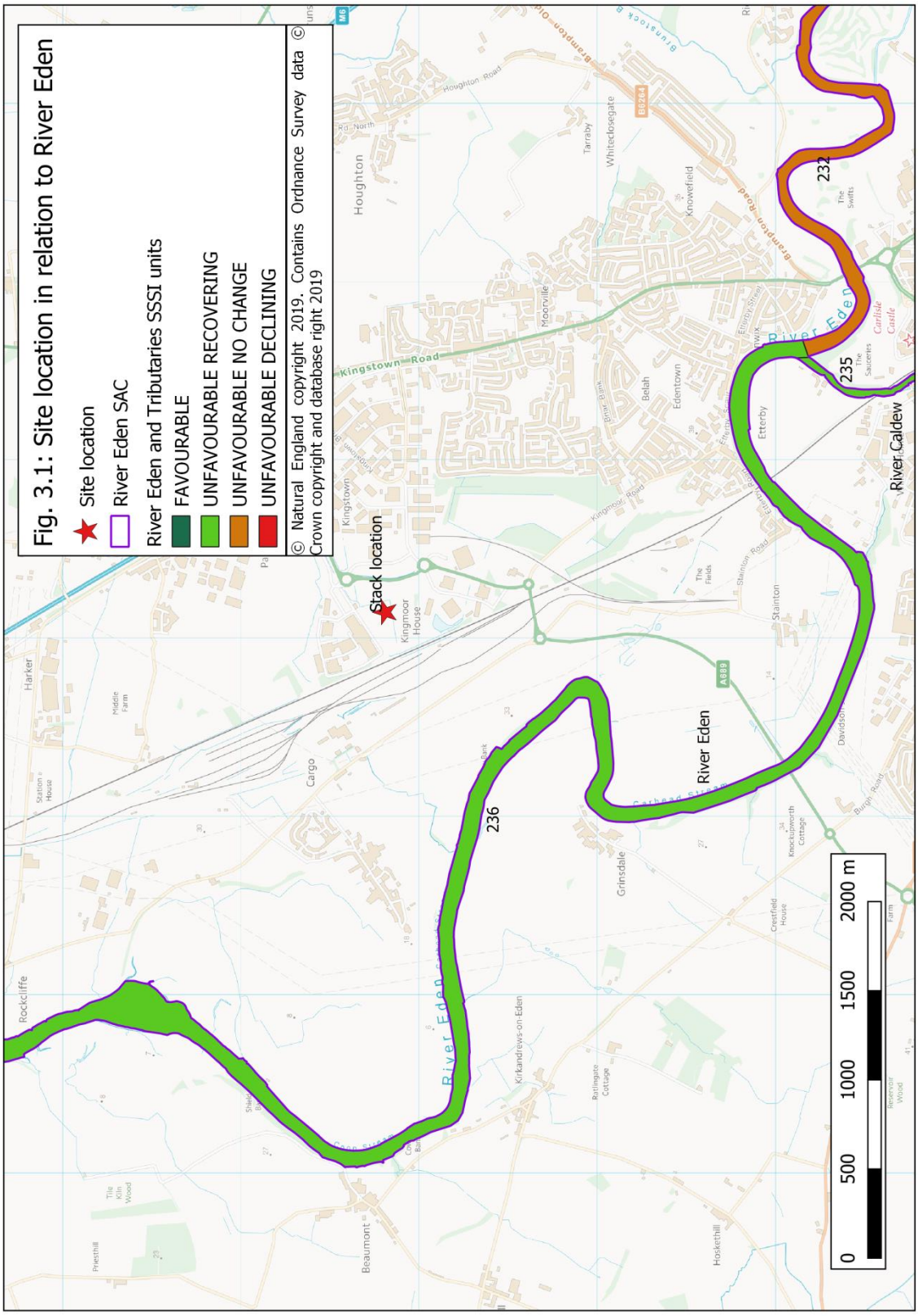
Fig. 3.1: Site location in relation to River Eden
Site location
River Eden SAC
River Eden and Tributaries SSSI units
FAVOURABLE
UNFAVOURABLE RECOVERING
UNFAVOURABLE NO CHANGE
UNFAVOURABLE DECLINING
© Natural England copyright 2019. Contains Ordnance Survey data © Crown copyright and database right 2019
Stack location
River Eden
River Caldew
236
235
232
Kingstown Road
Houghton
Whitesgate
Knowefield
Moorville
Belah
Edentown
Etterby
Stainton
Grinsdale
Kirkandrews-on-Eden
Beaumont
Rockcliffe
Cargo
Harker
Hesket hill
0
500
1000
1500
2000 m

4 Assessment of air quality effects

4.1 Predicted impacts

AQA predictions

This assessment takes the predicted process contributions (PC) and environmental concentrations for ammonia set out in Tables 50 of the AQA. For nitrogen and acid deposition rates, the values taking in-combination effects with the Kingmoor Power gas-fired peaking plant into account have been used, as set out in Table 47 of the AQA.

As the only qualifying or notified woodland habitats which may occur in the area of concern are alder woodlands, which are not considered sensitive to nitrogen or acid deposition, the assessment considers the grassland deposition velocities only. Note that this can be regarded as precautionary as the deposition velocities to open water surfaces are likely to be lower.

With respect to critical loads and critical levels, the 3µg/m^3 annual mean ammonia level set for the protection of ecosystems (without important bryophyte and lichen communities is used), but as it is not possible to assign a critical load to the relevant habitats and species, 1% screening thresholds for nitrogen and acid deposition are not defined. Note that as the predicted environmental concentration (PEC) for oxides of nitrogen is well below the 30µg/m^3 annual mean critical level, this parameter is not considered in the assessment of effects.

Table 4.1: Summary of predicted impacts

Parameter (sensitive receptor)	EQS (critical level or load)	Background (% EQS)	PC (% EQS)	PEC (% EQS)
NH_3 (all habitats)	3µg/m^3	3.00µg/m^3 (100%)	0.036µg/m^3 (1.2%)	3.04µg/m^2 (101.2%)
N deposition (rivers and associated species)	n/a	8.26kg N/ha/yr	0.247kg N/ha/yr	8.51kg N/ha/yr
Acid deposition (rivers and associated species)	n/a	N: 0.59 keq S: 0.13 keq S	0.077 keq/ha/yr N+S	0.80 keq/ha/yr

4.2 Effects of ammonia levels

Predicted ammonia levels only just exceed the 1% screening threshold, and represent a very low magnitude process contribution.

Although the values predict that the process contribution will cause an exceedance of the critical level, in practice this is unlikely to be distinguishable from spatial and temporal variations in background levels.

In terms of ecological effects, there are no qualifying or notified features regarded as particularly sensitive to ammonia within the area of concern. As background levels are predicted to be relatively high, it is likely that this will be visible in factors such as high populations of ammonia-tolerant *Xanthorion* community lichens on twigs of scrub on the edge of the river. The process contribution can be regarded as inconsequential to the background levels, and in terms of source attribution the contribution of agricultural practices is much more important. For example, the source attribution chart for reduced (NHx) atmospheric nitrogen deposition to River Eden and Tributaries SSSI shows a 64% contribution from livestock farming and 8% from fertiliser application.

Given the absence of ammonia-sensitive receptors in this section of the SSSI / SAC, and low magnitude of the process contribution, it can be concluded that ammonia levels will have no likely significant effect on the SAC, and would not cause significant harm to the SSSI.

4.3 Effects of nitrogen deposition

The predicted maximum nitrogen deposition rate of 0.247kg N/ha/yr is low in magnitude and in spatial extent (see AQA Figure 18). There is also a low modelled background rate, giving a PEC below the critical load for all but the most sensitive habitats, such as bogs or oligotrophic standing waters.

Natural England's *Supplementary Advice for Conservation Objectives*[9] for River Eden SAC for the water courses of plain to montane levels qualifying feature has a target to reduce nitrogen deposition to below the site-relevant critical load, as defined by APIS. However a critical load is not defined by APIS for this feature, and the advice goes on

[9] Natural England (2019). *European Site Conservation Objectives: Supplementary advice on conserving and restoring site features. River Eden Special Area of Conservation (SAC) Site Code: UK0012643*. 25 January 2019.

to state that '*nitrogen deposition at this site exceeds the critical load for the ecosystem protection and hence there is a risk of harmful effects*.'

Unlike critical levels, there is no critical load for 'ecosystem protection', so it is unclear which values Natural England are referring to.

Nitrogen levels in the River Eden are a current cause for concern; this is reflected in the *Supplementary Advice for Conservation Objectives*, and in a significant number of studies undertaken in the catchment and published in the scientific literature. However, in terms of source apportionment, atmospheric nitrogen deposition is very unlikely to be a significant determinant of water quality in the Eden. A European Environment Agency (EEA) source apportionment study[10] stated that atmospheric deposition is much smaller than diffuse agricultural pollution, and is only significant on large open water bodies such as the Baltic Sea or large lakes, where the surface area is large relative to catchment size. The Eden catchment covers a total area of 2308km^2, with 73% of land-cover as improved agricultural grassland; studies have shown agricultural fertiliser inputs in the range of 40 – 60kg N/ha/yr[11].

Detailed monitoring studies of two headwater streams on the Eden, Newby Beck and Pow Beck[12], have calculated estimates of nitrate – nitrogen outputs from each sub-catchment of 18,230kg and 20,470kg N/yr respectively (equivalent to an annual nitrate-N generation from each catchment of 14.6 kg and 19.6kg N/ha/yr respectively). While atmospheric N deposition to land will contribute to drainage waters, this illustrates the overwhelming contribution of surface water inputs to nitrogen levels in the lower reaches of the River Eden.

In this context, a process contribution of 0.247kg N/ha/yr is inconsequential, and can be regarded as not likely to have a significant effect on the water courses of plain to montane levels qualifying feature, or on qualifying species dependent on this feature as a supporting habitat.

4.4 Effects of acid deposition

[10] European Environment Agency (2005). *Source Apportionment of nitrogen and phosphorus inputs to the aquatic environment.* EEA Report No. 7/2005.

[11] Wang, L. & Burke, S.P. (2017). A catchment-scale method to simulating the impact of historical nitrate loading from agricultural land on the nitrate-concentration trends in the sandstone aquifers in the Eden Valley, UK. *Science of the Total Environment*, **579**, 133-148.

[12] Ockenden, M.C. *et al* (2016). Changing climate and nutrient transfers: Evidence from high temporal resolution concentration-flow dynamics in headwater catchments. *Science of the Total Environment*, **548-549**, 325-339.

Although the relevant qualifying features are regarded as sensitive to acid deposition, and there is a target in the *Supplementary Advice for Conservation Objectives* to maintain the pH of non-humic waters >6.54 mean value. Atmospheric deposition to poorly buffered headwater streams can be an issue; however the Energy Recovery Facility is located in the lowest reach of the river, which will be well buffered. The very low magnitude process contribution can therefore be regarded as inconsequential, and will not have a significant effect on the water courses of plain to montane levels qualifying feature, or on qualifying species dependent on this feature as a supporting habitat.

5 Conclusions

Further ecological interpretation of the results of the dispersion and deposition modelling undertaken in the AQA has been carried out. This has determined that some of the most sensitive qualifying and notified features identified in the AQA do not occur in the vicinity of Kingmoor ERF, and can be excluded from further consideration.

Alder woodland habitat, identified as sensitive to nitrogen and acid deposition by APIS as a SSSI notified feature, is not regarded as sensitive when listed as a qualifying feature of the SAC. There are sound ecological reasons for regarding this habitat as **not** sensitive, so it can be disregarded from further analysis of nitrogen and acid deposition effects.

The main habitat considered in the assessment is the river itself, which forms part of the Rivers of Plain to Montane Levels Annex I habitat and SAC qualifying feature. Although this habitat does not have a critical load assigned for acid or nitrogen deposition, it is regarded as sensitive. Several qualifying species can also be regarded as sensitive, due to indirect effects on the river as a supporting habitat.

Assessment of the river habitat concluded that the predicted nitrogen and acid deposition rates were inconsequential. Nitrogen levels, although regarded as a problem in the River Eden catchment, are primarily the consequence of agricultural activities. Concerns about acid deposition are focussed on poorly buffered headwaters, not the lower reaches in proximity to the ERF.

In conclusion, no likely significant effects are predicted on qualifying features of the SAC, and no significant harm is predicted for notified features of the SSSI.