Book 3 Water discharge activity operational permit habitats regulations assessment report

Proposed Sizewell C nuclear power station

July 2022

Version 1

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Environmental Permitting (England and Wales) Regulations 2016 (EPR 16) water discharge activity habitats regulations assessment report (HRAR)

1. Introduction

Sizewell C (SZC) nuclear power station will be constructed immediately to the north of the existing Sizewell B (SZB) power station. Construction of SZB started in 1988 and it began producing electricity in 1995 (Figure 1). To the south of SZB lies the Sizewell A (SZA) power station site, which is currently undergoing decommissioning. It was operational for 40 years between 1966 and 2006.

SZC will be ‘direct-cooled’ (also known as ‘open-cycle cooling’), with each of the 2 UK EPR™ units having its own dedicated cooling water (CW) intake tunnel extending approximately 3.0 to 3.5km offshore. Seawater will then be abstracted from the Greater Sizewell Bay in the North Sea via 2 dedicated intake heads and tunnels, one for each reactor, located approximately 500m apart.

In its operational phase, SZC will require a continuous supply of cooling water at a rate of 132m³/second at mid-tide level of seawater, which will vary between 125 and 140m³/s.

The offshore cooling water intakes will be located at I3 and I4, as indicated by the green circles in Figure 1. Three location options were identified for the intake heads; I3a, b and c, and I4a, b and c. I3a and I3b, and I4a and I4b were selected as the preferred options for the intakes (NNB GenCo 2020a; TR302), with I3c and I4c as reserve location options (NNB GenCo 2014a; TR301).

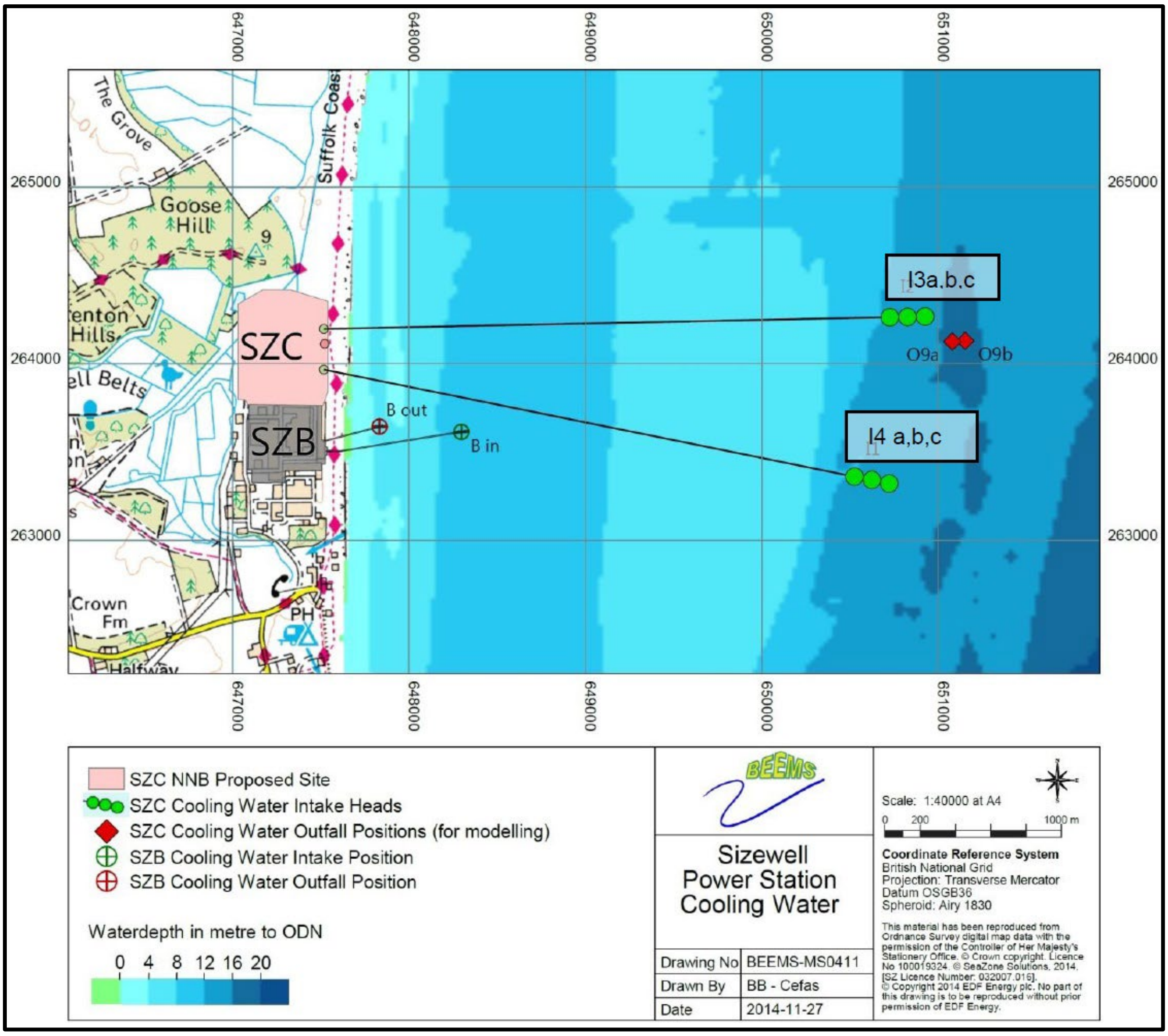

Figure 1: Location of the preferred SZC cooling intake and outlet structures in proximity to those at SZB (NNB GenCo, 2020a; TR302)

After being used within the power station the seawater would then be discharged back to the Suffolk coast via a long outlet tunnel with a mean excess temperature of 11.6°C above ambient background. In practice, both the temperature and volume would vary tidally due to the variable load on the cooling water pumps themselves. Where pumping rates are reduced towards higher tidal levels, there would be a corresponding increase in discharge temperature.

An extended set of options for the selection of the SZC cooling water outlet locations were modelled and then analysed, and a preferred location identified on the basis of minimising recirculation and environmental concerns. Location O9 offshore of the Sizewell-Dunwich Bank, the furthest west that a SZC CW outlet could be built (NNB GenCo, 2020b; TR306) was identified for 2 cooling water outlets (O9a and O9b). Their location is provided here and shown in Figure 2:

- cooling water outlet 1, O9a: TM 51080 64125

- cooling water outlet 2, O9b: TM 51155 64125

As a result of the direct cooling of the SZC power station with seawater, the EPR units at SZC will incorporate 2 fish recovery and return (FRR) systems to minimise the risk of injury to fish that are drawn into the cooling water system and return them to the Greater Sizewell Bay, but at a location where they are not likely to be returned to the cooling water intakes.

The 2 FRR system outlets are proposed to be located at the following National Grid references (NGRs) (as shown on Figure 2):

- FRR outlet 1: TM 47980 64000
- FRR outlet 2: TM 47980 64254

The specific design details of the 2 SZC FRR systems will largely replicate the Hinkley Point C (HPC) FRR design, taking into consideration the design best practice guidance, and will comply with marine licence conditions, when granted.

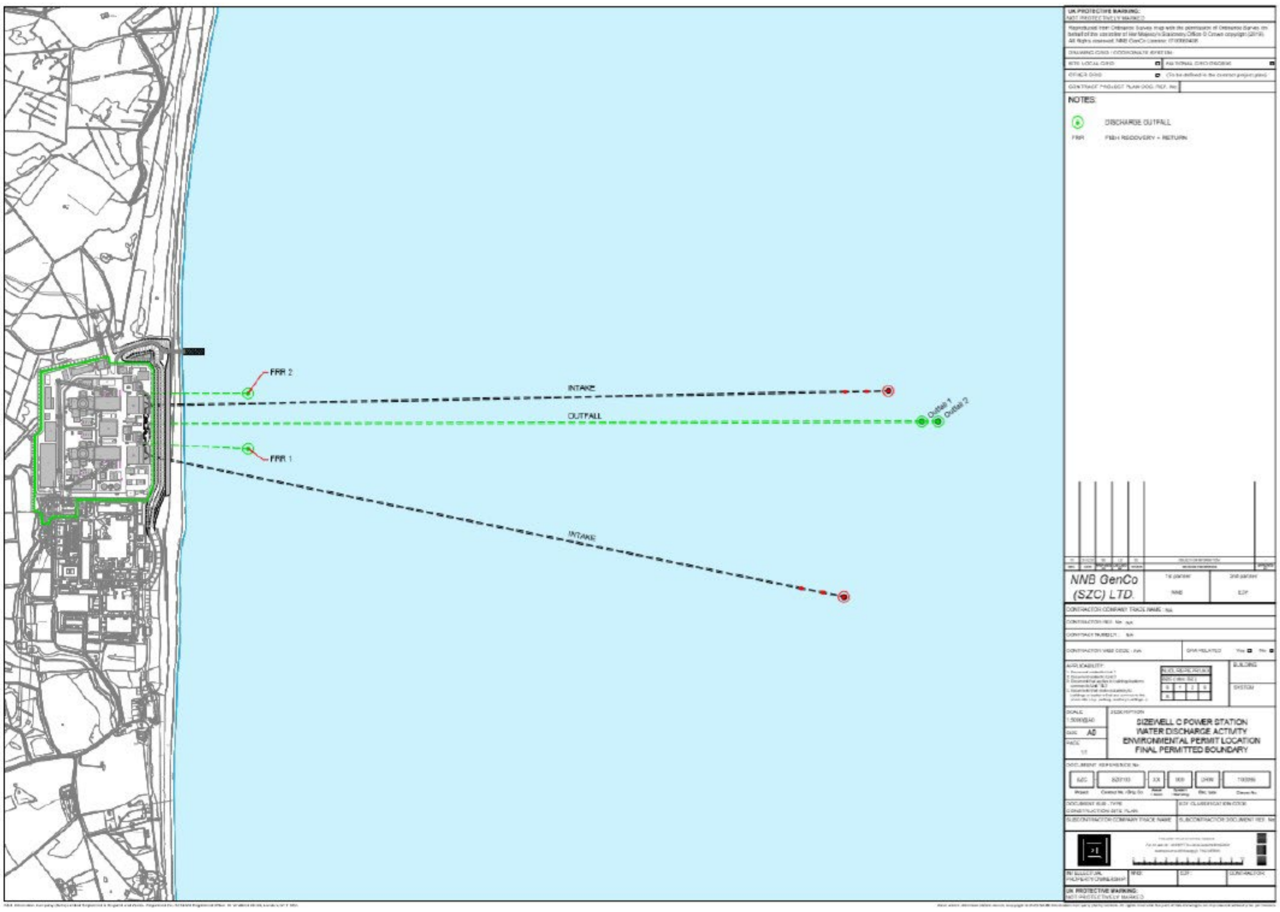

Figure 2: Location of the proposed cooling water inlets, discharge outlets and FRR system outlets (WDA permit application)

The proposed permit application will cover the operational water discharge activities (WDAs) from ‘hot functional testing’ during commissioning, through ‘operation’ and up until ‘decommissioning’ begins.

The conclusions of our HRA are based on the predicted environmental impact of SZC alone, and in combination with the operation of SZB, along with other processes.

The predicted environmental impact of SZC is defined by the operating criteria of the site, as set out in the environmental assessments carried out by the applicant. It is these assessments that this HRA is primarily based on, along with additional work we carried out in relation to the fish recovery and return (FRR) system discharge. The additional work was prompted by uncertainty in the conclusions drawn by the applicant from its own work.

Should the design or operation of SZC differ from that set out in the application documents, the environmental impact of the station may alter from that considered in this HRA. The impact of such changes would need to be assessed through a permit variation application and a new HRA would be carried out; any increase in environmental impact may alter the conclusions of the HRA. Any change in environmental impact would depend on the scale of the change and the nature of the process, or design aspect, that is altered.

The following are SZC operational components or processes which we relied on in our HRA assessment. The alteration of any of these would be expected to lead to a change in environmental impact:

- location and design of cooling water outfalls
- location and design of cooling water intakes
- cooling water abstraction and discharge rate
- generating capacity of power station and design of cooling water system, and discharge temperature of cooling water
- cooling water chlorination strategy, in terms of dose rate, duration of year when dosing is required, and point in cooling water circuit at which chlorination occurs (specifically whether occurs before or after the FRR system)
- hydrazine treatment process and thereby effluent concertation
- the design aspects of the FRR system that effect the survivability of organisms passing through the cooling water system
- processes undertaken for hot functional testing (HFT)
- outfall used to dispose of HFT effluents

The sources contributing to each of the proposed water discharge activities (WDAs) via waste streams A to H are described in some detail within section 4.0 of the permit application and are assessed within section 5.0 (via the applicant's Appendix A main supporting WDA application report). The sources brought forward for this HRAR have been determined using our H1 screening methodology (NNB GenCo, 2021a; TR193, see also 'Risk assessments for specific activities', available via www.gov.uk). The H1 methodology is used to identify any proposed hazardous chemical or other elements of discharges that represent a possible risk to the environment, and is required under the Environmental Permitting Regulations.

The chemicals associated with each waste stream are as follows:

Waste stream A

Effluent type: trade. Discharge rate of 132m^3/s (as a tidal mean).

Return of abstracted cooling water, which will be characterised by thermal content and will potentially be dosed with sodium hypochlorite to prevent biofouling of the cooling water infrastructure.

This will be the most significant discharge in terms of flow and will be discharged, in admixture with the effluents generated via waste stream B to G, back to the Greater Sizewell Bay via a dedicated cooling water tunnel and 2 outlets.

Chemicals associated with this waste stream include:

- total residual oxidant (TRO), as a result of adding biocide in the form of sodium hypochlorite to the incoming cooling water
- chlorination by-products (CBPs), from the reaction of residual oxidants with seawater

In addition to TRO and CBPs, Waste stream A will also result in increased temperature from the removal of waste heat from the condenser.

Waste stream B

Effluent type: trade. Maximum daily discharge volume, B+C, is 1,500m^3/day.

Trade effluent generated by operations within the nuclear island waste monitoring and discharge system.

The effluents generated by waste streams B and C will be discharged together in admixture with the continuous flow of cooling water generated by waste stream A.

Waste stream C

Effluent type: trade. Maximum daily discharge volume, B and C, is 1,500m^3/day.

Trade effluent generated by the steam generator blowdown system that cannot be recycled.

The effluents generated by waste streams B and C will be discharged together in admixture with the continuous flow of cooling water generated by waste stream A.

Chemicals or potential contaminants discharged from waste streams B and C

- ammonia, morpholine and ethanolamine: used to obtain, maintain and adjust the relevant pH to levels where minimum levels of corrosion occur
- hydrazine: used to eliminate oxygen in the steam generator feedwater to prevent fouling by corrosion products (principally iron oxides). Hydrazine decomposes when heated to produce ammonia
- lithium hydroxide: dosed into the primary circuit coolant in small amounts to counteract any changes in pH to maintain alkalinity to prevent equipment corrosion (to offset the acidity of boric acid)
- boric acid: used as a neutron absorber within the primary circuit to control reactivity
- trisodium phosphate: dosed into cooling and heating circuits to inhibit corrosion of circuits on contact with air (where an all-volatile treatment cannot be used)
- zinc acetate to inhibit corrosion
- metals arising from wear in the circuits and associated equipment (including aluminium, copper, chromium, iron, lead, manganese, nickel and zinc)
- hydrogen peroxide: to produce an oxidising environment during shutdown
- potential metal contaminants in process chemicals that are present in only trace amounts (cadmium and mercury)

One of the resulting detrimental effects is increased chemical oxygen demand (COD) which will come from the organic compounds (particularly detergents) to be used and also from oxidisable mineral salts in the water used.

Floor and equipment drains may be contaminated with cement dust (calcium compounds), possibly small concentrations of soaps and detergents, chemicals from closed cooling systems leaks or spills, decontamination water and other sources. The floor drains may also be high in dissolved organic materials and salts.

Waste stream D

Effluent type: trade. Maximum daily discharge volume is 1,500m^3/day.

Trade effluent generated from the turbine hall and uncontrolled area floor drains (excluding blowdown from the steam generator blowdown system).

Waste stream D will be discharged in an admixture with the continuous flow of cooling water generated by waste stream A.

Chemicals or potential contaminants discharged from waste stream D

- ammonia, morpholine and ethanolamine: Used to obtain, maintain and adjust the relevant pH to levels where minimum levels of corrosion occur
- hydrazine: used to eliminate oxygen in the steam generator feedwater to prevent fouling by corrosion products (principally iron oxides). Hydrazine decomposes when heated to produce ammonia
- trisodium phosphate: dosed into cooling and heating circuits to inhibit corrosion of circuits on contact with air (where an all-volatile treatment cannot be used)
- potential metal contaminants in process chemicals that are present in only trace amounts (cadmium and mercury)
- metals will arise from corrosion and erosion in the circuits where coolant and other process waters contact equipment. Metals used in the UK EPR™ equipment include aluminium (Al), copper (Cu), chromium (Cr), iron (Fe), manganese (Mn), nickel (Ni), lead (Pb) and zinc (Zn)
- suspended solids, largely arising from collected effluent that may be polluted by dust

One of the resulting detrimental effects is increased chemical oxygen demand (COD) which will come from the organic compounds, particularly detergents, to be used and also from oxidisable mineral salts in the water used.

Floor and equipment drains may be contaminated with cement dust (calcium compounds), possibly small concentrations of soaps and detergents, chemicals from closed cooling systems leaks or spills, decontamination water and other sources. The floor drains may also be high in dissolved organic materials and salts.

Waste stream E

Effluent type: trade. Maximum daily discharge volume is 35,000m^3/day.

Trade effluent generated from the site drainage system, including drainage from road and roof surfaces, uncontaminated water from oily water network and atmospheric condensate from chillers.

Waste stream E will be discharged on an intermittent basis, with the continuous flow of cooling water generated by waste stream A via the forebay.

Chemicals or potential contaminants discharged from waste stream E

- oils
- hydrocarbons
- suspended solids

Waste stream F

Effluent type: trade - known volume. Maximum daily discharge volume is 4,000m³/day.

Trade effluent from the production of demineralised water, which will be treated to neutralise extremes of pH before joining the main discharge.

Chemicals or potential contaminants discharged through waste stream F

- iron, predominantly introduced as ferric chloride into the demineralisation plant
- suspended solids, present in the slurry and filter back-washings from the demineralisation plant
- sulphates, introduced as sulphuric acid to (a) clean the resins and membranes within the demineralisation plant; and (b) treat effluent within the neutralisation pit
- sodium, introduced as sodium hydroxide to (a) clean the resins and membranes within the demineralisation plant; and (b) treat effluent within the neutralisation pit
- chlorides, introduced as ferric chloride or sodium hypochlorite in the demineralisation plant
- trace metal contamination of raw materials such as sodium hydroxide and sulphuric acid used in the demineralisation process. Contamination usually includes cadmium and mercury
- detergents
- sequestering agents

Waste stream G

Effluent type: domestic sewage. Maximum daily discharge volume is 190m³/day.

Sanitary effluent from administration and mess facilities, which will be treated in an appropriate effluent treatment plan before joining the main discharge.

The waste stream G treated sewage effluent will be discharged via one of the site's 2 outlet ponds (one per EPR unit) and into the main cooling water flow (waste stream A).

Chemicals or potential contaminants discharged through waste stream G

- suspended solids
- ammonia
- nitrate
- phosphate

One of the resulting detrimental effects is increased biochemical oxygen demand (BOD).

Waste stream H

Effluent type: trade. Maximum volume of 25,920m³/day per FRR system. Returned abstracted seawater from the 2 fish recovery and return (FRR) systems, operating on a continuous basis.

Chemicals or potential contaminants discharged through waste stream H

A proportion of the biota abstracted with the cooling water will not survive transit through the FRR systems, and any dead or moribund biota will also be returned to the receiving waterbody. It is the discharge of this moribund biota that constitutes a potential source of polluting matter, and the potential impacts on water quality and designated features must therefore be assessed.

This assessment will require consideration of the contribution to nutrients, un-ionised ammonia, organic enrichment, biochemical oxygen demand and de-oxygenation caused by decaying fish/biota from the 2 SZC FRR system discharges.

2. Relevant European sites for WDA permit

In order to assess the potential impact of the operation of Sizewell C, we first need to establish which sites could potentially be at risk; this requires us to define our screening parameters. The permission does not have to be located within a site or discharge directly into one in order for there to be an effect. For this assessment, we will consider if there is a source-receptor pathway for any potential effects from SZC.

Firstly, we have sites that have ‘direct connectivity’. These are sites where the permission is located within or discharges directly into it. There are also sites with ‘indirect connectivity’ where the pathway for the discharge to reach the site is by an indirect mechanism. One example of indirect connectivity would be if a sluice allowed sea water into a freshwater environment, therefore allowing any changes to that sea water as a result of the SZC operation to potentially impact on the freshwater environment and the sites and species that depend on it.

We also have identified a ‘zone of influence’ (ZOI). This is a geographic area around SZC, and anything within this area could potentially be impacted by operations due to proximity.

There are potentially a number of more distant UK sites that need considering in the HRAR. These sites have mobile features such as seabirds, marine mammals and migratory fish that can travel great distances. Such species could potentially be present within the waters affected by the SZC operation and therefore impact on them must be considered. In a case such as this, the area impacted by SZC is considered to be ‘functionally linked’ to these distant sites. For seabird features, we use the foraging range of the breeding birds to help define this – ‘distant bird sites’. For UK sites with marine mammal and migratory fish species, we use survey results from the SZC area to identify their presence – ‘distant mammal and fish sites’.

These mobile species may also come from a number of ‘continental sites’ that are designated for a variety of fish species which are recorded as being able to traverse great distances. These sites have therefore also been given due consideration.

The following list of European sites has been identified using principles outlined as requiring assessment within this HRAR. They all contain features that have the potential to be directly or indirectly affected by the permissions. Sites that were identified in the HRAR for the SZC project, but do not have the potential to be affected by the proposal (due to a lack of an impact mechanism or sensitive receptor), are not included in this assessment. Maps showing the location of the sites are provided in Environment Agency (2022a; Annex 1).

Sites with direct connectivity or within the potential zone of influence or Greater Sizewell Bay Area are as follows:

- Alde-Ore and Butley Estuaries SAC: located to the south of the main development site and there is therefore potential for water discharges to reach the site
- Alde-Ore Estuary Ramsar: located to the south of the main development site and there is therefore potential for marine water discharges to reach the site
- Alde-Ore Estuary SPA: located to the south of the main development site and there is therefore potential for marine water discharges to reach the site
- Benacre to Easton Bavents SPA: located 15km from the main development site
- Minsmere to Walberswick Heaths and Marshes SAC: adjacent to the main development site, so there is potential for the WDA to interact with the site
- Minsmere-Walberswick Ramsar: adjacent to the main development site, so there is potential for marine discharges to enter the freshwater element via the Minsmere Sluice
- Minsmere-Walberswick SPA: adjacent to the main development site, so there is potential for marine discharges to enter the freshwater element via the Minsmere Sluice
- Orfordness-Shingle Street SAC: located to the south of the main development site and there is therefore potential for marine water discharges to reach the site
- Outer Thames SPA: adjacent to the main development site and the operational outlet goes directly into the site
- Southern North Sea SAC: adjacent to the main development site and the operational outlet goes directly into the site

Further information on these sites is provided in Environment Agency (2022a; Annex 1) which contains maps, Environment Agency (2022b; Annex 2) which contains site information, and Environment Agency (2022c; Annex 3) which provides an ecological narrative of the features.

2.1. More distant sites with potential for functional linkage

In developing the methodology for this HRAR, we have referred to a Natural England commissioned report on functional linkage (Chapman and Tyldesley, 2016), which says the term ‘functional linkage’ refers to “the role or ‘function’ that land or sea beyond the boundary of a European site might fulfil in terms of ecologically supporting the populations for which the site was designated or classified. Such land is therefore ‘linked’ to the European site in question because it provides an important role in maintaining or restoring the population of qualifying species at favourable conservation status.”

We will therefore consider if there are any mobile species from more distant sites where the Greater Sizewell Bay Area could be considered to provide functional linkage.

2.2. Seabirds

The screening will consider if breeding seabirds could be ecologically supported by Greater Sizewell Bay (which is within the Outer Thames Estuary SPA) as functionally linked land, and therefore whether there is the potential for the cooling water and/or FRR system discharges to detrimentally affect them.

2.2.1. Methodology applied to assessment of breeding seabirds

Foraging areas

Breeding seabirds are central place foragers, meaning that foraging trips feature a departure from, and a return to, the nest. The potential foraging area from a colony can therefore be described as occurring within a circle, or arc, centred on the colony location, with a radius specific for each species, and equal to its foraging range.

If the foraging range of a breeding seabird feature overlaps with thermal or chemical plumes, or with the area of organic enrichment, then the feature may be affected. Woodward and others (2019) provide generic foraging ranges for seabird species based upon reviews of data from tracked seabirds. The mean maximum foraging range is the average maximum extent of the foraging range. We have used mean maximum foraging ranges plus their standard deviation (Woodward and others, 2019) in order to determine whether there is the potential for a breeding seabird feature to be functionally linked with the main development site (Table 1). The use of the standard deviation accounts for the variability in the mean maximum foraging ranges recorded for a particular species. The standard deviation describes, on average, how far each score lies from the mean.

Table 1: Foraging ranges of designated bird populations based upon reviews of data from tracked seabirds (Woodward and others, 2019)

Breeding seabird feature	Mean maximum + SD (km)	Mean maximum (km)
Lesser black-backed gull (Larus fuscus)	236.0	127.0
Sandwich tern (Sterna sandvicensis)	57.5	34.3
Little tern (Sternula albifrons)	-	5.0
Common tern (Sterna hirundo)	26.9	18.0
Fulmar (Fulmarus glacialis)	1,200	542.3
Gannet (Morus bassanus)	509	315.2
Kittiwake (Rissa tridactyla)	300	156.1
Puffin (Fratercula arctica)	265	137.1

The following sites have bird features that could potentially be impacted by the operation of SZC. This means that there is potential for functional linkage with the main development site as they lie within the mean maximum + standard deviation foraging ranges as outlined in Woodward and others (2019). Alternatively, there is potential for breeding seabird features to come into contact with areas affected by discharges from SZC. In short, a source-receptor pathway may exist for features of the following sites:

- Alde-Ore Estuary SPA: designated for lesser black-backed gull, sandwich tern and little tern
- Alde-Ore Estuary Ramsar: designated for lesser black-backed gull
- Benacre to Eastern Bavents SPA: designated for little tern
- Minsmere-Walberswick SPA: designated for little tern
- Flamborough and Filey Coast SPA: designated for gannet, kittiwake, fulmar (assemblage) and puffin (assemblage)*
- Coquet Island SPA: designated for fulmar (assemblage)*

*There are more distant seabird sites for these features that fall within the mean maximum + standard deviation, however these are the closest sites. These will be assessed in the first instance and further sites can be assessed if it is considered necessary.

Further information on these sites is provided in Environment Agency (2022a; Annex 1) which contains maps, Environment Agency (2022b; Annex 2) which contains site information, and Environment Agency (2022c; Annex 3) which provides an ecological narrative of the features.

2.3. Marine mammals

The relevant site screening will consider marine mammals that are ecologically supported by the Greater Sizewell Bay as potentially functionally linked land, and therefore will consider whether there is the potential for the cooling water and/or FRR system discharges to detrimentally affect them.

2.3.1. Methodology applied to assessment of marine mammals

In NNB GenCo (2021b; shadow HRA) the applicant tells us that:

- data from a telemetry tagging study of grey seals (Halichoerus grypus) showed that individuals travel from the Donna Nook haul-out site (which is within the Humber Estuary SAC and Ramsar) along the east coast of England and down to the Kent and Essex coastlines, including travelling through the Greater Sizewell Bay area
- the same telemetry study provided evidence of connectivity between the Donna Nook haul-out site and the northern France and Netherlands coastlines, but there was no evidence that individuals from the designated sites for grey seal in these areas travel to the Greater Sizewell Bay area. Tagged grey seals were shown to travel directly between Donna Nook and the north coasts of France and the Netherlands only and did not pass along the Suffolk or Kent coastline
- marine mammal observations in Greater Sizewell Bay have recorded grey seals near the SZB outlet and further offshore across and seaward of the Sizewell-Dunwich sandbank in the vicinity of the proposed SZC intake and outlet infrastructure. Observations occurred on a regular basis, and in the winter and spring survey, seals were recorded on almost 40% of survey days
- maps of grey seal distribution (produced by combining information about the movement patterns of electronically tagged seals with survey counts of seals at haul-out sites) predict grey seal presence in relatively low densities within the Greater Sizewell Bay area

Also:

- harbour seals (Phoca vitulina) typically travel 40 to 50km from their haul-out sites to foraging areas but data from telemetry tagging studies of harbour seals have shown individuals travelling from The Wash haul-out site (within The Wash and North Norfolk Coast SAC) along the Suffolk and Kent

coastlines, including passing through the Greater Sizewell Bay area. Connectivity has also been shown between harbour seals that haul out along the Kent and Essex coastlines with The Wash and North Norfolk Coast SAC population, with individuals passing through the Greater Sizewell Bay area
- some individuals from The Wash travelled repeatedly over 200km to foraging areas. However, there was a large variation in the distance travelled and the average was lower at 80km
- maps of harbour seal distribution (produced by combining information about the movement patterns of electronically tagged seals with survey counts of seals at haul-out sites) predict harbour seal presence in relatively low densities within the Greater Sizewell Bay area

The closest continental European site with harbour seal as a feature is the Unterweser SCI, but at a distance of 479km from Sizewell, this site and other continental European sites (see LSE screening spreadsheet, available at [Information regarding three new environmental permit applications for the proposed Sizewell C power station - Environment Agency - Citizen Space]), are beyond the foraging range of harbour seal and therefore have no potential for functional linkage.

It is therefore considered that the following sites have the potential for functional linkage for grey seal and so these sites are scoped into the assessment:

- Humber Estuary SAC
- Humber Estuary Ramsar

It is also considered that the following site has the potential for functional linkage for the harbour seal, and so this site is scoped into the assessment:

- The Wash and North Norfolk Coast SAC

Further information on these sites is provided in Environment Agency (2022a; Annex 1) which contains maps, Environment Agency (2022b; Annex 2) which contains site information and in Environment Agency (2022c; Annex 3) which provides an ecological narrative of the features.

2.4. Fishes

2.4.1. Methodology applied to Annex II fish species

Impingement monitoring at SZB recorded the following 4 Annex II fish species (NNB GenCo, 2020c; TR406), with no Annex II species recorded during entrainment monitoring (NNB GenCo, 2019a; TR318):

- river lamprey (Lampetra fluviatilis)
- sea lamprey (Petromyzon marinus)

- twaite shad (Alosa fallax)
- allis shad (Alosa alsoa)

These features therefore need to be considered further.

The applicant identified that the closest UK North Sea coast protected sites where these features are found is the Humber Estuary SAC and Ramsar for both the sea lamprey and river lamprey. No UK North Sea coast sites were identified for twaite shad or for allis shad.

The applicant also identified that river lamprey, sea lamprey and twaite shad are features of 10 continental North Sea sites that are Sites of Community Importance (SCI). The closest of these is just under 200km away (see Environment Agency (2022a; Annex 1) site maps and LSE screening table, available at Information regarding three new environmental permit applications for the proposed Sizewell C power station - Environment Agency - Citizen Space).

The closest UK site for which allis shad are a qualifying feature is the Plymouth Sound and Estuaries SAC, over 500km from SZC (see Environment Agency (2022a; Annex 1) site maps and LSE screening table, available at Information regarding three new environmental permit applications for the proposed Sizewell C power station - Environment Agency - Citizen Space).

Further information on these sites is provided in Environment Agency (2022a; Annex 1) which contains maps, Environment Agency (2022b; Annex 2) which contains site information, and Environment Agency (2022c; Annex 3) which provides an ecological narrative of the features.

3. General methodology for assessment of discharges to surface waters

This HRAR has been carried out in line with guidance that describes how to complete a risk assessment for bespoke environmental permits (under The Environmental Permitting (England and Wales) Regulations 2016) that include discharges containing hazardous chemicals and elements to surface freshwaters, transitional and coastal (TraC) waters (Environment Agency, 2019).

The Environment Agency sets limits on environmental permits for the substances in 2008/105/EC, (as amended by 2013/39/EU), the Environmental Quality Standards Directive (EQSD) and for specific pollutants covered by Annex 8 of 2000/60/EC the Water Framework Directive (WFD). The standards for these substances were transposed into UK legislation through The Water Framework Directive (Standards and Classification) Directions (England and Wales) 2015.

Environment Agency (2019) lists environmental quality standard (EQS) thresholds for 'hazardous chemicals and elements'. An EQS is the concentration below which a substance is not believed to be detrimental to aquatic life, based on the results of toxicity tests on organisms covering a range of levels within food chains. Each substance has its own EQS which can differ depending on whether the receiving environment is fresh, transitional, or coastal water.

Hazardous chemicals and elements in Environment Agency (2019) are comprised of:

- pollutants classed as either priority hazardous substances, priority substances or 'other pollutants' by the EQSD
- specific pollutants listed in The Water Framework Directive (Standards and Classification) Directions (England and Wales) 2015
- substances which have an operational (non-statutory) environmental quality standard (EQS)

Environment Agency (2019) can also be applied to assess the environmental risk of substances with ecotoxic properties which are not within the above categories, but that are present in discharges at sufficient concentrations to be of potential environmental concern. Rather than an EQS, these substances may have an equivalent environmental/ecotoxic threshold such as a predicted no effect concentration (PNEC) value. The Environment Agency's ecotoxicology advisory service (ETAS) typically reviews any PNECs or other alternative threshold values that are proposed by an applicant for substances without an EQS, to confirm that the PNEC has been appropriately derived.

Substances with EQSs will have either a maximum allowable concentration (MAC) or an annual average concentration standard or both, and so the risk assessment will take into consideration mixing zones (section 3.1), short-term (section 3.2) and long-term effects (section 3.3).

3.1. Mixing zones

The mixing zone is defined as the predicted area of the receiving waterbody that is expected to contain concentrations of these substances above the relevant EQS or PNEC value as a result of the discharge.

For each substance, computer modelling will be used to determine the extent of the mixing zone created by the cooling water discharge in order to determine the environmental impact and pollution risk of these relevant substances. The extent of the predicted mixing zone, with reference to the underlying toxicity data, can then be used to determine whether there would be an adverse effect on designated features or sites.

Based on the modelling and appropriate assessment outcomes, we may include specific conditions within any granted permit to control relevant hazardous chemicals or elements within the WDAs from the site. For example, numeric compliance conditions or limits could be applied for a substance to ensure the modelled mixing zone is not exceeded resulting in an adverse effect on site integrity. However, we may refuse the permit application if the impact on the receiving environment is determined to be unacceptable as a result of the proposed discharge and where we cannot conclude no adverse effect on site integrity.

3.2. Short-term effects

The MAC EQS of the proposed substance will be considered in order to evaluate the short-term environmental impact that the proposed discharge of the substance may cause. For substances with PNEC values, the short-term environmental impact is assessed via an appropriately derived acute PNEC value (calculated as a maximum allowable concentration, or maximum as a 95th percentile).

3.3. Long-term effects

The annual average EQS concentration of the proposed substance will be considered in order to evaluate the long-term environmental impact that the proposed discharge may cause. For substances with PNEC values, the long-term environmental impact is assessment via an appropriately derived chronic (calculated as a mean/average) PNEC value.

3.4. Application to assessing cooling water systems

For power stations with direct (or partial direct) cooling water systems, a specific allowance and methodology has been developed for the assessment of hazardous chemicals and elements (Environment Agency, 2019). This is to assess the substances within any continuous or batched process waste streams that are discharged into the main cooling water stream (which provides an effective ‘initial dilution’ of these process waste streams) before they are discharged in admixture into the receiving environment.

Circumstances where this allowance can be made for dilution by the cooling water stream are those power stations discharging to lower estuaries or to coastal waters. This is the case with the proposed operational water discharge activities from Sizewell C that are the subject of this HRAR.

As part of the assessment, the applicant must take into account existing background concentrations of the hazardous chemicals and elements within the abstracted cooling water from the coastal waterbody. This provides the prevailing environmental conditions that must be considered when concluding an HRAR.

4. Risks and hazards associated with current application from the WDA

The following are the reasonably foreseeable risks for this type of project, as generated via our internal Habitat Regulations Assessment system (HRAS) database:

1. change in thermal regime
2. toxic contamination
3. nutrient enrichment
4. turbidity
5. siltation
6. physical damage
7. pH
8. change in salinity regime

Some of these risks may not be relevant to the proposed operational WDA at SZC and this will be explained in sections 4.1 to 4.8. Risks which are not relevant do not require further assessment within this HRAR.

The sensitivity of the European sites and features are shown in Environment Agency, 2022b; Annex 2.

4.1. Change in thermal regime

This risk is relevant as SZC will discharge heated water from the cooling system.

Background to this risk: This risk can occur due to substantial increases or decreases in receiving water temperatures as a result of a water discharge activity (WDA), for example, by a discharge of water/effluent that is a different temperature to the receiving waterbody. Water temperature influences aquatic organisms and affects the composition of biological communities. The effects can be seen in their growth and development, tolerance to toxic substances, success in reproduction, disease resistance and, ultimately, whether they survive. Water temperature can also affect egg development, fish survival, feeding and growth. Temperature can also have an indirect effect on aquatic species by causing changes to water chemistry, for example, oxygen is less soluble in warmer water. Long-term increases can also introduce the risk of the establishment of non-native species. Dissolved oxygen becomes limiting at high temperatures, particularly where there are additional pressures such as siltation and nutrient enrichment, which may lead to low dissolved oxygen conditions within gravels.

For this assessment change in thermal regime will consider:

- change in thermal regime arising from the discharge of cooling water.
    - direct effects may occur through the feature encountering the heated water discharged from the CWS
    - indirect effects may occur if prey avoid areas of heated water, leading to a reduction in prey availability, or an increase in energy expenditure required to locate displaced prey

4.2. Toxic contamination

Chemicals will be discharged via the CWS which have the potential to cause toxic contamination.

Background to risk: Emissions from WDAs that could be toxic or harmful to the flora and fauna of the protected/designated sites, and/or could result in damage to vegetation and/or other sensitive organisms and qualifying features. For example, direct impacts (for example, a discharge containing concentrations of pollutants killing fish within the receiving waterbody), or indirectly (for example, heavy metal take-up by vegetation which is then grazed by birds).

All significant direct sources of chemicals to the environment are controlled and generally assessed against recognised standards such as environmental quality standards (EQS), groundwater quality standards or formal threshold values. These standards are designed to protect aquatic habitats and species.

This assessment will consider:

- toxic contamination (chemical) arising from the discharge of chemicals in the cooling water system
    - direct effects may occur through the feature coming into contact with toxic chemicals
    - indirect effects may occur if toxic contamination alters communities in supporting habitats
    - indirect effects may occur through prey coming into contact with toxic chemicals, and the prey items then being eaten by the feature (bioaccumulation)
    - indirect effects may occur if prey avoid areas of toxic contamination, leading to a reduction in prey availability

4.3. Nutrient enrichment

There will be a discharge from the onsite sewage treatment works (STW) (waste stream G) while dead and moribund biota from the FRR systems (discharged with waste stream H) could also contribute to nutrient enrichment.

Background to this risk: Eutrophication is the gradual increase and enrichment of ecosystems by nutrients such as nitrogen (N) and/or phosphorus (P). For example, WDAs containing treated sewage effluent will have elevated phosphorus and nitrogen levels relative to the receiving water. The addition of nutrients may lead to changes in nutrient sensitive vegetation, either directly affecting protected habitats and species of flora, or indirectly affecting protected species dependent upon existing habitats.

When there are excessive nutrients in intertidal habitats, dense algal mats can form. These can smother the intertidal habitat, prevent oxygen and nutrient flow, and block light. Algal mats can also form a barrier to birds which feed by probing the intertidal mud. This can, in turn, impact on the availability and suitability of bird breeding, rearing, feeding and roosting habitats. In salt marshes, changes to the nutrient status of the underlying sediment (away from typical natural values) and/or the processes that allow the effective cycling of nutrients may affect the vegetation communities.

High concentrations of nutrients in the water column can also cause ‘phytoplankton’ and opportunistic ‘macroalgae’ blooms, leading to reduced dissolved oxygen availability. This can impact sensitive fish, as well as biological communities living on or within the substrate, and therefore adversely affect the availability and suitability of bird breeding, rearing, feeding and roosting habitats.

This assessment will consider:

- changes in nutrients/eutrophication arising from sewage discharge via the cooling water system and from the discharge of dead and moribund biota from the fish recovery and return (FRR) systems
    - indirect effects may occur if the integrity of the site is affected by changes in water quality. Our assessment considers:
        - nutrient concentrations
        - un-ionised ammonia
        - dissolved oxygen
        - phytoplankton production
        - organic enrichment

4.4. Turbidity

The WDA has the potential to increase turbidity (the amount of suspended solids in the water) due to the discharge of nutrients, leading to an increase in plankton production. This risk will therefore be considered under section 4.3 nutrient enrichment. There are no other potential turbidity effects as the turbidity of the water being discharged will effectively be equal to that being abstracted, and to the background level.

Background to risk: Water turbidity is a result of material suspended in the water, including sediment, plankton, pollution and/or other matter. Turbidity levels can change (rise and fall) rapidly as a result of different factors, including biological (for example, plankton blooms), physical (for example, storms/floods) or human (for example, physical disturbance from coastal development or discharge activities).

Increased turbidity associated with suspended solids in the discharge can decrease the depth light is able to penetrate water, which can affect photosynthesis by plants and macro algae (for example, if light is not able to reach the seabed). This could affect invertebrates both directly, and as food for birds. Young fish can be damaged if sediment becomes trapped in the gills. Suspended solids can affect filter-feeding organisms through clogging and damage to feeding and/or breathing equipment, and/or affect seabed sedimentation rates.

4.5. Siltation

There will be a discharge of suspended solids via the STW.

Background to risk: Physical damage caused by the deposit of suspended solids from WDAs. If coarser substrate is blocked by fine sediment, it restricts water flow-through. This can be damaging if it is excessive, or if it reduces the dissolved oxygen in critical patches of habitat. This can particularly affect fish spawning areas and gravels housing protected invertebrates. Siltation can cover food for birds and kill macro invertebrates or render them inaccessible. It may also affect the feeding behaviour of birds and other animals that detect prey by sight.

4.6. Physical damage

The WDA discharge points are directly into the Southern North Sea SAC and Outer Thames Estuary SPA. We will therefore consider if there is potential for physical damage from erosion caused by the discharge.

Background to risk: Physical damage to vegetation or other sensitive features from a WDA as a result of its rate and frequency of occurrence, as well as its proximity to the designated site(s) and/or qualifying features. For example, damage caused by erosion/scour of sediment by a surface water or trade effluent WDA. This could, in turn, impact sensitive fish, epifauna and infauna communities which rely on the impacted sediment, and/or within the surrounding receiving waterbody/water column.

4.7. pH

There will be no change in pH as the discharge will be heated seawater and chemicals/sewage and discharge from FRR systems. This risk will not be considered further in this assessment.

4.8. Changes in salinity regime

There will be no change in salinity as the discharge will be heated seawater and chemicals/sewage and discharge from FRR systems. This risk will not be considered further in this assessment.

4.9. Conclusion

This assessment will therefore focus on the following risks:

- change in thermal regime
- toxic contamination (from any chemicals discharged)
- nutrient enrichment (this will also include eutrophication and turbidity from increasing nutrients)

In addition to the above risks, for the sites that the WDA discharges directly into (Southern North Sea SAC and Outer Thames Estuary SPA), this assessment will also consider the potential for:

- siltation
- physical damage

5. Likely significant effect

Regulation 63(1) of The Conservation of Habitats and Species Regulations 2017 requires the competent authority to carry out a screening exercise to identify those permissions, plans or projects (PPP) that are likely to have a significant effect on the features of a European site. These effects are then subject to appropriate assessment.

For this assessment, a very high level and precautionary likely significant effect (LSE) stage will be carried out considering a simple source-receptor pathway link due to the bespoke detailed modelling submitted with the application and associated detailed assessment work that was carried out for this HRAR. This is in line with Bagmoore Wind case law, which says:

> A project is 'likely to have a significant effect' if there is a real risk of a likely significant effect occurring that is, the risk of it occurring cannot be excluded on the basis of objective information
>
> "If the absence of risk in the plan can only be demonstrated after a detailed investigation, or expert opinion, that is an indicator that a risk exists and the authority must move from preliminary examination to appropriate assessment".

For the operational WDA permit, we have used a simple source-receptor pathway approach for the LSE screening as follows:

1. Is there a pathway such that the potential hazard could affect the interest features alone? If it is considered there is no connectivity, or any connectivity or effect would be of low-impact and too small to result in a conceivable effect on the feature or site then no in-combination assessment is required.

2. What is the exposure of the feature to this hazard?

3. For each hazard, is the potential scale or magnitude of any effect likely to be significant? The aim of the screening process is to identify those hazardous chemicals and elements within the process waste streams that may contribute to the deterioration of the receiving waterbody. This may be through preventing the achievement of the conservation objectives for a European site.

For any hazardous chemicals and elements that fail the screening process, there will be a need for further assessment or investigation via the completion of appropriate bespoke modelling. The applicant completes this modelling as part of its supporting information and we review and audit it as part of the permit application's determination and appropriate assessment.

The applicant submitted a discharges H1-type assessment report (NNB GenCo, 2021a; TR193) as part of the operational WDA permit application to determine the environmental significance of relevant substances and to inform NNB GenCo (2021b; shadow HRA).

The H1 screening methodology is used to identify any proposed hazardous chemical or other elements of discharges that represent a possible risk to the environment and is required under the Environmental Permitting Regulations. For marine discharges, the standard approach for determining the potential impacts to water quality from industrial aqueous discharges is to apply the Environment Agency/Defra screening of contaminant contributions from surface drainage sources from the Environment Agency's H1 Environmental Risk Assessment. Any substances identified as a potential risk in the H1 process are then subject to further analysis and detailed modelling.

We have reviewed this assessment and agree with the applicant's conclusions that hydrazine, chlorine produced residual oxidants (TRO) and bromoform concentrations in the operational discharge will exceed the acute EQS/PNEC values and will therefore be taken forward for assessment via more detailed modelling in the appropriate assessment. The H1 assessment conclusions are summarised here and further detail is contained in Appendix C.

The phosphate input is several times above background (Appendix C), and as phosphate can contribute to nutrient status it will be given further consideration in the following appropriate assessment.

Un-ionised ammonia was 35% of its EQS (Appendix C) and will be considered further in the following assessment. The 24-hour discharge concentration of dissolved inorganic nitrogen was 49% of the site 99th percentile winter standard for water bodies of intermediate turbidity (Appendix C). As the loading of dissolved inorganic nitrogen (DIN) may influence algal growth, this will be considered further in the appropriate assessment.

Copper, zinc, lithium hydroxide, aluminium, boron (boric acid), morpholine and DIN also appeared to fail the H1 screening (Appendix B). However, they will not be considered further for the following reasons:

Copper, zinc, and boron exceedance of EQS assessment criteria is due to high background loading rather than discharge concentration (Appendix B). Lithium hydroxide, phosphate and aluminium do not have EQS or PNEC values, but instead reference site mean backgrounds, and so failure is also due to background loading (Appendix B).

Morpholine was 58% of its derived PNEC for 24 hour discharges but is a readily degradable chemical and has a low likelihood of bioconcentration (Appendix B of

NNB GenCo, 2021a; TR193), which coupled with its low toxicity indicates it would have negligible effects on marine species under this discharge scenario.

5.1. LSE assessment for the European sites

The potential for likely significant effect on European sites is considered in sections 5.1.1 to 5.1.4. Firstly, we consider the potential for LSE on designated sites within the Greater Sizewell Bay area (section 5.1.1). Migratory and highly mobile features of more distant designated sites are then considered to establish whether they are ecologically functionally linked to the Greater Sizewell Bay area (sections 5.1.2, 5.1.3 and 5.1.4).

Please note that the likely significant effect conclusions for all sites and features for the 3 permits applied for are summarised in the LSE screening spreadsheet (available at Information regarding three new environmental permit applications for the proposed Sizewell C power station - Environment Agency - Citizen Space).

5.1.1. Sites within the zone of influence or the Greater Sizewell Bay Area

Alde-Ore and Butley Estuary SAC

Features

- Atlantic salt meadows
- mudflats and sandflats not covered by seawater at low tide: intertidal coarse sediment: intertidal mixed sediment: intertidal mud: Intertidal sand and muddy sand
- estuaries: Atlantic salt meadows: Intertidal coarse sediment: Intertidal mixed sediments: Intertidal mud: Intertidal sand and muddy sand: Subtidal mud: Subtidal mixed sediments

Conclusion

The site is to the south of the main development site, and the features could be sensitive to change in thermal regime, toxic contamination (chemical) and nutrient enrichment.

There is therefore considered to be LSE alone and the site and features will be taken forward into appropriate assessment to assess, by detailed modelling, whether the WDA discharges could reach the site and therefore the habitat features (section 7.1).

Alde-Ore Estuary Ramsar

Features

- avocet, Recurvirostra avosetta (wintering)
- lesser black-backed gull, Larus fuscus (breeding)

- redshank, Tringa totanus (wintering)
- waterbird assemblage (wintering)
- wetland bird assemblage (breeding)
- wetland invertebrate assemblage
- wetland plant assemblage

Conclusion

The site is to the south of the main development site, and the features could be sensitive to change in thermal regime, toxic contamination (chemicals) and nutrient enrichment.

As detailed bespoke modelling work to define the extent of the WDA effects will be carried out, it is considered that there is a likely significant effect alone and therefore the site and features will be taken forward into appropriate assessment (section 7.2).

In addition, lesser black-backed gull will be considered in detail in the appropriate assessment as marine foraging ranges show that the feature could come into contact with WDA discharges (section 8).

Alde-Ore Estuary SPA

Features

- avocet, Recurvirostra avosetta (breeding)
- avocet, Recurvirostra avosetta (non-breeding)
- lesser black-backed gull, Larus fuscus (breeding)
- little tern, Sterna albifrons (breeding)
- marsh harrier, Circus aeruginosus (breeding)
- redshank, Tringa totanus (non-breeding)
- ruff, Philomachus pugnax (non-breeding)
- Sandwich tern, Sterna sandvicensis (breeding)

Conclusion

It is considered there is a likely significant effect alone for this site and its features as they are considered sensitive to change in thermal regime, toxic contamination (chemicals) and nutrient enrichment.

Little tern, Sandwich tern and lesser black-backed gull will be considered in detail in the appropriate assessment (section 8) as foraging ranges and site-specific surveys provided by the applicant show they could feed in the wider marine environment outside the designated site.

For the other features, the appropriate assessment will first consider, through detailed modelling, if the WDA could reach the site as a source-receptor pathway will be dependent upon the discharge from the WDA reaching the Alde-Ore Estuary itself (section 7.3).

Benacre to Easton Bavents SPA

Features

- bittern, Botaurus stellaris (breeding)
- little tern, Sterna albifrons (breeding)
- marsh harrier, Circus aeruginosus (breeding)

Conclusion

For the bittern and marsh harrier it is considered there is no source-receptor pathway link due to the freshwater requirements of the features and the distance from the SZC site.

It is considered there is a likely significant effect alone for the little tern feature as bespoke modelling will be required to determine whether marine foraging ranges will allow the feature to come into contact with WDA discharges.

This will be considered in detail within the appropriate assessment (section 8). The other features will not be considered further.

Minsmere to Walberswick Heaths and Marshes SAC

Features

- annual vegetation of drift lines: This habitat type occurs on deposits of shingle lying at or above mean high-water spring tides
- perennial vegetation of stony banks: This habitat occurs above the high tide line
- European dry heaths: terrestrial feature, so no connectivity to the marine environment

Conclusion

There is no source-receptor pathway between the features and the discharge from the CWS or FRR systems. The marine discharge will only reach the site on exceptional occasions as the features are above the high tide line. As any connectivity would be of low-impact and too small to result in a conceivable effect, it is considered there is no likely significant effect alone or in combination, and the site and features will not be considered further.

Minsmere to Walberswick Ramsar

Features

- mosaic of marine, freshwater, marshland and associated habitats
- wetland bird assemblage - breeding

- wetland invertebrate assemblage

Conclusion

This site and its features will be considered further in order to assess potential connectivity between the freshwater habitats and the WDA via the Minsmere Sluice using a bespoke, detailed model. It is therefore considered that there is a likely significant effect alone and it will be considered within the appropriate assessment (section 7.4).

Minsmere to Walberswick SPA

Features

- avocet, Recurvirostra avosetta (breeding)
- bittern, Botaurus stellaris
- gadwall, Anas strepera (breeding)
- gadwall, Anas strepera (non-breeding)
- greater white-fronted goose, Anser albifrons albifrons (non-breeding)
- hen harrier, Circus cyaneus (non-breeding)
- little tern, Sterna albifrons (breeding)
- marsh harrier, Circus aeruginosus (breeding)
- nightjar, Caprimulgus europaeus (breeding)
- shoveler, Anas clypeata (breeding)
- shoveler, Anas clypeata (non-breeding)
- teal, Anas crecca (breeding)

Conclusion

Nightjar is a terrestrial feature with supporting terrestrial habitat. It is considered that there is no likely significant effect from the WDA permit, as there is considered to be no connectivity between plumes and the terrestrial habitat of dry heath. This feature will not be considered further

The other bird features that rely on the freshwater habitats will be taken forward into appropriate assessment (section 7.4) because of the linkage through the Minsmere Sluice and potential sensitivity to toxic contamination (chemicals), change in thermal regime and nutrient enrichment. The extent of the discharges from the WDA and linkages will be considered by a bespoke detailed model and it is therefore not possible to conclude no LSE alone for these features at this stage.

There are 2 further species for this site that we must consider for the marine environment: bittern and little tern. The potential risks for these 2 species are:

- bittern: this species relies on the freshwater and reedbed habitats and there are no direct effects from a discharge into the marine environment. However, there is a potential source-receptor pathway from the sea water intake via Minsmere Sluice. There are also indirect effects of the discharges to the marine environment on European eel (Anguilla anguilla) as a prey species of bittern. These risks will be considered further by detailed bespoke assessment within the appropriate assessment (section 7.4)

- little tern – forages off the coast with potential direct interaction with WDA discharges. It is considered that there is a likely significant effect, and this feature will be considered in more detail in the appropriate assessment (section 8)

Orfordness to Shingle Street SAC

Features

- coastal lagoons
- annual vegetation of drift lines
- perennial vegetation of stony banks; coastal shingle vegetation outside the reach of waves

Conclusion

The site is to the south of the main development site, and the features could be sensitive to change in thermal regime, toxic contamination (chemicals), and nutrient enrichment.

There is therefore considered to be LSE alone and the site and features will be taken forward into appropriate assessment to assess, by detailed modelling, whether the WDA discharges could reach the site and therefore the habitat features (section 7.5).

Outer Thames Estuary SPA

Features

- common tern, Sterna hirundo (breeding)
- little tern, Sternula albifrons, (breeding)
- red-throated diver, Gavia stellata, (non-breeding)

The outlets from the CWS and FRR systems discharge directly into this site and the following risks are therefore relevant:

- toxic contamination (chemicals)
- change in thermal regime
- nutrient enrichment/eutrophication (including turbidity)
- siltation
- physical damage

Detailed bespoke modelling work to define the extent of the WDA effects will be carried out for 3 risks: change in thermal regime, toxic contamination (chemical) and changes in nutrients.

It is considered that there is a likely significant effect alone, and the site and features will be taken forward into appropriate assessment for these 3 risks (sections 8.6, 8.7 and 8.8).

The following risks will be considered within the LSE stage:

- siltation
- physical damage

Siltation

There will be a discharge of suspended solids as a part of the STW discharge (waste stream G). This will therefore be considered further to see if it could cause siltation (any potential to cause nutrient enrichment will be considered under the changes in nutrients/organic enrichment section).

Water discharge activity permits are typically given a standard limit regarding the concentration of suspended solids that can be discharged. This standard limit for an STW discharge is 30mg/l. This is less than the mean observed suspended solid concentration at the SZC outlet location of 55.5mg/l (NNB GenCo, 2019b; TR314).

However, in addition to considering is the concentration of suspended solids being discharged, we should also consider the dilution. As a worst-case scenario when discharging 190m^3/day for refuelling or outages due to maintenance, the STW discharge will receive around 60,000 times dilution via the 132m^3/s CWS flow before it reaches the receiving environment. For the day-to-day operation, a 90m^3/day quantity will receive 126,270 times dilution via the CWS flow before it reaches the receiving environment.

It is therefore considered that the suspended solids ultimately discharged to the environment as part of the STW discharge (waste stream G) will be low impact and too small to result in a conceivable effect. There is no likely significant effect and no in-combination assessment is required.

Physical damage

The discharge of 132m^3/s of water from the cooling water outlet has the potential to cause physical damage through scouring of the seabed.

The outlet heads will be located a few hundred metres away from the northerly intakes and around a kilometre from the southerly intakes, with the outlets being up to 8m deeper than the intakes (Figure 1). The natural turbidity of the North Sea would therefore not be expected to differ between these locations. As the abstracted water passes through the cooling water system, the turbidity of the water being discharged will effectively be equal to that being abstracted.

The applicant has described how scour is likely to occur around both of the submerged cooling water outlets as a result of the disruption in local hydrodynamic flow patterns and how jet scour from the discharges will add to this (NNB GenCo, 2018; TR310). Worst-case scour depths of 4.67m (due to the structure) and 6.75m (jet scour) are predicted around the cooling water outlets, leading to an area of habitat change of around 0.5ha (5,000m²). However, this is a conservative estimate as it assumed that the jet will be discharged at bed level, when it will in fact be offset above the bed. The cooling water outlets will be of the same design as those used at Hinkley Point C, with these being 3.2m high, with water discharging horizontally from the top of the structure (NNB Generation Company (HPC) Limited , 2016) (Figure 3). Also, cooling water forms a buoyant plume and so will quickly raise above bed level, further reducing the effect. While scouring may well take place in the short-term, in the longer term, an equilibrium would be expected such that over the lifetime of the project, the effects of jet scour or scour resulting from the structures themselves, will not significantly alter the turbidity of the surrounding water body.

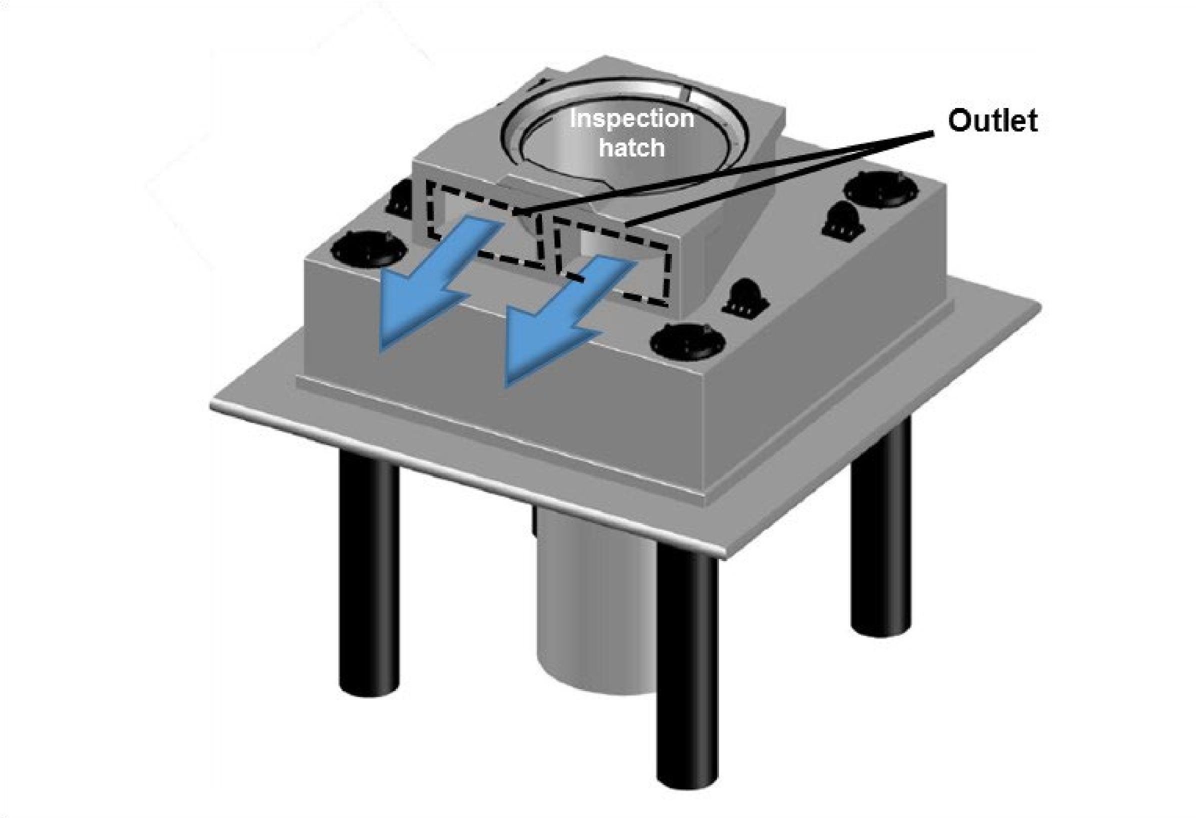

Figure 3: Three-dimensional view of the cooling water outlet structure showing how water is discharged parallel to, but raised above, the seabed (NNB Generation Company (HPC) Limited, 2016)

At 25,920m³/day, equivalent to 0.3m³/s, discharge from the 2 FRR system outlets is of a much lower volume than discharge from the cooling water outlets, but will discharge further inshore than the abstraction point. As it will not have passed through the cooling water system, the FRR system discharge will not form a buoyant plume. There will be no additional suspended solids added to the FRR system discharge. NNB GenCo (2018; TR310) predicts worst case jet scour depths around the FRR system outlet as being up to 0.74m, again noting this is a conservative assessment assuming the jet is discharged at bed level rather than being elevated above bed level as is planned. Jet scour from the FRR system would not exceed the scour depth of up to 2.07m resulting from the effect of the outlet structure itself. As with the cooling water outlets, scouring may take place in the short-term, but an equilibrium will be reached such that over the lifetime of the project, the effects of jet scour or scour resulting from the structures themselves will not significantly alter the turbidity of the surrounding water body.

The discharge of water from the CWS outlets and the FRR system outlets will not result in an increase in erosion or siltation of sufficient magnitude to result in a conceivable effect on the conservation objectives, so it is considered to be low impact. There is no likely significant effect and no in-combination assessment is required.

Southern North Sea SAC

Feature

- harbour porpoise, Phocoena phocoena

The outlets from the CWS and FRR systems discharge directly into this site and the following risks are therefore relevant:

- change in thermal regime
- toxic contamination (chemicals)
- nutrient enrichment
- siltation
- physical damage

The thermal and chemical plumes associated with the cooling water operational discharge may result in local displacement of harbour porpoise and/or avoidance behaviour in prey fish, impacting on prey availability. Nutrient enrichment from the FRR system may also potentially alter biological communities, which may impact prey availability. As the water discharge activities are taking place directly into the Southern North Sea SAC, and as these risks will be considered using detailed bespoke modelling, there is a likely significant effect alone for the harbour porpoise feature. The potential impacts will be examined further in the appropriate assessment (section 8.9).

The siltation and physical damage risks are also being considered for this site and feature, but the information pertaining to those risks are the same as that of the Outer Thames Estuary SPA site, so please refer to the LSE assessment for the Outer Thames Estuary SPA for further detail.

The discharge of water from the CWS outlets and the FRR system outlets will not result in an increase in erosion or siltation of sufficient magnitude to result in a conceivable effect on the conservation objectives, so it is considered to be low impact. There is no likely significant effect and no in-combination assessment is required.

5.1.2. Potential functionally linked sites - seabirds LSE

Using mean maximum + standard deviation foraging ranges published by Woodward and others (2019) (Table 1) the following distant seabird sites were identified. If it is considered there is no LSE for these sites, more distant sites with these features will not be considered.

- Coquet Island SPA. This site is designated for the following species:
    - fulmar, Fulmarus glacialis, designated as part of the breeding seabird assemblage
- Flamborough and Filey Coast SPA. This site is designated for the following species:
    - gannet, Morus bassanus (breeding)
    - kittiwake, Rissa tridactyla (breeding)
    - fulmar Fulmaris glaciallis (breeding seabird assemblage)
    - puffin Fratercula arctica (breeding seabird assemblage)

LSE assessment

The foraging and migration routes of mobile species, such as the seabirds could be affected by changes in water quality due to the discharge activities from the cooling water system and FRR systems, including increased water temperatures and increased chemical inputs and nutrients. Effects could also arise due to direct or indirect effects on prey species.

Using the foraging ranges of Woodward and others (2019) highlights the potential for the wide-ranging seabirds to reach the site. However, the SZC site is at the further extremes of the breeding season foraging range.

The information that the applicant provided via the Schedule 5 process tells us that:

- seabirds are central place foragers during the breeding season, due to the need to return to the colony to undertake incubation duties and to feed young
- the potential foraging area is constrained by the costs (in terms of energy budgets and time) of commuting between foraging sites and the colony, while the need to minimise these costs means that birds should forage as close to the colony as possible, all else being equal
- tracking of kittiwakes from the Flamborough and Filey Coast SPA demonstrates that most activity occurs close to the colony (relative to the

mean maximum + standard deviation foraging range), with the majority of the area encompassed by the 50% utilisation distribution being within 150km of the SPA

- there is no evidence of tracked kittiwakes using waters close to the project site from several years of tracking studies
- data from tracking studies of gannet from the Flamborough and Filey Coast SPA show that neither the modelled 50% nor 75% utilisation distributions approach the vicinity of the project site. This is also true for the individual tracks of gannets from 3 years of study, involving almost 20,000 locations from 42 tracked birds (with the closest locations being approximately 40 to 50km off the Norfolk Coast)
- there are no tracking data available for fulmar or puffin from the above SPA populations

It is therefore considered that there is no functional linkage between the 2 sites. Greater Sizewell Bay does not provide an important role in maintaining or restoring the breeding seabird populations of Coquet Island SPA and Flamborough and Filey Coast SPA.

Consequently, there is no likely significant effect alone from the water discharge activities of SZC on the breeding seabird features of Coquet Island SPA and Flamborough and Filey Coast SPA. As there is no functional linkage for these 2 sites, and no likely significant effect alone, there will also be no functional linkage or likely significant effect alone for more distant sites with these breeding seabird features.

Although there is no functional linkage between SPAs with breeding kittiwake features and Greater Sizewell Bay, the species does occur locally, with a colony located on the Sizewell Rigs County Wildlife Site. This is situated a short distance offshore and is associated with SZA and SZB infrastructure. However, as the colony is not a feature of an SPA, potential impacts from the water discharge activities of SZC are not considered as part of this HRAR.

5.1.3. Potential for functionally linked sites – marine mammals

The foraging and migration routes of mobile species, including grey seal and harbour seal could be affected by changes in water quality due to the discharge activities from the cooling water discharge system, including increased water temperatures and increased chemical inputs. Effects on marine mammal features could also arise due to direct or indirect effects on prey species.

Grey seal is a feature of the Humber Estuary SAC and the Humber Estuary Ramsar. Telemetry data show that seals that use the Donna Nook haul-out site within the Humber Estuary SAC and Ramsar can be present in the Greater Sizewell Bay area.

This assessment will examine whether there is a likely significant effect for the grey seal feature of the Humber Estuary SAC and Ramsar.

Harbour seal is a feature of The Wash and North Norfolk Coast SAC and telemetry data show that seals using haul-out sites within this SAC can be present in the Greater Sizewell Bay area. This assessment will examine whether there is a likely significant effect for the harbour seal feature of The Wash and North Norfolk Coast SAC.

Humber Estuary SAC and Ramsar

The thermal and chemical plumes associated with the cooling water operational discharge may result in local displacement of grey seal and/or avoidance behaviour in prey fish, impacting on prey availability. Nutrient enrichment from the FRR system may also potentially alter biological communities, which may impact prey availability.

Telemetry studies have shown movements of grey seals between the Donna Nook haul-out site in the Humber Estuary SAC and Ramsar and Greater Sizewell Bay. However, the applicant also tells us that:

- tracking of individual seals has shown that most foraging probably occurs within 100km of a haul-out site, with ranges of approximately 145km, although they can feed up to several hundred kilometres offshore, with ranges of 1,088 to 6,400km recorded
- studies of regular foraging and dispersal between winter breeding sites, and summer foraging and haul-out sites indicates ranges of 1,000km
- individual grey seals based at a specific haul-out site often make repeated trips to the same region offshore, but will occasionally move to a new haul-out site and begin foraging in a new region
- tracks of grey seals tagged at Donna Nook (over 190km north of Sizewell) and at Blakeney Point (over 100km north of Sizewell) show the extensive journeys undertaken by individuals from these sites (Blakeney Point is within The Wash and North Norfolk SAC, but grey seal are not a feature of the site) (Figure 4)

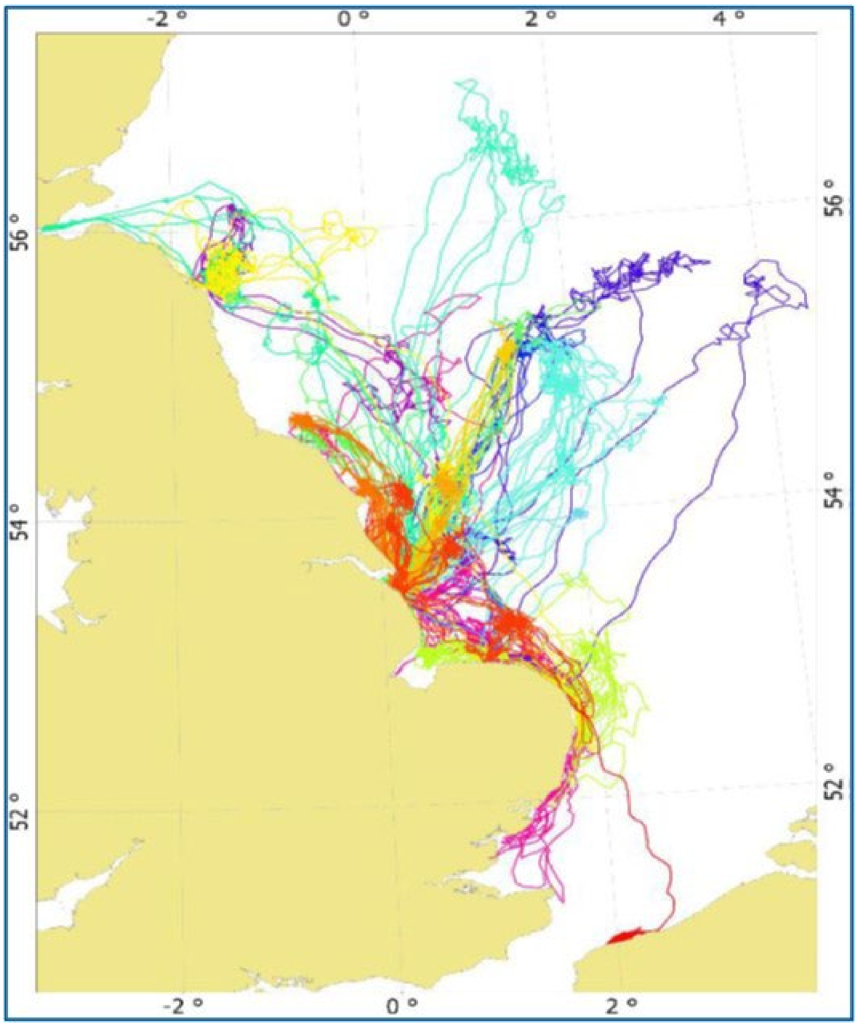

Figure 4: Tagged grey seal movements along the east coast of England, reproduced from Plate 6.15 in NNB GenCo (2021b, shadow HRA)

At over 190km from Donna Nook, the waters off Sizewell are beyond the typical foraging range of grey seal. Any displacement of grey seal or avoidance behaviour by their prey will take place over such a small proportion of the potential foraging area of Humber Estuary SAC and Ramsar grey seals that there will be no material effect on grey seal foraging pathways, particularly as offshore movements appear common. If only a small number of grey seals are travelling to the Suffolk coast, as may be the case if individuals are making repeated trips to the same foraging area, then any effect from SZC will also only be experienced by these individuals rather than by all individuals in the colony (which numbered 6,526 in 2016, 75% of the total number in the south-east England grey seal management unit) (NNB GenCo, 2021b; shadow HRA).

Thermal and chemical plumes from SZC would lie entirely within the potential foraging range of Humber Estuary SAC grey seals (NNB GenCo, 2021b shadow HRA). Were prey fish to undertake any avoidance behaviour in response to these plumes, they would still remain within the seals' foraging range and any increase in foraging distance would be insignificant when compared to the distance between the Humber Estuary SAC and Ramsar and the Suffolk coast.

Grey seal distribution in UK waters has been mapped by combining information about the movement patterns of electronically tagged seals with survey counts of seals at haul-out sites (NNB GenCo, 2021b; shadow HRA). From these maps, a density of 0.038 grey seals/km² can be predicted at the location of the SZC main development site, and 0.030 grey seals/km² over the wider area (up to 25km from the SZC project red line boundary) (NNB GenCo, 2021b; shadow HRA). These are low densities when compared to the 6,526 population of the Humber Estuary SAC and Ramsar. The calculation of grey seal density will have taken into account grey seals from haul-out sites closer than the Humber, which are not SACs or within which grey seal are not features. These include The Wash (688 seals in 2016), Blakeney Point (502 seals in 2016), Scroby Sands (425 seals in 2016) and haul-out sites in Essex/Kent (481 seals in 2016) (NNB GenCo, 2021b; shadow HRA).

Any avoidance behaviour resulting from thermal or chemical plumes discharged by SZC will be so small compared to the at-sea movements of grey seal from the Humber Estuary SAC/Ramsar that there will be no material effect on foraging behaviour. Due to the low density of grey seals in the vicinity of SZC, there will also be no displacement of grey seals from key habitat with limited availability.

The extensive potential foraging area of Humber Estuary SAC and Ramsar grey seals combined with the low density of grey seals off the coast at Sizewell means that there is no functional linkage between the 2 sites – Greater Sizewell Bay does not provide an important role in maintaining or restoring the Humber Estuary SAC/Ramsar population of grey seals at/to favourable conservation status.

There is no likely significant effect alone from the water discharge activities of SZC on the grey seal feature of the Humber Estuary SAC and Ramsar. With regard to the in-combination risk, any effect will be negligible and therefore no in-combination assessment is required.

The Wash and North Norfolk Coast SAC

The thermal and chemical plumes associated with the cooling water operational discharge may result in local displacement of harbour seal and/or avoidance behaviour in prey fish, impacting on prey availability. Nutrient enrichment from the FRR system may also potentially alter biological communities, which may impact prey availability.

Telemetry studies have shown harbour seals at hauling-out sites in The Wash and North Norfolk Coast SAC, for which harbour seal are a feature, can be present in the Greater Sizewell Bay area (NNB GenCo, 2021b; shadow HRA). However, the applicant also tells us (NNB GenCo, 2021b; shadow HRA) that:

- harbour seals generally make smaller foraging trips than grey seal, typically travelling 40 to 50km from their haul-out sites to foraging areas. The Wash population may travel larger distances, averaging 80km, but with a large variation and some individuals repeatedly travel over 200km to foraging areas

- tracks of telemetry-tagged harbour seals show concentrated activity in The Wash and in the Thames Estuary, but little activity in the area off Sizewell (Figure 5). There is connectivity between The Wash and the Thames estuaries with movements taking place, nearshore, along the Norfolk/Suffolk coast (Figure 5). Within the Thames Estuary, foraging occurs over a large area, but with greater levels of activity occurring at 5 locations, the closest of which to SZC is at north-east Buxey Sand (70km from the main development site)

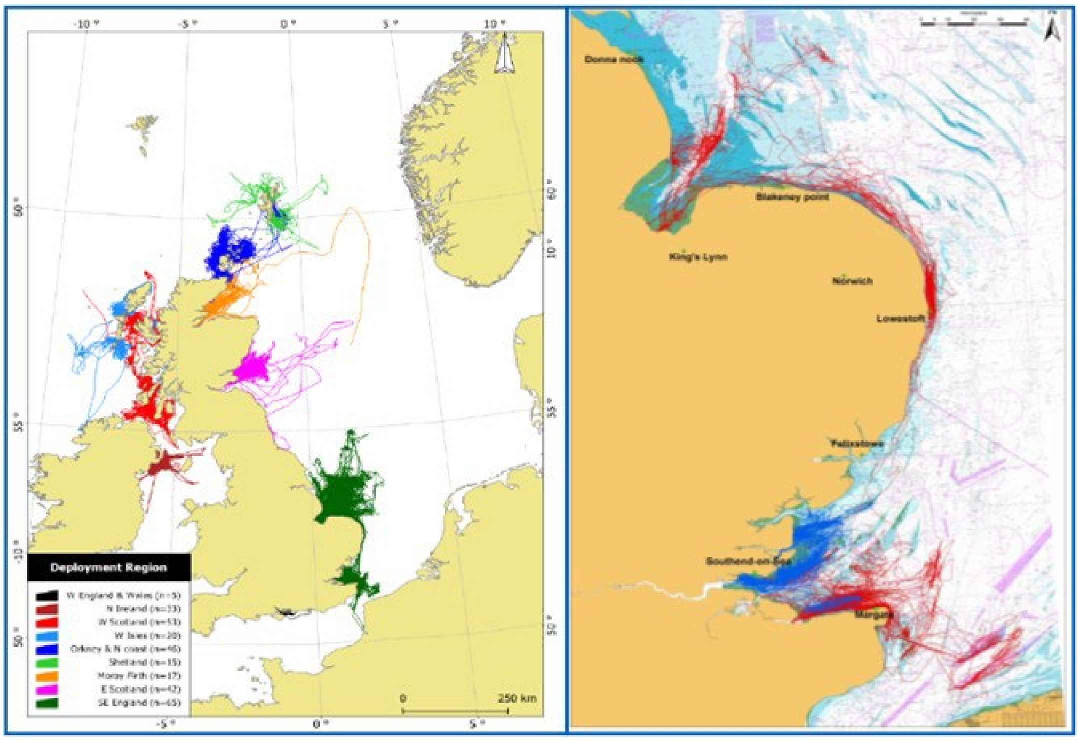

Figure 5: Telemetry tracks by deployment region for harbour seals aged one year or over between 2001 and 2012 (left) and for harbour seal tagged at Marsh End Sand (blue) and Margate Sands (red) (left). Reproduced from Plate 6.19 in NNB GenCo (2021b; shadow HRA)

At distances of over 100km to the north of Sizewell, haul-out sites at Blakeney Point and The Wash are beyond the average foraging distance for harbour seals. As such, any displacement of harbour seal or avoidance behaviour by their prey will take place over such a small proportion of the potential foraging area of The Wash and North Norfolk Coast SAC harbour seals that there would ordinarily be no material effect. However, connectivity between the relatively intensively used Thames

Estuary and The Wash means that there may be functional linkage between these sites, with the Thames Estuary providing an important role in maintaining or restoring the harbour seal population of The Wash and North Norfolk Coast SAC at/to favourable conservation status. If so, then given that harbour seal movements between these sites appear to follow the coastline, and that their movement tracks (Figure 5) do not generally show the same degree of offshore movement as for grey seals (Figure 4), there is potential for the water discharge activities of SZC to impede the movement of harbour seals between functionally linked sites.

Though relatively distant from The Wash and North Norfolk Coast SAC, thermal and chemical plumes from SZC would lie entirely within the potential maximum foraging range of its population of harbour seals (NNB GenCo, 2021b; shadow HRA). Were prey fish to undertake any avoidance behaviour in response to these plumes, they would still remain within the seals' foraging range and still be available as prey.

Harbour seal distribution in UK waters has been mapped by combining information about the movement patterns of electronically tagged seals with survey counts of seals at haul-out sites (NNB GenCo, 2021b; shadow HRA). From these maps, a density of 0.039 harbour seals/km^2 can be predicted at the location of the SZC main development site, and of 0.011 harbour seals/km^2 over the wider area (up to 25km from the SZC project red line boundary) (NNB GenCo, 2021b; shadow HRA). This is a low density when compared to the 3,200 seals of The Wash haul-out site and the 399 at the Blakeney Point haul-out sites, within the Wash and North Norfolk Coast SAC (2011 to 2016 counts) (NNB GenCo, 2021b; shadow HRA). Harbour seals using Greater Sizewell Bay may also originate from other nearby haul-out sites, which are not SACs or within which harbour seals are not features. These include haul-out sites in Essex and Kent (694 seals, 2011 to 2016) and Scroby Sands (271 seals, 2011 to 2016) (NNB GenCo, 2021b; shadow HRA).

Any avoidance behaviour resulting from thermal or chemical plumes discharged by SZC will be small compared to the at-sea movements of harbour seal from The Wash and North Norfolk SAC, while the low density of harbour seals in the vicinity of SZC suggests that Greater Sizewell Bay does not represent key foraging habitat for the feature.

Given the potential for thermal or chemical plumes to disrupt the coastal movement of seals between The Wash and North Norfolk Coast SAC and the potentially functionally linked Thames Estuary, there is a likely significant effect alone from the water discharge activities of SZC on the harbour seal feature of The Wash and North Norfolk Coast SAC. Potential impacts on the harbour seal feature of The Wash and North Norfolk Coast SAC will be examined further in the appropriate assessment (section 7.6).

5.1.4. Potential for functionally linked sites - fishes

Sea lamprey (Petromyzon marinus), river lamprey (Lampetra fluviatilis), twaite shad (Alosa fallax) and allis shad (Alosa alosa) could potentially avoid areas of thermal uplift or chemical exceedance resulting from the water discharge activities of SZC. If this were to occur, this could lead to a reduction in available foraging area, or to the disruption of their migratory routes. Annex II fish species may also be affected if their prey were to avoid thermal or chemical plumes from SZC.

Humber Estuary SAC and Ramsar

These sites are designated for the following species:

- sea lamprey
- river lamprey

Sea lamprey LSE assessment

Sea lamprey may avoid areas of thermal uplift or chemical exceedance. However, sea lampreys are widely distributed at sea, occurring in shallow, coastal, and deep offshore waters (Maitland, 1980; Elliott and others, 2021). The marine feeding phase of the sea lamprey life cycle may last for a year or more (Silva and others, 2013). So, localised avoidance of thermal or chemical plumes produced by SZC would not be of significance to the wide-ranging North Sea population of sea lampreys.

Due to the lack of homing behaviour, if migrating adult sea lampreys were deterred from entering East Anglian rivers, it is possible that they could continue migrating along the coastline to spawn elsewhere. If this occurred, the offspring would still contribute to the wider North Sea population - there would be no overall effect on the potential for the offspring to enter protected sites when they spawn. In a worst-case, though, East Anglian sea lampreys, deflected by avoidance of thermal or chemical plumes, might be unable to find a suitable river for spawning and could die without reproducing. However, SZC is not located within an estuary or a river, where the confined habitat may increase the probability of migrating sea lampreys encountering thermal or chemical plumes as compared to an open coastal environment.

During 9 years of impingement monitoring at SZB, only one sea lamprey has been recorded, suggesting that the species is not common in the Greater Sizewell Bay (NNB GenCo, 2020c; TR406), and that the area is of no particular importance to the North Sea population. The current International Union for Conservation of Nature (IUCN) status of anadromous sea lamprey in Europe is of ‘least concern’ and, although it has been suggested that this should be reclassified to ‘vulnerable’ to reflect its status in important areas of its distribution (NNB GenCo, 2020d; SPP103), there is no indication that localised avoidance behaviour by sea lampreys in Greater Sizewell Bay would be of significance to the North Sea population as a whole.

Therefore, there is no likely significant effect alone for sea lamprey on the Humber Estuary SAC and Ramsar and no in-combination required.

As there is no likely significant effect alone for the Humber Estuary SAC and Ramsar, there will also be no LSE for more distant continental sites for which sea lamprey are features (see LSE screening spreadsheet Information regarding three new environmental permit applications for the proposed Sizewell C power station - Environment Agency - Citizen Space and maps of site locations in Environment Agency (2022a; Annex 1)).

River lamprey LSE assessment

River lamprey is an anadromous species, which begins its life in freshwater, migrates to the sea to feed parasitically on fish, before returning to freshwater to spawn. River lampreys do not survive beyond spawning. Like sea lamprey, river lampreys are not thought to return to their 'home' rivers to spawn, but are instead attracted into rivers by pheromones from river-resident juveniles (Gaudron and Lucas, 2006) meaning that different rivers do not necessarily support unique populations of river lamprey.

While distribution at sea is likely to be dependent to some extent upon the movements of host fishes, river lampreys are not thought to stray as far from the coast as sea lampreys (Maitland, 1980; Elliott and others, 2021).

River lampreys have not been recorded in rivers or estuaries along the Suffolk coast and so it is unlikely that thermal or chemical plumes from SZC would prevent or delay the freshwater entry of river lamprey, local to SZC. However, due to its more coastal distribution when at sea, thermal or chemical plumes close to shore could potentially disrupt the migration of this species and so this assessment will examine whether there is a likely significant effect for river lamprey features.

Any river lamprey within the vicinity of the SZC discharge plumes would be a considerable distance from the closest SACs, either the Humber Estuary SAC (163km straight line distance) or the Schelde (197km). Given these distances and the lack of homing behaviour in the species, had they originated in designated sites in the Humber or Schelde catchments, river lamprey off Sizewell would be unlikely to return to their river of origin. Recent evidence from stable isotope analysis also suggests that Humber catchment river lampreys might feed predominantly within the estuary, and so be unlikely to travel as far as Greater Sizewell Bay (Nunn and others, 2021). An average of 1,144 individual river lamprey impinged per year at SZB shows that Greater Sizewell Bay is frequented by river lamprey. However, should localised displacement occur, it is unlikely to adversely affect the number of individual river lampreys migrating into or through SACs, with numbers in the Humber Estuary SAC estimated at >700,000 (in 2018), and with hundreds of thousands in each of the Schelde, Eider, Elbe, Weser and Ems (NNB GenCo, 2020c; TR406**).** Therefore, there is no likely significant effect on the Humber Estuary SAC and Ramsar or on continental protected sites alone and no in-combination required. Please refer to the LSE screening spreadsheet (Information regarding three new environmental permit applications for the proposed Sizewell C power station - Environment Agency - Citizen Space) for a full listing of continental sites and Environment Agency (2022a; Annex 1) for maps showing the site locations.

We therefore conclude that there is no functional linkage and consequently, there is no likely significant effect from the water discharge activities of SZC on any of the protected sites for river lamprey.

Plymouth Sound SAC

This site is designated for the following feature:

- allis shad

Allis shad LSE assessment

Allis shad are anadromous members of the herring family which return to their home river to spawn. Repeat spawning is not common. The closest UK site for which allis shad are a qualifying feature is the Plymouth Sound and Estuaries SAC, and there are also continental sites (listed in the LSE screening spreadsheet Information regarding three new environmental permit applications for the proposed Sizewell C power station - Environment Agency - Citizen Space with locations mapped in Environment Agency (2022a; Annex 1)).

Only one allis shad has been caught during 9 years of impingement monitoring at SZB, indicating that the species is not common in Greater Sizewell Bay. Given the scale of marine migrations undertaken by allis shad, any avoidance behaviour resulting from thermal or chemical plumes discharged by SZC will be so small that there will be no material effect on migratory pathways, even if the species becomes more common in the southern North Sea - as may become the case in future if reintroduction attempts prove successful (NNB GenCo, 2020d; SPP103). There will also be no displacement of allis shad from key habitat with limited availability.

We therefore conclude that there is no functional linkage and consequently, there is no likely significant effect from the water discharge activities of SZC on any protected sites for allis shad.

Sites designated for twaite shad

10 continental sites with locations mapped in Environment Agency (2022a; Annex 1).

Twaite shad LSE assessment

Twaite shad are an anadromous member of the herring family which home to their river of origin and are capable of spawning there for many successive years. There are no UK spawning rivers near SZC, with the nearest spawning taking place in tributaries of the Severn Estuary. Twaite shad in Greater Sizewell Bay are likely to originate from mainland Europe where a number of rivers, estuaries and coastal waters are designated to protect the species (see the LSE screening spreadsheet Information regarding three new environmental permit applications for the proposed Sizewell C power station - Environment Agency - Citizen Space and maps in Environment Agency (2022a; Annex 1)). Impingement records from SZB show an average of 1,168 twaite shad being caught per year (NNB GenCo, 2020c; TR406) and so the species is clearly present in Greater Sizewell Bay. However, any avoidance behaviour resulting from thermal or chemical plumes discharged by SZC will be so small compared to the at-sea movements of this species around the North Sea that there will be no material effect on twaite shad migratory pathways. There will also be no displacement of twaite shad from key habitat with limited availability.

We therefore conclude that there is no functional linkage and consequently, there is no likely significant effect from the water discharge activities of SZC on any of the protected sites for twaite shad.

6. Appropriate assessment (AA) methodology

The following risks have been brought forward from LSE to this AA:

- change in thermal regime
- toxic contamination (chemical)
- nutrient enrichment/eutrophication (including turbidity)

6.1. Change in thermal regime

For this assessment, change in thermal regime will consider:

- change in thermal regime arising from the discharge of cooling water.
    - direct effects may occur through the feature coming into contact with heated water
    - indirect effects may occur if prey avoid areas of heated water, leading to a reduction in prey availability, or an increase in energy expenditure required to locate displaced prey

Thermal discharges, for the main part, affect species that live within the water column. The thermal plume is buoyant, caused by the lower density of the warmer water. This causes the heated effluent to rise in an inverted cone towards the surface, thereby limiting the likelihood of contact with the seabed. The seabed immediately beneath the plume, therefore, receives little warming effect. As the plume spreads, the temperature falls rapidly as a result of dilution and loss to the atmosphere. Therefore, where the plume does make contact with the seabed, it is at a much-reduced temperature.

6.1.1. Thermal plume modelling

The cooling water system outlet will create a thermal plume due to the water being discharged at a higher temperature from the power station than the surrounding receiving water. The applicant modelled the thermal plume from SZC using the validated Sizewell General Estuarine Transport Model (GETM); full details of the model and detailed thermal plume maps are presented in NNB GenCo (2020a; TR302), with a summary of the model provided within NNB GenCo (2020b; TR306).

The General Estuarine Transport Model (GETM) is a three-dimensional hydrodynamic model used for simulating water moments in the marine environment. Within the model, the sea is divided into a three-dimensional grid, with cells extending across the surface, and vertically down to the seabed. The model uses parameters to simulate the physical, chemical, and biological properties of water, and the interactions between these, within each cell over a period of time, with the sum of these results describing patterns throughout the whole of the coastal zone that is modelled. Calculations are performed for very small timesteps (less than one minute) with the models' output summarised for each hour, or for longer periods of time such as a season, or a full year. The GETM model has been calibrated and validated for the zone of influence of the proposed SZC power station.

The GETM model was set up and run for a year following Environment Agency modelling guidelines. The year was selected by examining the inshore temperature network data managed by Cefas for Sizewell. 2009 was chosen to be modelled because, in relation to temperature, it was an average year (NNB GenCo, 2020a; TR302), with the mean annual temperature in 2009 the same as the mean annual temperature from 2003 to 2012.

Additionally, the availability of boundary forcing elevation data and meteorological forcing were also primary considerations for selecting 2009; these data were available for 2009 by mid-2010 (NNB GenCo, 2020a; TR302). An oceanography field programme to collect calibration data for currents and tides was undertaken at Sizewell in September 2008, along with a further thermal plume validation exercise in 2009. These separate calibration and validation studies enabled estimates of the accuracy of the model to be determined (NNB GenCo, 2020a; TR302).

We have accepted the SZC GETM model as fit for purpose for its intended use in calculating both the thermal and chemical plumes.

6.1.2. Assessment of thermal plume

There are 2 thermal changes that need considering: absolute water temperature and thermal uplift. Absolute water temperature refers to the temperature of the sea as it could be measured with a thermometer. Thermal uplift is the degree to which the sea temperature has been increased above what it would otherwise be by the discharge of heated water from the cooling water system. For example, when SZC is operational, temperature at the sea surface near to the CWS discharge point might be measured as 15°C – this would be the absolute temperature. Without the influence of the cooling water, the surface temperature might otherwise have been 13°C – in which case the surface water would be experiencing 2°C thermal uplift.

Absolute water temperature

The direct effects of change in thermal regime will be assessed by reference to modelled absolute water temperatures at the sea surface.

While the Habitats Directive has no specific temperature requirements, the UK Technical Advisory Group on Water Quality for the Water Framework Directive recommended temperature thresholds for assessing the impact of thermal discharges on SPAs and SACs (WQTAG sub-group, 2006).

For SPAs, WQTAG sub-group (2006) includes a maximum temperature of 28°C as a 98th percentile at the edge of the mixing zone. The threshold of 28°C as a 98th percentile means that, within the mixing zone, sea surface temperatures will exceed 28°C for 2% or more of a year. The mixing zone is the area around a discharge within which a regulator permits a quality standard to be exceeded.

For SACs, WQTAG sub-group (2006) includes a maximum temperature threshold of 21.5°C as a 98th percentile at the edge of the mixing zone. However, this threshold is set to protect salmonid fish, considered the most sensitive organisms to thermal impacts (WQTAG sub-group, 2006) and is therefore not appropriate for use in examining impacts on sites in the Greater Sizewell Bay.

As it passes through SZC cooling water system, seawater will experience a thermal uplift of 11.15°C (NNB GenCo, 2020b; TR306). Sea temperatures at SZB peak in August at around 19.0°C, with the monthly mean sea temperature for 2009 being 19.8°C (2009 being the year for which the GETM model was run) (Table 2). With a sea temperature of 19.8°C, the cooling water would reach a maximum temperature of 30.95°C as it passed through the system.

Table 2: Monthly mean sea temperatures (°C) at SZB power station. Source: Cefas Inshore Temperature Network, data from Table 8 in NNB GenCo (2020a; TR302)

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Mean
2009	4.9	4.4	6.3	9.4	12.7	16.2	18.6	19.8	17.4	13.8	11.6	7.9	11.9
1967-2012 mean	5.9	5.4	6.1	8.4	11.5	15.1	18.0	19.0	17.7	14.8	11.3	7.8	11.8
2002-2012 mean	6.8	6.3	6.1	8.5	11.5	15.1	18.0	19.0	17.7	14.8	11.3	7.8	11.9

Under baseline conditions (when SZB is operating alone) the sea surface will not be exposed to temperatures in excess of 28°C as a 98th percentile (NNB GenCo, 2020b, TR306).

Similarly, when SZC is operating alone the sea surface will not be exposed to temperatures in excess of 28°C as a 98th percentile (Table 21 in NNB GenCo, 2020b; TR306).

When SZC and SZB are operating in combination, 0.11ha (0.0011km^2) of the sea surface will be exposed to temperatures in excess of 28°C as a 98th percentile (Table 21 in NNB GenCo, 2020b; TR306). However, at the immediate point of discharge, the maximum predicted temperatures at the surface will not exceed 8°C above ambient (NNB GenCo, 2021M, Sch 5. No.5).

During maintenance scenarios, when one of the pump systems is under maintenance, the flow of cooling water would be halved, but the heat content would remain approximately the same. However, the warmer plume loses heat faster to the atmosphere, which reduces the size of the excess temperature plume compared to that arising during normal operation. As a result, the maintenance scenario is not considered further as the thermal plume effects of any maintenance would be within the extent of the effects experienced during normal operation (Environment Agency, 2022d; Water Framework Directive Assessment for the Sizewell C WDA).

Thermal uplift

The Habitats Directive has no specific water temperature requirements. However, WQTAG sub-group (2006) recommended temperature thresholds for assessing the impact of thermal discharges on SPAs and SACs, which included a 2°C deviation from ambient as a maximum allowable concentration at the edge of the mixing zone, as a 100th percentile. The annual 100th percentile plume describes the area within which thermal uplift greater than the specified value is exceeded at any point during the year. Thermal uplift of 2°C is not considered to have any link to specific ecological effects but serves as a precautionary threshold to trigger further investigation (NNB GenCo, 2021b; shadow HRA).

The applicant's GETM model predicts that the surface area of the annual 2°C (100th percentile) thermal uplift plume from SZC alone would be 16,775ha (167.75km²) at the surface and 12,244ha (122.44km²) at the seabed, (NNB GenCo, 2021b; shadow HRA). The surface extent of the plume is equivalent to 4.27% of the 392,450ha (3,924.5km²) total surface area of the Outer Thames Estuary SPA and 0.45% of the 3,695,100ha (36,951km²) Southern North Sea SAC, into both of which it directly discharges.

The area within the annual ≥2°C thermal uplift (100th percentile) plume includes any model cell in the GETM for which ≥2°C thermal uplift is experienced at any point during the year, regardless of the duration of the exceedance. For example, a cell experiencing ≥2°C thermal uplift for one hour out of the whole year would be within the plume. Having established that there would be exceedance of the annual ≥2°C thermal uplift (as a 100th percentile) threshold as a result of the CWS discharge of SZC alone, the applicant investigated further by using its GETM to predict annual thermal uplift plumes, as 98th percentiles (Figure 6). The annual 98th percentile plume describes the area within which thermal uplift, greater than the specified value, is exceeded for at least 2% of the time steps modelled. Outside of the annual 98th percentile plume, thermal uplift is less than the specified value for 98%, or more, of the time steps modelled.

The area of the annual ≥2°C thermal uplift plume (as a 98th percentile) is 1,551ha (15.5km²) at the sea surface for SZC alone, as compared to the 16,775ha (167.75km²) of the equivalent 100th percentile plume (Figure 6) (data from Tables 21 and 23 in NNB GenCo, 2020b; TR306). 1,551ha is equivalent to 0.40% of the Outer Thames Estuary SPA and 0.04% of the Southern North Sea SAC for SZC alone.

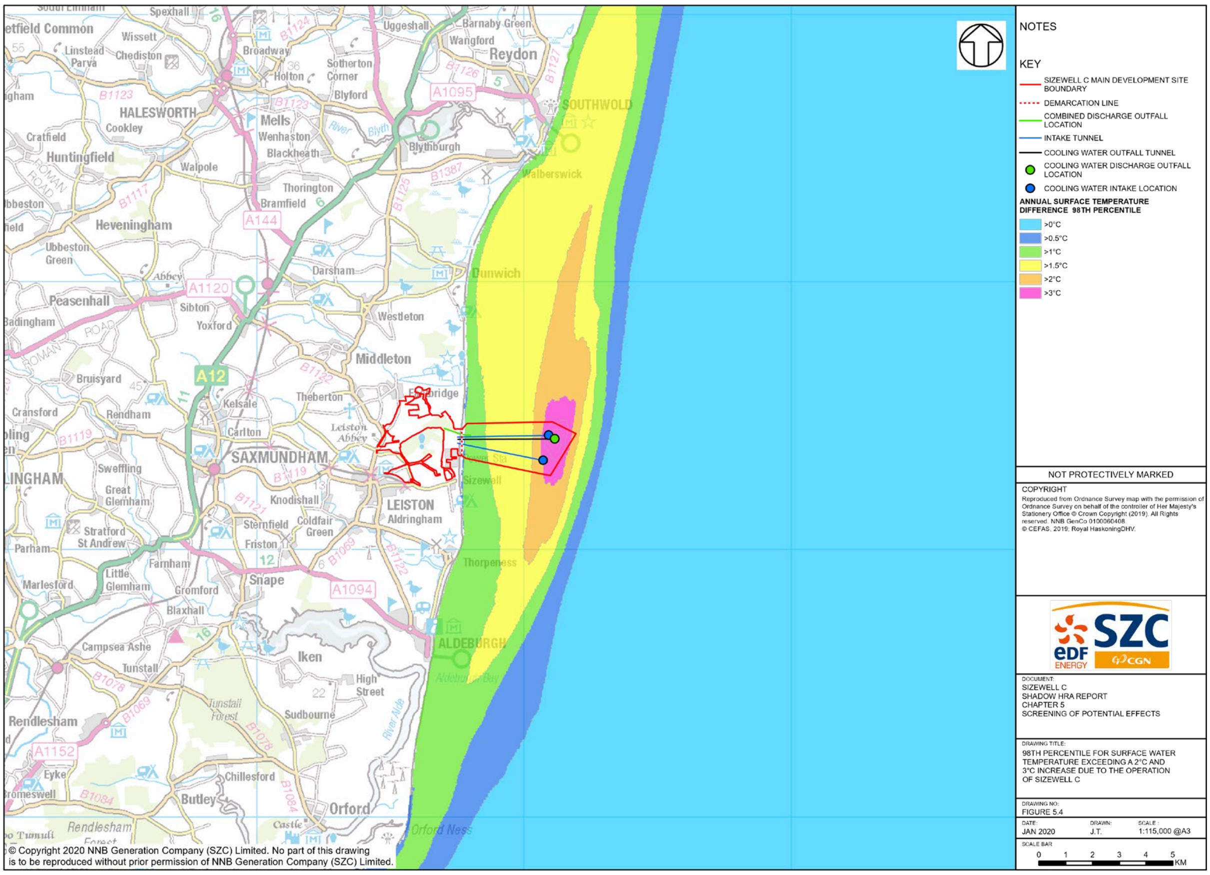

Figure 6: Annual thermal uplift (98th percentile) plumes for SZC. Reproduced from Figure 5.4 in NNB GenCo (2021b; shadow HRA)

Although this application is for an operational discharge from SZC, there is an existing thermal plume from SZB (operational since 1995) the assessment of effects from the thermal plume has also been undertaken with SZC and SZB operating in combination. The water temperature increase caused by the SZB thermal plume forms part of the baseline. However, there is a synergistic effect at the interface between the SZB and SZC plume, meaning that the area of thermal uplift plumes for SZC and SZB in combination may be greater than the sum of the areas of the SZC alone and SZB alone thermal uplift plumes (Figure 7).

The area of the annual ≥2°C thermal uplift plume (as a 98th percentile) at the sea surface is 7,899ha (79.0km²) for SZC and SZB in combination (data from Table 22 in NNB GenCo, 2020b; TR306). This is equivalent to 2.01% of the Outer Thames Estuary SPA and 0.21% of the Southern North Sea SAC for SZC and SZB in combination.

Under the baseline condition of SZB alone, the area of the annual ≥2°C thermal uplift plume (as a 98th percentile) at the sea surface is 2,433ha (24.3km²) (data from Table 22 in NNB GenCo, 2020b; TR306), which is equivalent to 0.62% of the Outer Thames Estuary SPA and 0.07% of the Southern North Sea SAC.

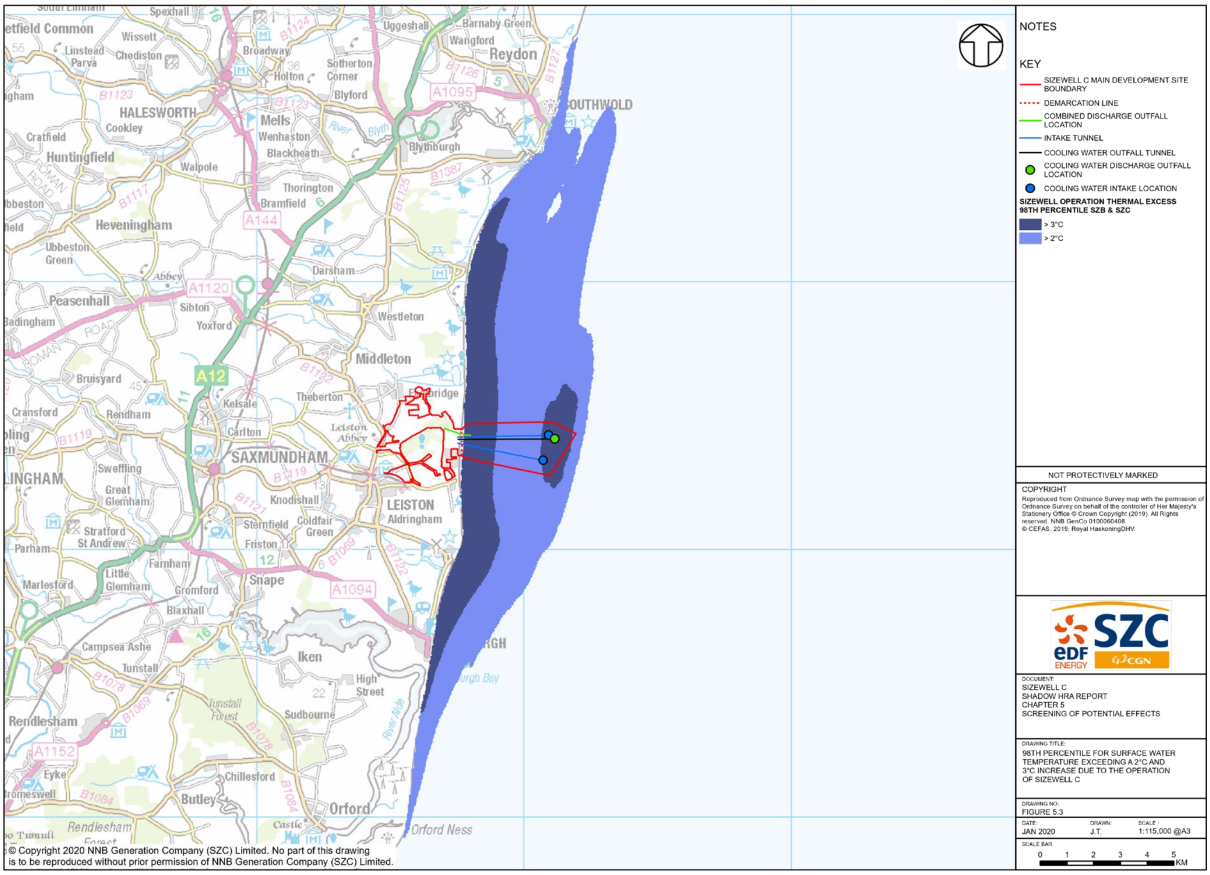

Figure 7: Annual thermal uplift (98th percentile) plumes for SZB and SZC in combination. Reproduced from Figure 5.3 in NNB GenCo (2021b; shadow HRA)

The assessment of the effects of the change in thermal regime on the European sites are discussed in section 7.

6.2. Toxic contamination

Toxic contamination (chemical) arising from the discharge of chemicals within the cooling water system.

- direct effects may occur through the feature coming into contact with toxic chemicals
- indirect effects may occur if toxic contamination alters communities in supporting habitats

- indirect effects may occur through prey coming into contact with toxic chemicals, and the prey fish then being eaten by the feature (bioaccumulation)
- indirect effects may occur if prey avoid areas of toxic contamination, leading to a reduction in prey availability

Following on from the H1 risk assessment screening process (section 5 and Appendix C) the following chemical require further consideration:

- chlorine as total residual oxidant (TRO)
- bromoform
- hydrazine

TRO originates from the combination of chlorine and organic material during chlorination of the cooling water system. Chlorination deters settling of biofouling organisms and is only anticipated to be needed continuously when temperatures are 10°C or higher, although spot chlorination (short-duration chlorination) may occur outside of this temperature range (NNB GenCo, 2021b; shadow HRA, see also Table 2 for monthly mean sea temperatures). For protection of the marine environment, chlorine has a maximum allowable concentration (MAC) EQS expressed as a 95^{th} percentile (as TRO) of 10 micrograms per litre (µg/l) for discharges to transitional and coastal (TRaC) waters (Environment Agency, 2019).

The applicant has modelled the TRO resulting from the combination of chlorine and organic material in the abstracted water, based on laboratory testing of seawater at Sizewell (NNB GenCo, 2019c; TR303; section 6.2.2).

Due to the water chemistry at Sizewell, bromoform is the predominant chlorinated by-product. Since bromoform is a product of chlorination, the same modelling scenarios were considered as for TRO. There is no published EQS for bromoform, so the applicant proposed a calculated PNEC of 5µg/l as a 95^{th} percentile. The amount of bromoform that is discharged mainly depends on the amount of chlorine that is added, but also on the amount of mixing at the outlet. The applicant's modelling of bromoform discharges is described further in section 6.2.3.

Hydrazine is an oxygen scavenger used in power plants to inhibit corrosion in steam generation circuits. The applicant proposes to use hydrazine at SZC. Liquid effluent containing residual hydrazine concentrations will be generated from the site's boiler cooling water circuits to control pH and prevent corrosion (present within SZC waste streams B/C and D). This effluent will be released periodically (also known as a 'batched' discharge) to the environment via the main cooling water stream (waste stream A) and its 2 long sea outlets. There is evidence that hydrazine is harmful to aquatic organisms at low concentrations, with a low to moderate persistence within the marine environment, depending upon its concentration and the receiving water quality. There is no established EQS for hydrazine, so the applicant proposed a chronic PNEC of 0.4 nanograms per litre (ng/l) for long-term effects (calculated as the mean of the concentration values) and an acute PNEC of 4.0ng/l for short-term effects (represented by the 95th percentile) (NNB GenCo, 2021b; Shadow HRA)). The applicant's modelling of hydrazine discharges is described further in section 6.2.4.

6.2.1. Chemical plume modelling - setup

Bespoke computer modelling is required to assess the potential environmental impact of the discharges of TRO, bromoform and hydrazine. If the concentration of a hazardous chemical or hazardous substance exceeds the relevant EQS (annual average and/or MAC or percentile standard) or PNEC (chronic and/or acute) within the cooling water flow, then a mixing zone will be created at the point of discharge; this being the area within which the environmental standard is exceeded.

In NNB GenCo (2019c; TR303), the applicant defined mixing zones for TRO, bromoform and hydrazine using the same GETM model as for the thermal plume studies (NNB GenCo, 2014a; TR301 and NNB GenCo, 2020a; TR302).

The GETM is a three-dimensional hydrodynamic model used for simulating water moments in the marine environment. Within the model, the sea is divided into a three-dimensional grid, with cells extending across the surface, and vertically down to the seabed. The model uses parameters to simulate the physical, chemical and biological properties of water, and the interactions between these, within each cell over a period of time, with the sum of these results describing patterns throughout the whole of the coastal zone that is modelled. Calculations are performed for very small time steps (less than one minute), with the models' output summarised for longer periods of time.

The potential effects of the chemical plume are on the local biology and so the applicant's modelling studies focused on the period of the year of highest biological productivity. Chemical discharges were modelled for one month only because the dispersion of chemical discharges is related to the hydrodynamics of the spring neap tidal cycle, which does not change significantly with each month. May was chosen as it has the highest phytoplankton growth which drives the whole marine ecosystem. One of the effects investigated was chlorination of the cooling water system to deter settling of biofouling organisms. Control measures will need to be applied during May as it coincides with mussel spawning and larval dispersion (NNB GenCo (2019c; TR303).

6.2.2. Assessment of chlorine as total residual oxidant (TRO)

Chlorine is commonly applied to prevent biofouling of cooling water infrastructure. Due to the known biofouling risk from historic operation of the power stations at Sizewell A and B, chlorination of the SZC cooling water system (waste stream A) will be required to maintain control of biofouling risks to its cooling water infrastructure and other critical plant. The applicant's operational policy is to continuously dose during the growing season (when seawater temperature exceeds 10ºC) to achieve a minimum TRO dose (within the required cooling water infrastructure and condenser inlets) of 0.2 milligrams per litre (mg/l) (NNB GenCo, 2021c; TR316).

The resulting TRO concentration discharged to the receiving waterbody via the 2 cooling water outlets would therefore be 0.15mg/l. The applicant confirmed that chlorination of the required cooling water infrastructure will not be applied before the SZC drum or band screens, and that the flushing water used to improve flow in the 2 FRR systems' fish gutters (located after the drum screens) will not be chlorinated (waste stream H).

The TRO predicted to result from the combination of chlorine and organic material in the water were modelled using an empirical demand/decay formulation derived from experiments with Sizewell seawater coupled into the GETM Sizewell model (NNB GenCo, 2014b; TR143).

For TRO, the area exceeding the EQS of 10µg/l TRO (as a 95th percentile) is approximately 2ha (0.02km²) at the seabed and 337ha (3.37km²) at the sea surface (Table 3).

The discharge from SZC will be directly into 2 European sites, the Outer Thames Estuary SPA (3,924km²) and the Southern North Sea SAC (36,951km²).

Although this application is for an operational discharge from SZC, there is an existing TRO plume from SZB (operational since 1995). So, where appropriate, our assessment of effects will also consider the area of TRO exceedance when SZC and SZB are both operating. For SZC, TRO exceedances are offshore and do not come into contact with the coast, or with the TRO exceedance plume for SZB (Figure 8). Unlike the situation for thermal uplift, there is no synergistic effect between the TRO exceedance plumes of SZC and SZB (Figure 9).

For SZC alone, the offshore 337ha (3.37km²) surface TRO exceedance plume corresponds to 0.09% of the total surface area of the Outer Thames Estuary SAC, and 0.01% of the area of the Southern North Sea SAC (Table 3, Figure 8).

When SZC and SZB are both operating, 726ha (7.3km²) of the sea surface exceeds the TRO EQS, corresponding to 0.10% of the total surface area of the Outer Thames Estuary SAC, and 0.01% of the area of the Southern North Sea SAC (Table 3). However, the total area of exceedance is comprised of 2 separate plumes (Figure 9).

For SZB alone, the nearshore 388ha (3.9km²) surface TRO exceedance plume corresponds to 0.10% of the total surface area of the Outer Thames Estuary SAC, and 0.01% of the area of the Southern North Sea SAC (Table 3).

Table 3: The total surface area of TRO exceedance for SZC alone, SZB alone, and SZC and SZB in combination. Data from Table 25 in NNB GenCo (2020b; TR306) and Table 9 of NNB GenCo (2019c; TR303)

	Area TRO ≥ EQS 10µg/l (95^{th} percentile) plume on the seabed	Area of TRO ≥ EQS 10µg/l (95^{th} percentile) plume at the sea surface	Area of surface plume as a % of Outer Thames Estuary SPA (3,924km²)	Area of surface plume as a % of Southern North Sea SAC (36,951km²)
SZC alone	2.13ha (0.02km²)	337.56ha (3.4km²)	0.09%	0.01%
SZB alone	164.95ha (1.65km²)	388.56ha (3.9 km²)	0.10%	0.01%
SZC and SZB in combination	167.08ha (1.67km²)	726.21ha (7.3km²)	0.19%	0.02%

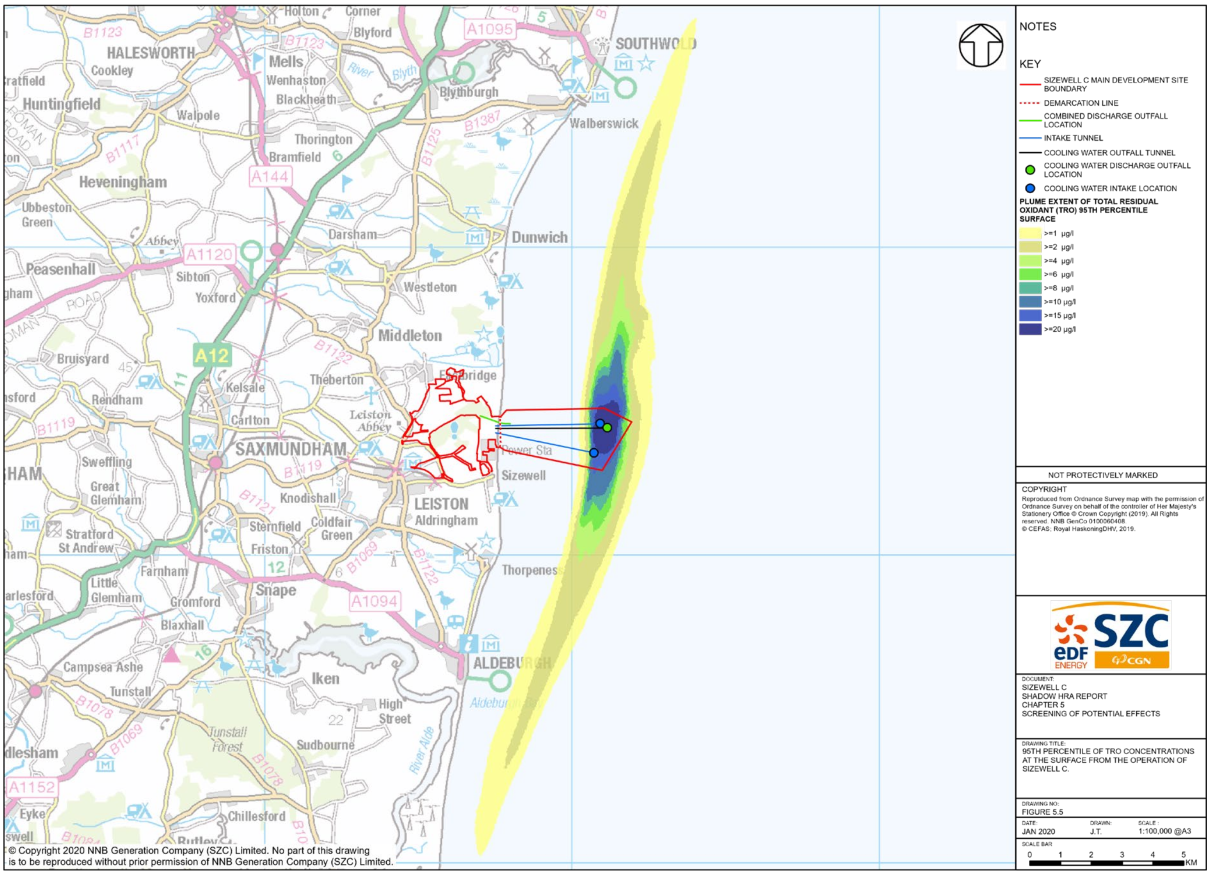

Figure 8: The applicant's modelling of surface TRO concentrations (as 95th percentiles) for SZC alone. Map reproduced from Figure 5.5 of NNB GenCo (2021b; shadow HRA)

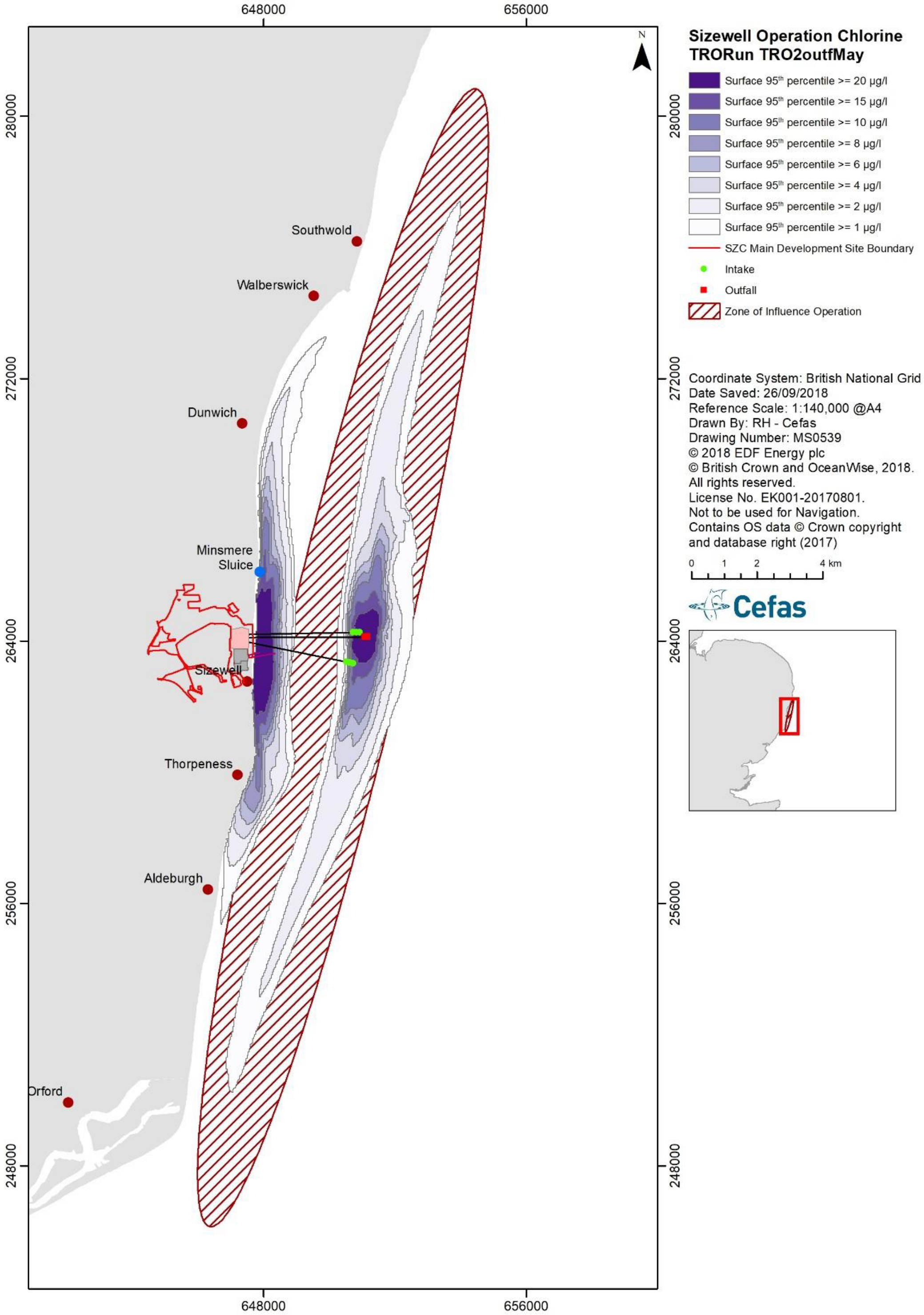

Figure 9: The applicant's modelling of surface TRO concentrations (as 95th percentiles) when SZC and SZB are both operating. The hatched area shows the outer tidal excursion. Map reproduced from Figure 10 in NNB GenCo (2021a; TR193)

6.2.3. Chlorinated by-products (CBP), in particular bromoform

In addition to TRO, chlorination of seawater results in chlorination by-products (CBPs) due to the result of complex chemical reactions in seawater. The number and type of CBPs formed are site-specific, being dependent on the composition and physical parameters of the seawater, with losses from the marine environment occurring largely via ‘volatilisation’ to the atmosphere.

Bromoform was found to be the most dominant of those CBPs detected in laboratory simulations using Sizewell seawater - the amount of bromoform discharged is mainly dependent on the amount of chlorine added, as well as the amount of mixing that occurs (NNB GenCo, 2020b; TR306).

As there is no EQS for bromoform, the applicant used a derived PNEC of 5.0µg/l (calculated as a 95th percentile) for its modelling assessment. This PNEC value is consistent with that used in determination of the Hinkley Point C operational WDA permit application (reference EPR/HP3228XT, granted on 13/03/2013).

Our ecotoxicology advisory service (ETAS) reviewed the PNEC for bromoform and confirmed that the derivation of the PNEC for bromoform was in line with the available ecotoxicology data, and that the assessment factors (AFs) used were also appropriate.

The applicant’s modelling shows that like the TRO plume, the bromoform plume from SZC is a long, narrow feature parallel to the coast (Figure 10).

As with the TRO exceedance plumes, there is no interaction between the bromoform plumes of SZC and SZB when both stations are operating, with the SZB plume remaining inshore of the Sizewell-Dunwich Bank and the SZC plume being outside of the Bank (Figure 11).

Both SZC and SZB plumes are strongly stratified, with larger areas at the surface than at the seabed. The SZC plume is generally smaller and narrower than that resulting from SZB. This is due to the lower initial discharge concentration and greater water depth at the SZC outlet location (16m depth versus 5.0m depth for SZB outlet).

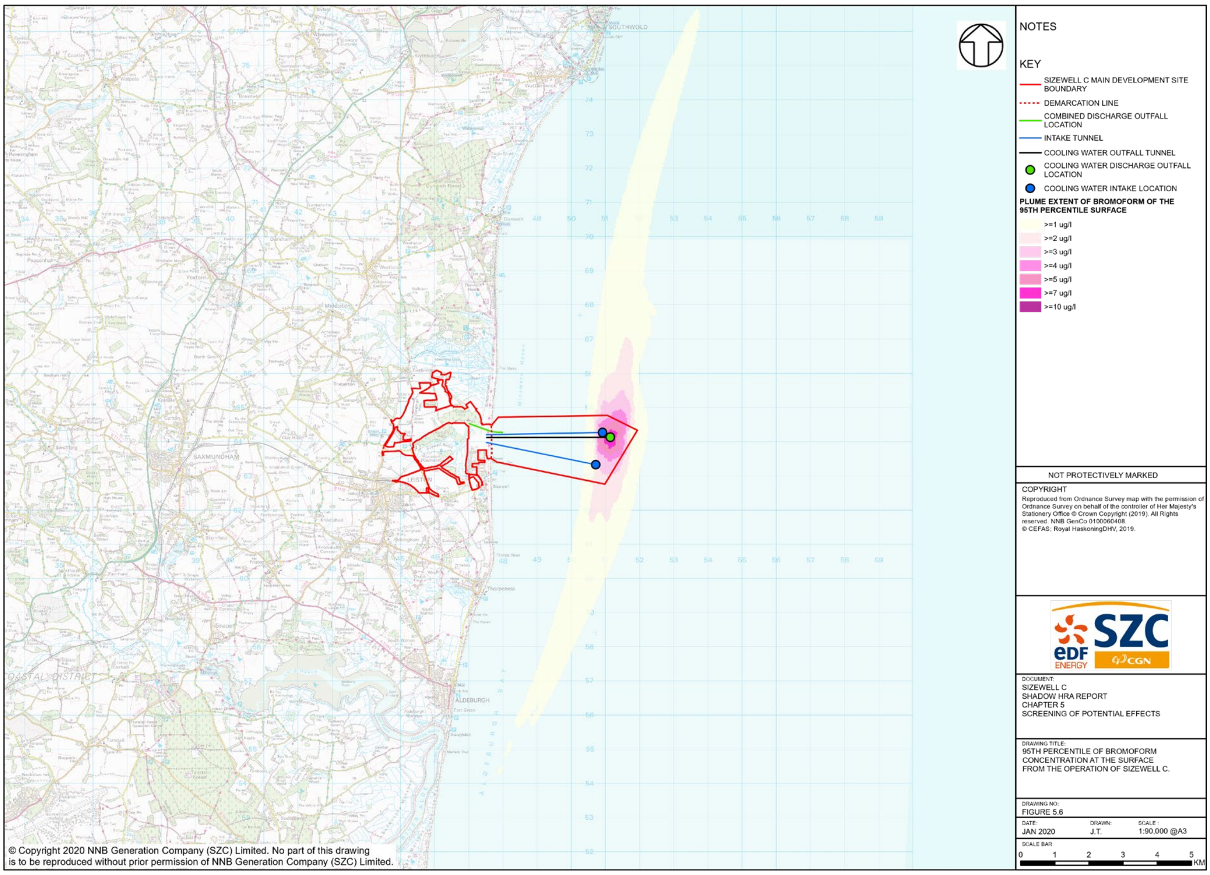

Figure 10: The applicant's modelling of surface bromoform concentrations (as 95th percentiles) for SZC alone. Map reproduced from Figure 5.6 of NNB GenCo (2021b; shadow HRA)

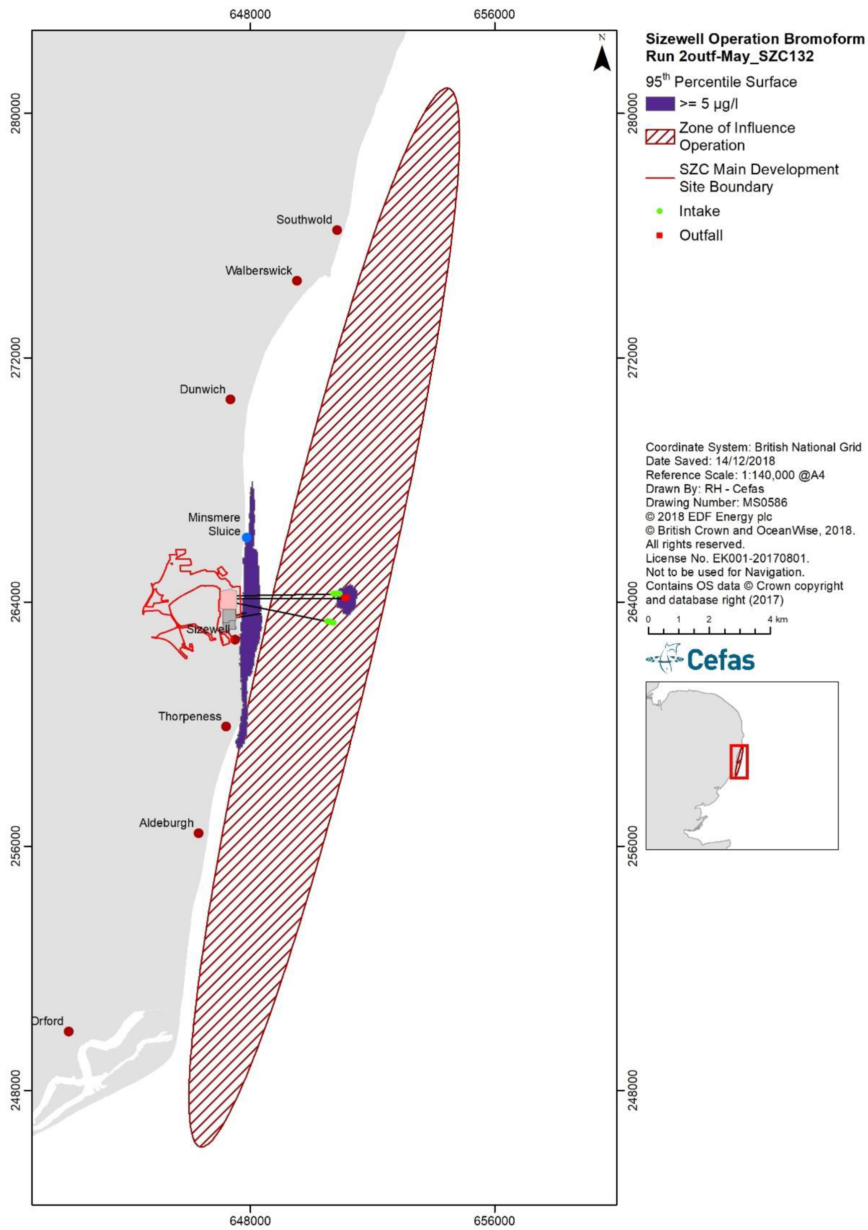

Figure 11: 95th percentile of the bromoform concentration at the surface for chlorination from SZB and SZC. Black line delineates the PNEC of 5µg/l. The hatched area shows the outer tidal excursion. Reproduced from Figure 14 in NNB GenCo (2020b; TR306)

The applicant has calculated the areas of bromoform exceedance, where bromoform is greater than or equal to the PNEC value of 5µg/l as a 95th percentile.

For SZC alone, the offshore 52ha (0.5km^2) surface bromoform exceedance plume corresponds to 0.01% of the total surface area of the Outer Thames Estuary SAC, and <0.01% of the area of the Southern North Sea SAC (Table 4, Figure 10).

When SZC and SZB are both operating, 358ha (3.6km^2) of the sea surface exceeds the bromoform PNEC, corresponding to 0.09% of the total surface area of the Outer Thames Estuary SAC, and 0.01% of the area of the Southern North Sea SAC (Table 4). However, the total area of exceedance is comprised of 2 separate plumes (Figure 11).

For SZB alone, the nearshore 306ha (3.1km^2) surface bromoform exceedance plume corresponds to 0.08% of the total surface area of the Outer Thames Estuary SAC, and 0.01% of the area of the Southern North Sea SAC (Table 4).

Table 4: The total area of bromoform exceedance for SZC alone, SZB alone, and SZC and SZB in combination. Data from Table 27 in NNB GenCo (2020b; TR306) and Table 12 in NNB GenCo (2019c; TR303)

	Area bromoform ≥ PNEC 5µg/l (95th percentile) plume on the seabed	Area of bromoform ≥ PNEC 5µg/l (95th percentile) plume at the sea surface	Area of surface plume as a % of Outer Thames Estuary SPA (3,924km^2)	Area of surface plume as a % of Southern North Sea SAC (36,951km^2)
SZC alone	0.67ha (0.007km^2)	52.14ha (0.5km^2)	0.01%	< 0.01%
SZB alone	129.52ha (1.30km^2)	305.80ha (3.1km^2)	0.08%	0.01%
SZC and SZB in combination	130.19ha (1.30km^2)	357.94ha (3.6km^2)	0.09%	0.01%

6.2.4. Hydrazine

There is no environmental quality standard (EQS) for hydrazine. Due to the use of hydrazine at several of its operational power station sites, EDF Energy (NNB Generation Company (SZC) Limited) conducted multiple research projects (reported in NNB GenCo, 2008; TR352) to analyse the available ecotoxicology data, proposing 2 predicted no-effect concentrations (PNECs) for use as thresholds in environmental risk assessments:

- a chronic PNEC value of 0.4ng/l (calculated as a mean) for assessing long-term effects
- an acute PNEC value of 4.0ng/l (calculated as a 95th percentile) for assessing short-term effects

Since this earlier research, more recent assessments used in support of Canadian Federal Water Quality Guidelines (FWQGs) for hydrazine indicate concentrations below 200ng/l have a low probability of adverse effects/impacts for marine life, while a freshwater threshold of 2.6µg/l has been applied based on a greater availability of data in the freshwater environment (Environment Canada, 2013). Although these standards have not been adopted within the UK, they will be considered here against any extreme acute exposure (for example, maximum concentrations experienced) where appropriate.

The fate of hydrazine in the aquatic environment is dependent on several variables, including dilution and dispersion, chemical and biological degradation, and processes such as volatilisation and sedimentation (Kuch, 1996).
Our ecotoxicology specialists (ETAS) have reviewed the applicant's supporting documentation and justification for the 2 derived PNECs and agreed that, in the absence of an established EQS, the derived PNECs can be used as an effect threshold for both purposes of surface water and habitats regulations assessments (Appendix A).

The applicant has assessed the daily discharges from SZC in relation to an annual hydrazine discharge of 24.3 kilograms per year (kg/y) into the cooling water flow (waste stream A via waste stream D). A daily mean hydrazine discharge of 66.6 grams (g) into a 125m^3/second cooling water flow was also assumed, with the concentration in the treatment tank being 0.089mg/l or 0.044mg/l depending on whether one or two holding tanks are used.

To understand the impact of different discharge rates from the treatment tanks and assuming no treatment, the applicant studied 2 discharge scenarios for the operational SZC (NNB GenCo, 2020b; TR306):

1) a hydrazine discharge of 69ng/l in daily pulses of 2.32 hours (2 hours 18 minutes) starting at 12pm
2) a hydrazine discharge of 34.5ng/l in daily pulses of 4.63 hours (4 hours 38 minutes) duration starting at 12pm

The 2 scenarios simulate hydrazine being discharged by either one or two treatment tanks. The daily discharge concentration in the cooling water flow would be 69ng/l over a 2.32 hour period if one tank were used, or 34ng/l over a 4.63 hour period if two tanks were used. The modelling simulations for these 2 scenarios show that both resulted in similar plume sizes; the calculated concentration of the hydrazine plume is higher at the surface than at the seabed, as was the case for the TRO and bromoform modelling results (Table 5, Table 6). No hydrazine is released by SZB and so the area of exceedance plumes when both SZC and SZB are operating will be the same as for SZC alone.

Table 5: The total area of chronic hydrazine exceedance for SZC alone. Data from Table 29 in NNB GenCo (2020b; TR306)

		Area of chronic hydrazine ≥ PNEC 0.4ng/l (as a mean) plume on the seabed	Area of chronic hydrazine ≥ PNEC 0.4ng/l (as a mean) plume at the sea surface	Area of surface plume as a % of Outer Thames Estuary SPA (3,924km²)	Area of surface plume as a % of Southern North Sea SAC (36,951km²)
SZC alone	69ng/l release	0.56ha (<0.01km²)	158.11ha (1.58km²)	0.04%	<0.01%
SZC alone	34ng/l release	0.34ha (<0.01km²)	156.88ha (1.56km²)	0.04%	<0.01%

Table 6: The total area of acute hydrazine exceedance for SZC alone. Data from Table 29 in NNB GenCo (2020b; TR306)

		Area of acute hydrazine ≥ PNEC 4ng/l (95th percentile) plume on the seabed	Area of acute hydrazine ≥ PNEC 4ng/l (95th percentile) plume at the sea surface	Area of surface plume as a % of Outer Thames Estuary SPA (3,924km²)	Area of surface plume as a % of Southern North Sea SAC (36,951km²)
SZC alone	69ng/l release	0.22ha (<0.01km²)	13.79ha (0.14km²)	<0.01%	<0.01%
SZC alone	34ng/l release	0.0ha (<0.01km²)	17.38ha (0.17km²)	<0.01%	<0.01%

For SZC alone, the offshore 158ha (1.58km²) surface chronic hydrazine exceedance plume under the 69ng/l release scenario corresponds to 0.04% of the total surface area of the Outer Thames Estuary SAC, and <0.01% of the area of the Southern North Sea SAC (Table 5, Figure 12). Under the 34ng/l release scenario, the surface chronic PNEC exceedance is very similar at 157ha (1.57km²), representing essentially the same proportion of the protected areas (Table 5).

For SZC alone, the offshore 14ha (0.14km²) surface acute hydrazine exceedance plume under the 34ng/l release scenario corresponds to <0.01% of the total surface area of the Outer Thames Estuary SAC, and <0.01% of the area of the Southern North Sea SAC (Table 6, Figure 13). Under the 34ng/l release scenario, the surface acute PNEC exceedance is larger than under the 69ng/l scenario, being around 17ha (0.17km²), although this still represents less than 0.01% of the protected areas (Table 6).

Due to the offshore location of the SZC CWS outlets, neither the chronic nor the acute hydrazine exceedance plumes come into contact with the coastline (Figure 12, Figure 13).

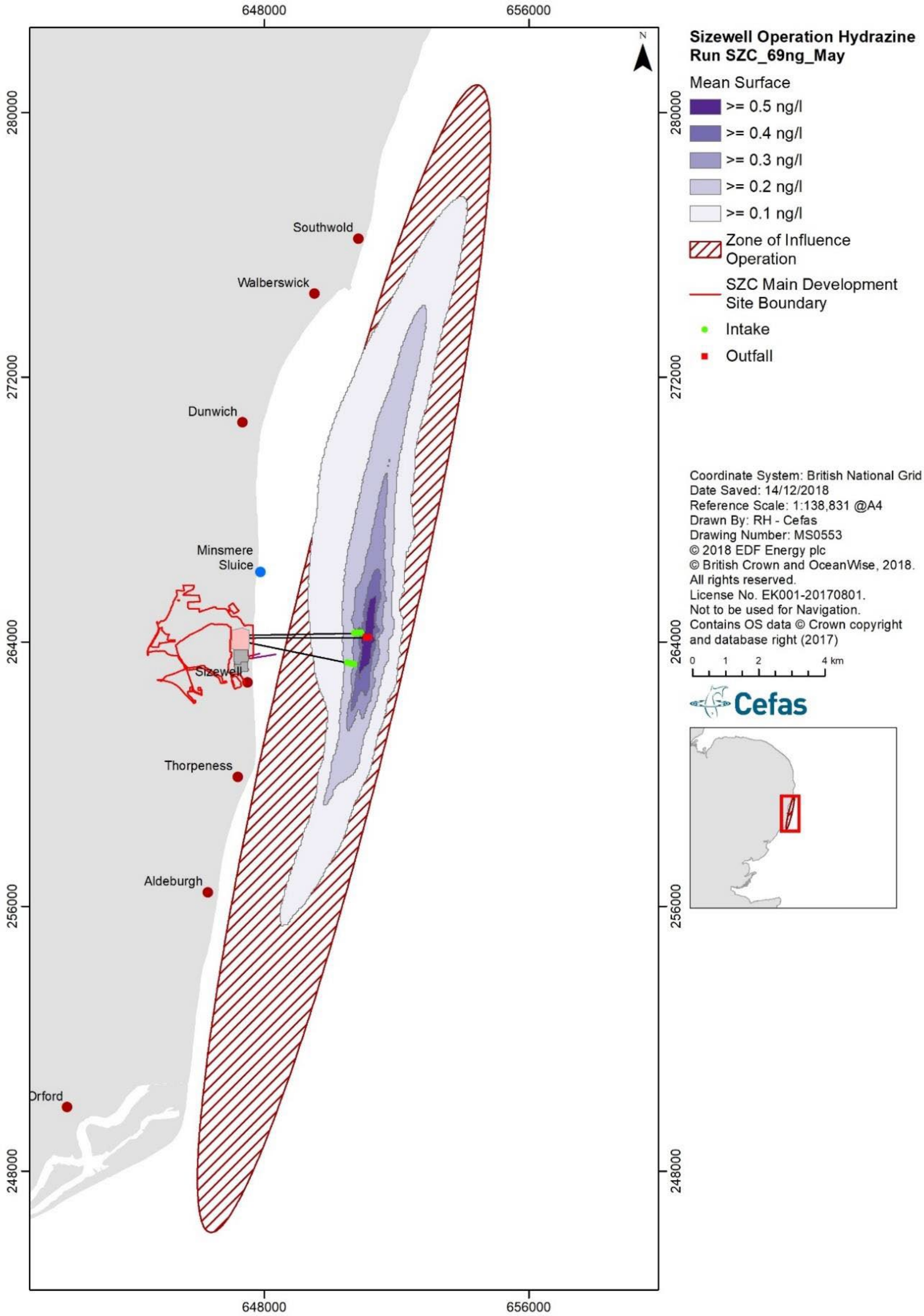

Figure 12: Mean hydrazine concentrations at the surface after release of 69ng/l in pulses of 2.32h from SZC. The ≥0.4ng/l contour represents the chronic PNEC value. Map reproduced from NNB GenCo (2021a; TR193)

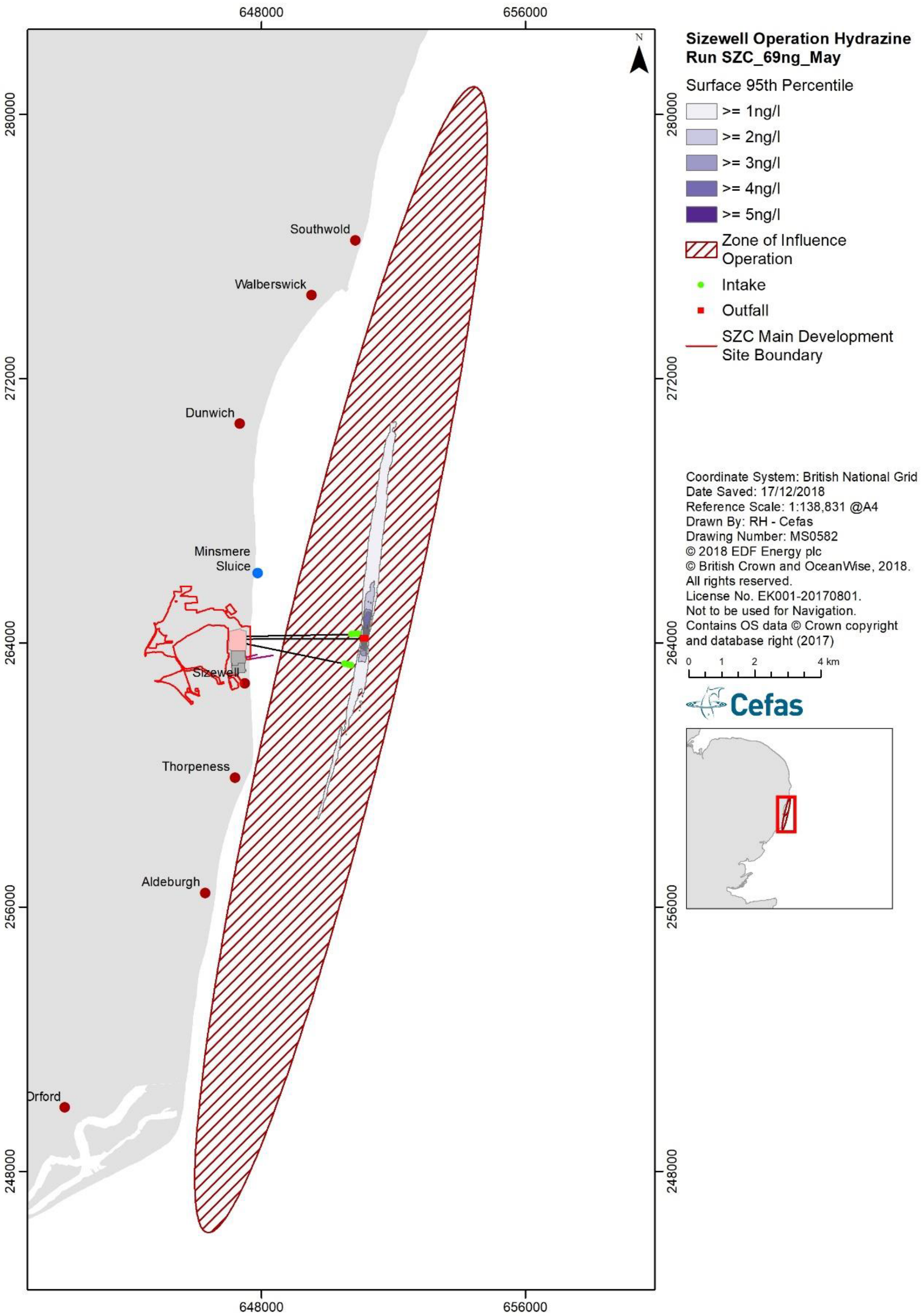

Figure 13: 95th percentile of hydrazine concentrations at the surface after release of 69ng/l in pulses of 2.32h from SZC. The ≥ 4.0ng/l contour represents the acute PNEC value. Map reproduced from NNB GenCo (2020b; TR306)

6.3. Changes in nutrient and organic enrichment

Changes in nutrients or eutrophication arising from sewage discharge and from the discharge of dead and moribund biota from the FRR system.

- Indirect effects may occur if the integrity of the site is affected by changes in water quality. Our assessment considers:
  - nutrient dissolved inorganic nitrogen (DIN) concentrations
  - un-ionised ammonia
  - dissolved oxygen
  - phytoplankton production
  - organic enrichment

There are 2 potential sources of nutrient and organic enrichment:

- fish return and recovery systems – discharged through outlets around 0.8km offshore
- sewage treatment works (via waste stream G) discharging via the CWS outlets 3km offshore

These will both be considered in the following assessment, which demonstrates that the discharges from the STW and FRR systems will not result in a change to nutrient and organic enrichment in the Greater Sizewell Bay.

6.3.1. Assessment of sanitary/treated sewage effluent (waste stream G)

The operational Sizewell C (SZC) power station site will generate black wastewater and grey wastewater from the site's lavatories, welfare, and kitchen and office facilities, which will receive treatment by an appropriately sized sewage treatment plant (STP). This will discharge treated sanitary effluent to the site's main cooling water stream, which will discharge to the marine environment via the site's 2 cooling water discharge outlets.

The sewage treatment plant will be designed to deal with varying numbers of site staff that considers both day-to-day operations (typical, normal operations) and site outage operations (infrequent occurrences when the site requires maintenance/refuelling which will require additional workers). These represent a maximum/worst-case scenario for the demand placed on the STP by variations in the site's personnel. Daily wastewater flows are considered to be:

- normal 24 hour/daily flow: based on a site staff/worker population equivalent of 900 people using 100 litres per person per day (l/p/d) equates to a treated effluent volume of 90,000 litres per day (l/d) or 90 cubic metres per day (m^3/d)

- maximum 24 hour/daily flow: based on a site staff/worker and contractor population equivalent of 1,900 people using 100l/p/d equates to a treated effluent volume of 190,000l/d or 190m³/d

The normal and maximum volumes are based on the combined flows from personnel serving the whole site (that is, for 2 operational EPR units), and is based on the operational Hinkley Point C (HPC) WDA permit application estimates used to determine maximum discharge concentrations of inputs into the sewage treatment plant serving HPC (reference EPR/HP3228XT, granted on 13/03/2013).

The flow of 100l/p/d is based on guidance from British Water (2009) for industrial/factory sites with office and canteen facilities for its staff/workers.

The sewage treatment plant will be designed to treat the influent to the following standard as a minimum before it is discharged into the cooling water stream:

- biochemical oxygen demand ($BOD_{5\text{-}atu}$) concentration of 20 milligrams per litre (mg/l)
- suspended solids concentration of 30mg/l
- ammoniacal nitrogen (as N) concentration of 20mg/l

Based on the above maximum site population and treated effluent standards, the following annual loads can be calculated based on the maximum (worst-case) volume of 190m³/day:

- biochemical oxygen demand ($BOD_{5\text{-}atu}$) loading of 1,387 kilograms per year (kg/y)
- suspended solids loading of 2,080kg/y
- total ammonia loading of 1,387kg/y
- total nitrogen (as N) loading of 1,595 kg/y

We have screened out the discharge of suspended solids as having no likely significant effect due to the concentration discharged being lower than the suspended solid concentration in the receiving water, as well as the diluting effect of the cooling water system flow. This is discussed in the LSE assessment for the Outer Thames Estuary SAC (section 5.1.1).

6.3.2. Assessment of un-ionised ammonia

As temperature may influence the relative amount of un-ionised ammonia, the operational SZC discharge has been further assessed by considering temperature elevation via modelling.

During operation, sources of ammonia will be discharged from SZC. As discussed in section 6.3.1, the site's proposed sewage treatment plant will discharge a minimum treated sewage effluent quality of 20mg/l ammoniacal nitrogen (as N).

The annual ammonia discharge from SZC is calculated as 14,396kg/year, which results in a calculated mean ammonia discharge concentration of 3.9μg/l (3.06μg/l NH_4 as N) (NNB GenCo, 2021a; TR193). These values are based on data from Table 25 in NNB GenCo 2021a; TR193), specifically:

- the worst-case annual loading for ammonia from the sewage treatment plant of 1,387kg/year (waste stream G)
- the worst-case annual discharge of nitrogen (as NH_4) resulting from the circuit/plant conditioning chemicals used for the 2 EPR units of 13,009kg/year (waste stream B + C + D)
- a cooling water discharge of 125m^3/second

As a conservative assumption, this worst-case value has been added to the site-specific background mean and 95th percentile values to derive the un-ionised ammonia calculation.

The applicant has calculated the SZC un-ionised ammonia concentrations using the Environment Agency calculator (Clegg and Whitfield, 1995) using:

- the GETM output for temperature elevation to account for operation of SZB and SZC, and SZB alone
- observed values for background water quality parameters (temperature, salinity and pH)
- background ammonia concentrations

This was to allow consideration of the cooling water discharge with the annual average EQS of 21μg/l for un-ionised ammonia, with the model run to replicate an annual cycle. Table 7 displays the results of the derived un-ionised ammonia concentrations using combinations of mean and 95th percentiles for temperature and pH, mean and 5th percentile of salinity and mean ammonia.

These calculations show that the derived un-ionised ammonia concentrations result in un-ionised ammonia values that are low in comparison to the annual average EQS of 21μg/l; for example, a maximum concentration of 0.52μg/l based on the thermal input for SZB and SZC, and 0.5μg/l for that from SZB alone.

No figures for SZC alone are available. Since the SZC alone figure will be less than the corresponding SZC and SZB figure, and that the SZC and SZB figure is acceptable, it follows that the SZC alone figure would also be acceptable. On this basis, we do not consider the omission of a SZC figure to be important.

The 24-hour discharge figure for un-ionised ammonia is just over a third of the EQS at 7.92μg/l, but the site background concentration is also low (maximum concentration of 5.2μg/l). In all cases (including worst-case) for un-ionised ammonia, no areas at the surface within the receiving waterbody exceed the annual average EQS of 21μg/l in the modelled scenarios.

Additional potential contributions of ammonia from operation of SZC have also been considered via the operational use of hydrazine, morpholine and/or ethanolamine:

- hydrazine breakdown during operation (or subsequently during holding and potentially treatment on site) may result in nitrogen loss to the atmosphere
- ethanolamine/morpholine may not readily break down to directly release ammonia

However, estimated maximum ammonia inputs from the combined loadings of these 3 substances could contribute a 4.0% (percent) increase to the annual loading. This additional potential loading is considered to be sufficiently small in addition to the terms of the assessment results summarised in Table 39 in NNB GenCo (2021a; TR193) so as not to be of significance to background elevation.

Table 7: Summary of relative proportion of model domain areas associated annual mean increase of un-ionised ammonia concentration (EQS is 21µg/l as an annual mean) at the surface. Data from Table 39 in NNB GenCo (2021a; TR193)

Combination of temperature, ammonia, pH and salinity conditions	Percentile	Un-ionised ammonia for SZB and SZC	Un-ionised ammonia for SZB
mean temperature, mean ammonia, pH, salinity	50	0.25	0.25
mean temperature, mean ammonia, pH, salinity	95	0.27	0.26
mean temperature, mean ammonia, pH, salinity	99	0.29	0.27
mean temperature, mean ammonia, pH, salinity	Maximum	0.52	0.50
95 percentile temperature, mean ammonia, pH, salinity	50	0.8	0.46
95 percentile temperature, mean ammonia, pH, salinity	95	0.8	0.47
95 percentile temperature, mean ammonia, pH, salinity	99	0.9	0.52
95 percentile temperature, mean ammonia, pH, salinity	Maximum	1.2	0.91
mean temperature, 95 percentile ammonia, pH, 5 percentile salinity	50	0.8	0.81
mean temperature, 95 percentile ammonia, pH, 5 percentile salinity	95	0.8	0.83
mean temperature, 95 percentile ammonia, pH, 5 percentile salinity	99	0.9	0.88
mean temperature, 95 percentile ammonia, pH, 5 percentile salinity	Maximum	1.61	1.55

6.3.3. Assessment of dissolved inorganic nitrogen (DIN)

The applicant's modelling showed that the release of nitrogen as N in the cooling water would be 484.3µg/l, this being a combination of the background level of N in the seawater and the amount of N discharged by the power station, which includes 4.4kg/day (1,595kg/y) from sanitary effluent (Table 32 in NNB GenCo, 2021a; TR193). A release of 484.3µg/l is 49% of the EQS value of 980µg/l (as a 99th percentile), this EQS being the winter standard for water bodies of intermediate turbidity (Table 32 in NNB GenCo, 2021a; TR193). As the loading of DIN may influence algal growth, the applicant completed further assessment using a combined macroalgal and phytoplankton (CMP) model which incorporated the influence of chlorination upon phytoplankton survival (NNB GenCo, 2020e; TR385).

The applicant states that it is only in the summer that the discharge of additional nutrients needs to be assessed. During winter, there is no effect resulting from the additional supply of nutrient because light is the limiting factor for phytoplankton growth. In NNB GenCo (2020e; TR385) the applicant demonstrates that during operation the maximum daily loading of nitrogen reaches approximately 2.0% of the daily exchange for Sizewell Bay, but that the average daily value is low at 0.2% of this daily exchange – at which level the input of nitrogen from SZC would be indistinguishable from background concentrations. This is based on a maximum operational 24 hour loading of nitrogen from all sources of 332kg, and a maximum operational annual loading of 11,725kg/year (which equates to 32.1kg/d) (NNB GenCo, 2020e; TR385).

During operation of SZC, the use of hydrazine, morpholine and/or ethanolamine via waste streams B and C have the potential to contribute to the nitrogen input to the marine environment via the 2 cooling water discharge outlets. These 3 substances are used as conditioning chemicals to inhibit corrosion in circuits in contact with air, where volatile inhibitors cannot be used. Hydrazine breakdown during operation, or subsequently during holding and potentially treatment before discharge, may result in nitrogen loss to the atmosphere. The applicant estimated that maximum nitrogen inputs from the combined loadings of hydrazine, ethanolamine and morpholine could contribute a loading of 1.3kg/day. But, this additional potential loading is small relative to the 32kg/day from other sources, would be insignificant relative to the daily exchange, and would not be expected to influence phytoplankton growth above that predicted for other operational inputs of nitrogen (NNB GenCo, 2021a; TR193).

When additional sources of nitrogen are added from the 2 fish recovery and return (FRR) system discharges (section 6.3.4), the small amount of additional nitrogen from operational use of hydrazine, morpholine and ethanolamine is proportionally even smaller.

The conclusion within the applicant's CPM modelling report is that total phytoplankton production in the modelled abstraction area is predicted to be reduced by approximately 5% due to phytoplankton entrainment mortality from operations at SZB and SZC, which is well within the natural variability of phytoplankton in the area (NNB GenCo, 2020e; TR385). The applicant concludes that "there is greater daily exchange of water between Sizewell Bay and the greater Southern North Sea than there is daily extraction of water due to the power stations. Due to this exchange, the apparent concentration of phytoplankton will not be reduced in Sizewell Bay when considered against the high natural variability. In particular, the predicted effect of either the present SZB or the proposed SZC would not be observable in any monitoring programme." (NNB GenCo, 2020e; TR385).

While our assessment includes a higher figure for fish impingement at SZC and, therefore, a higher input of additional nutrients from the FRR system discharge (section 6.3.4), we agree with the applicant's conclusion that there will be no impact on the phytoplankton growth due to these nutrients.

6.3.4. Potential for nutrient and organic enrichment from the FRR systems

The design for the cooling water system at SZC includes 2 measures which are proposed to work together to reduce the environmental impact of that water discharge activity (WDA). These measures are low velocity side entry (LVSE) intake heads and the fish recovery and return (FRR) systems.

The power station's cooling water system is protected by a series of screens to reduce risks of blockage or biofouling. Any debris and biota larger than the screen mesh size will be trapped on the screens ('impinged').

Some of this biota will still be alive, and the purpose of the FRR system is to return these individuals back to Greater Sizewell Bay. However, a proportion of this biota will not survive impingement, and this dead or moribund biota will also be returned to Greater Sizewell Bay via the FRR system discharge outlet. The discharge of this moribund biota constitutes a WDA as it is considered a discharge of polluting matter under Schedule 21 of The Environmental Permitting (England and Wales) Regulations 2016.

Our assessment methodology for all impacts of dead biota from the FRR systems' discharge is detailed in Appendix B. Our assessment is precautionary, being based on the upper 95% confidence level of either the annual, or the Q1 (Quarter 1 - January, February, March) mean daily loading of fish and invertebrates - our 'reasonable worst-case with invertebrates' scenario, these being 4,083kg biota impinged per day (annual mean daily loading) and 8,046kg biota impinged per day (Q1 mean daily loading) (Table 53 in Appendix B).

For biochemical oxygen demand (BOD) and thereby impact on dissolved oxygen (DO), smothering of benthic habitat by organic carbon deposition is potentially important. Similarly, for un-ionised ammonia, short-term acute effects are potentially important. Calculations of un-ionised ammonia and the potential effects on dissolved oxygen from the FRR systems' discharge are therefore based on the upper 95% confidence level of the Q1 mean daily loading as this is the worst-case period of maximum impinged biomass.

For nutrient input, the upper 95% confidence level of the annual mean daily loading is used both for comparison of DIN to the WFD standard, and to assess the secondary impact of increased nutrients on phytoplankton growth. The annual mean daily loading is used because, while the largest quantity of dead biomass is returned in January, February, and March, light is the limiting factor for phytoplankton growth during these months. Therefore the nutrients released at this time will not lead to increased phytoplankton growth. Dead biomass returned during the summer months is the most relevant loading as this coincides with periods of nutrient limitation. However, as a precautionary measure the annual loading has been used instead (the annual loading being higher than the summer loading).

Nutrient enrichment, un-ionised ammonia and dissolved oxygen from the FRR system

The inputs of additional nutrients (N and P), un-ionised ammonia or decrease in dissolved oxygen have been assessed in terms of the surface area required to dilute the input to the EQS, with the input from the FRR systems being based on the upper 95% confidence level of the mean of our 'reasonable worst-case with invertebrates' scenario (Appendix B). For SZC alone this loading is not expected to exceed 4,083kg/day (Table 53). For SZC and SZB combined, the daily loading is the sum of the daily loading from SZB and SZC and is not typically expected to exceed 5,846kg/day.

The surface area required to dilute to the EQS is then related to the size of the tidal excursion within Greater Sizewell Bay, this being the horizontal area over which a particle would be transported through the ebb and flow of a tidal cycle. This gives an indication of how the discharge from the FRR system will be dispersed and mixed as it leaves the outlet. Given the diffuse nature of the inputs from discharged biota, this is a more useful indicator for this purpose than the calculation of plume size and its percentage of the SPA and SAC area (the method used to assess TRO, bromoform and hydrazine discharges from the cooling water system of SZC).

Nutrient input from SZC alone is not expected to exceed 20.4kg of P per day and 142.9kg of N, based on the upper 95% confidence interval of the mean of our 'reasonable worst-case with invertebrates' scenario (Table 8).

The applicant modelled the effect of phosphate and nitrates discharged from SZC alone on phytoplankton productivity, concluding that while there may be an increase in local phytoplankton productivity:

> "the effect of discharged nutrients is more than offset by entrainment mortality. Combining the effects of entrainment mortality, increased nutrient discharges and the effects of the thermal plumes, the predicted local reduction in total phytoplankton production by SZC+SZB is about 6% over the reference (no stations) condition. There is greater daily exchange of water between Sizewell Bay and the greater Southern North Sea than there is daily extraction of water due to the power stations. Due to this exchange, the apparent concentration of phytoplankton will not be reduced in Sizewell Bay when considered against the high natural variability. In particular, the predicted effect of either the present SZB or the proposed SZC would not be observable in any monitoring programme." (NNB GenCo, 2020e; TR385)

The applicant's modelling was based on average daily loads of all operational N discharges and included an average daily N load for April to September from the FRR system discharge of 14kg and an annual value of 37kg per day. Our reasonable worst-case scenario for impingement calculates a daily input of N from the FRR system discharge of around 4 times the amount of N input the applicant has calculated, but this too would have a negligible impact on phytoplankton growth.

The surface area required to dilute un-ionised ammonia to the EQS, and the surface area needed to meet oxygen demand through re-aeration show the same general pattern, with inputs/areas higher for SZC alone, than for SZB alone, and higher still for SZC and SZB (Table 8). This is due to the greater volume of moribund biota discharged from the FRR system of SZC alone (≤4,083kg/day), compared to SZB alone (≤1,763kg/day), and the effects of SZC and SZB in combination, being based on the sum of the moribund biota from both stations (≤5,846kg/day).

Un-ionised ammonia can be toxic to marine life. However, only 428.3m² (with thermal uplift) is required to dilute the un-ionised ammonia (NH_4) resulting from the FRR system discharge of SZC alone to its EQS of 21µg/l (as an annual mean), with the equivalent figure for SZC and SZB being 613.9m² (Table 8). This does not mean that there will actually be an area of exceedance of these dimensions. The actual area of exceedance, if any, will be much smaller as biota are discharged throughout the day and night from 2 outlets (for SZC alone), rather than over one short time period, and all in a single location. Discharges from SZB and SZC outlets will be further dispersed again. Biota will also be dispersed away from the outlets, with a proportion consumed by scavengers, rather than all settling in one place.

The applicant conducted a particle tracking modelling study which indicated sprat-like particles may disperse over an area of up to 32.7km² (NNB GenCo, 2021d; TR511). Furthermore, the discharge is taking place in a tidal environment, with a flow of water moving past the discharge points with the tides. The surface area of water required to dilute the un-ionised ammonia (NH_3) resulting from the FRR system discharge of SZC alone to its EQS value is slightly below 0.001% of the tidal excursion (43.6km²) (NNB GenCo, 2020b; TR306), and for SZC and SZB in combination, the figure is 0.001%.

The surface area required to meet the daily oxygen demand of the discharge from the FRR system of SZC alone was calculated as being 1.056km², with the corresponding figure being 1.514km² for SZC and SZB (Table 8).The actual areas over which effects on oxygen levels occur will be smaller due to the continuous discharge of biota from 2 separate outlets, the dispersal of that biota away from the outlets, the consumption of a proportion by scavengers, and the tidal movement of water past the outlets. The surface area of water required to meet the daily oxygen demand of the discharge from the FRR system of SZC alone (1.056km²) is just 2.4% of the tidal excursion (43.6km²) (NNB GenCo, 2020b; TR306) and for SZC and SZB in combination, the figure is 3.5%.

Table 8: Summary of FRR system discharge loading estimates for SZC alone, SZB alone, and SZC and SZB in combination, based on the upper 95% confidence limit of the mean of the Environment Agency's 'reasonable worst-case with invertebrates' scenario

		SZC alone	SZB alone	SZC and SZB
Nutrient input (P)	Max daily P content (kg)	20.4	8.8	29.2
Nutrient input (N)	Max daily N content (kg)	142.9	61.7	204.6
Un-ionised ammonia	Area required to dilute to the EQS (21µg/l as an annual mean) with temperature uplift (m²)	428.3	185.6	613.9
Influence on dissolved oxygen	Area needed to meet oxygen	1.056	0.458	1.514

		SZC alone	SZB alone	SZC and SZB
	demand through reaeration (km²)			

Organic enrichment from the FRR systems

Organic enrichment refers to carbon released by the decomposition of dead fish and invertebrates discharged from the FRR systems. As a proxy for an EQS, 100g organic carbon/m^2/year has been used to assess the negative impacts of organic enrichment (Appendix B).

In the following assessment, the potential impact of organic enrichment is examined by reference to the maximum potential area of organic exceedance for SZB alone, SZC alone, and SZC and SZB in combination.

The maximum potential area of organic exceedance is the area over which the annual discharge of dead fish and invertebrates from the FRR systems discharge could theoretically be spread to achieve an even thickness that will release carbon at the proxy EQS rate over the whole area (in the manner of spreading fish paste on toast, to an even thickness). The annual discharge of dead fish and invertebrates from the FRR system discharge is calculated as described in Appendix B.

Tidal parameters from the thermal plume have been used to scale the area of organic exceedance into a shape which approximates a plume. This method produces a plume based on our reasonable worst-case impingement scenario and provides a 'ballpark' figure for examining potential impacts.

For SZB alone, the maximum potential area of organic exceedance is 3.97km² and approximates to an ellipse 5.46km long by 0.92km wide (Figure 14). This is equivalent to 0.10% of the total area of the Outer Thames Estuary SPA and 0.01% of the area of the Southern North Sea SAC.

For SZC alone, the maximum potential area of organic exceedance is greater than that of SZB alone at 9.16km², and approximates to an ellipse 8.296km long by 1.406km wide (Figure 14). This is equivalent to 0.21% of the total area of the Outer Thames Estuary SPA and 0.02% of the area of the Southern North Sea SAC.

For SZC and SZB, the maximum potential area of organic exceedance is 13.19km² and approximates to an ellipse 9.932km long by 1.683km wide (Figure 14). This is equivalent to 0.34% of the total area of the Outer Thames Estuary SPA and 0.04% of the area of the Southern North Sea SAC.

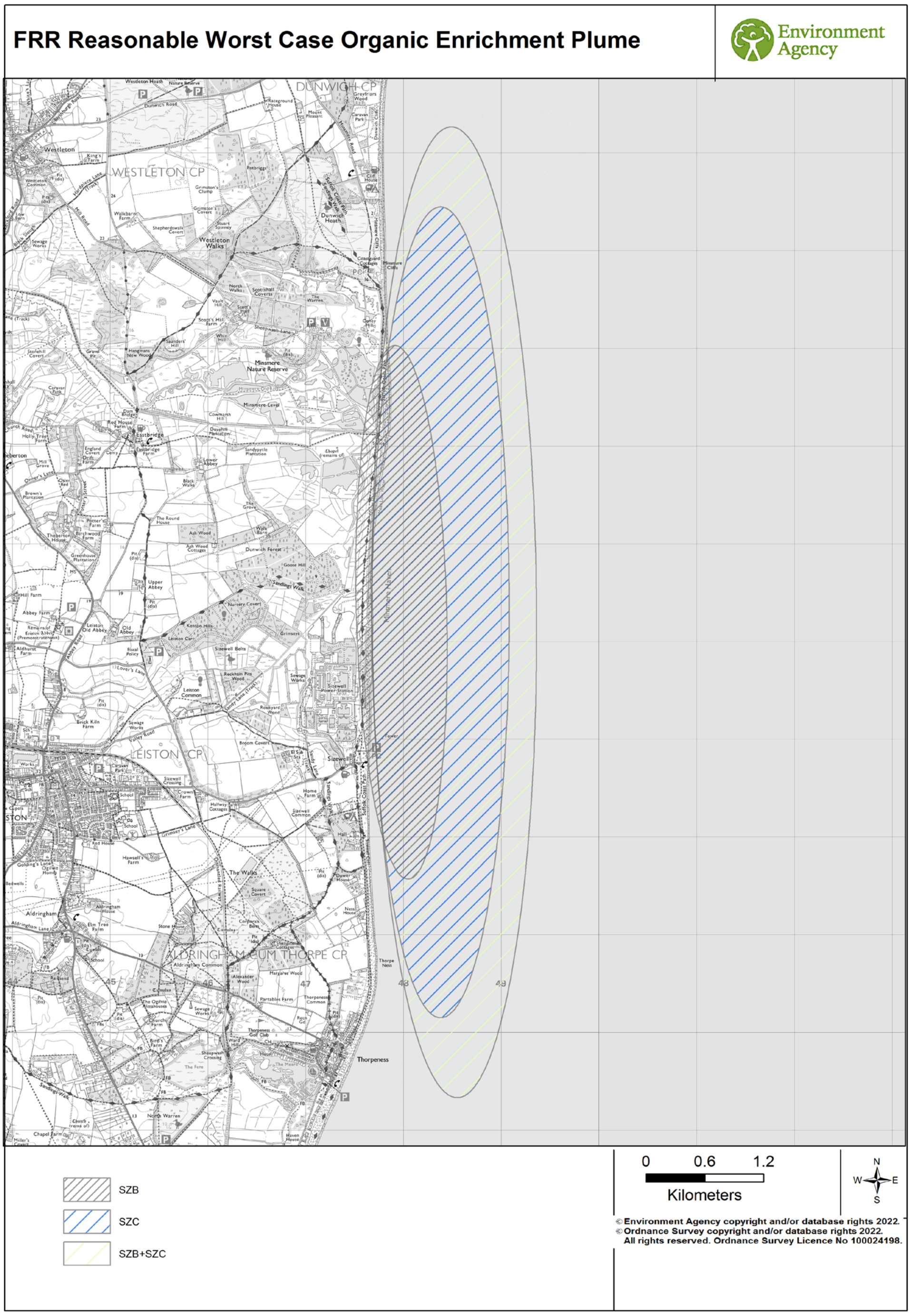

Figure 14: The maximum potential area of organic exceedance for SZC alone, SZB alone, and SZC and SZB in combination, based upon the upper 95% confidence limit of the mean of the Environment Agency's precautionary 'worst-case with invertebrates' scenario

The maximum potential area of organic exceedance is the largest area over which biology could be affected by the FRR system discharge. Should biota be dispersed further away from the outlet than the plume approximation indicates, then the release of carbon over that wider area would occur at less than the proxy EQS rate of 100g carbon/m^2/year.

The applicant conducted a particle tracking study (NNB GenCo, 2021d; TR511), which modelled the distribution of sprat-sized particles from the SZC FRR system discharge, from which we know that these particles will be distributed over at least 32.7km^2 (Figure 15). The maximum potential area of organic exceedance for SZC alone is 9.16km^2. If the biota were distributed over the area identified by the particle tracking studies, the density of enrichment would be 9.16km^2 / 32.7km^2 = 0.28 of the proxy EQS of 100g carbon/m^2/year. Therefore, it follows that if the biota from the FRR system of SZC alone were spread evenly over the wider 32.7km^2 area indicated by the particle tracking model, it would contribute 28g carbon/m^2/year, rather than 100g carbon/m^2/year (Figure 15).

Similarly, the maximum potential area of organic exceedance for SZC and SZB in combination is 13.19km^2. So, if the biota were distributed over the 32.7km^2 identified by the particle tracking studies the density of enrichment would be 13.19km^2 / 32.7km^2 = 0.40 of the proxy EQS of 100g carbon/m^2/year. This means that if the biota from the FRR systems of both SZC and SZB in combination were spread evenly over the wider 32.7km^2 area indicated by the particle tracking study, it would be contributing 40g carbon/m^2/year, rather than 100g carbon/m^2/year (Figure 15).

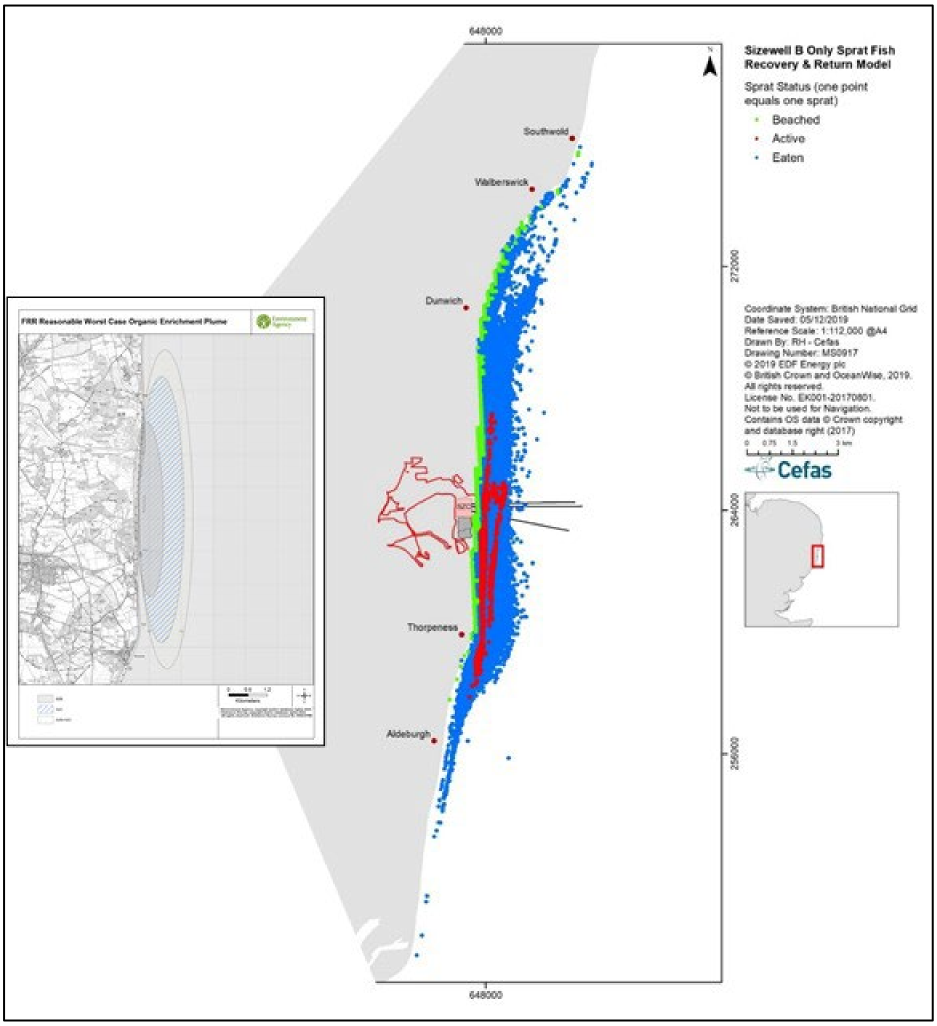

Figure 15: The Environment Agency's maximum potential area of organic exceedance for SZC alone, SZB alone, and SZC and SZB in combination (left inset) compared to the distribution of sprat-like particles in the applicant's particle tracking study (main map – reproduced from Figure 7 in NNB GenCo, 2021d; TR511)

The applicant's particle tracking model is conservative in that it does not account for re-suspension or advection of particles once they have sunk. When they have reached the seabed they remain there and move no further, but they are likely to continue to be resuspended and moved. The decomposition and consumption of organic matter will also aid its dispersal. Estimates of dead/moribund biota are also precautionary, being based on our reasonable worst-case scenario (Appendix B), which represents a level of impingement that we do not expect to be exceeded during the operation of SZC (except in the case of rare, short-term extreme events, such as sprat inundations).

7. Discussion of risks for each site

The first step within this assessment is to consider if there is any potential connectivity between the sites and features and the discharge assessment that are shown in the previous sections. Where there is an overlap, we will carry out further assessment.

For the following sites, there is direct connectivity as the WDA outlets of the CWS and FRR systems discharge directly into the following sites:

- Outer Thames Estuary SPA
- Southern North Sea SAC

These sites and features will therefore be considered in detail in the seabird and harbour porpoise chapter (section 8).

For the following sites, the discharges are not directly into the sites, but there is the potential for the discharges to reach the sites or the features to come into contact with the discharges. The sites and features are discussed in the following section.

7.1. Alde Ore and Butley Estuaries SAC

7.1.1. Qualifying features

- Atlantic salt meadows
- estuaries
- mudflats and sandflats not covered by seawater at low tide (intertidal mudflats and sandflats)

7.1.2. Discussion

The Habitats Directive has no specific water temperature requirements. However, the UK Technical Advisory Group on Water Quality for the Water Framework Directive recommended temperature thresholds for assessing the impact of thermal discharges on SACs and SPAs, which included a 2°C deviation from ambient as a maximum allowable concentration as the edge of the mixing zone (as a 100th percentile) (WQTAG sub-group, 2006). The maximum allowable concentration is another way of describing a 100th percentile. The annual 100th percentile plume describes the area within which thermal uplift greater than the specified value is exceeded at any point during the year. Thermal uplift of 2°C is not considered to have any link to specific ecological effects, but serves as a precautionary threshold to trigger further investigation (NNB GenCo, 2021b; shadow HRA).

Although Figure 17 shows that the annual 100th percentile plume for SZC and SZB in combination reaches the site, Figure 6 shows that the site is outside of the ≥2°C thermal uplift plume from Sizewell C alone, when shown as a 98th percentile. The ≥2°C contour for SZC alone is over 12km to the north of the site. Outside of the 98th percentile plume, the sea surface experiences thermal uplift of ≥2°C for less than 2%

of the year and given the distance from the contour, probably considerably less than 2% of the year.

We can therefore conclude that any potential change to the thermal regime affected by the discharge from SZC will not have any impact on this site and its features.

The modelled areas exceeding the EQS/predicted no-effect concentration (PNEC) for total residual oxidants (TRO), bromoform and hydrazine modelled plumes are offshore and there is no connectivity with the site or estuary features (Figure 8, Figure 10, Figure 12, Figure 13). We can therefore conclude that any potential toxic contamination resulting from the chemical discharge will not have an impact on this site or its features.

The assessment shows that there is no predicted increase in organic or nutrient enrichment in the Greater Sizewell Bay Area and therefore there will be no effect on the site or estuary features.

7.1.3. Conclusion

We have considered the relevant risks associated with the discharges from SZC that are the subject of this application on the features of the Alde Ore and Butley Estuaries SAC, in light of the designated sites’ conservation objectives.

For the reasons discussed previously in this assessment, we have been able to conclude that there will be no adverse effect on the qualifying features from the water discharge activities of SZC in terms of maintaining or restoring the:

- extent and distribution of the habitats of the qualifying features
- structure and function of the habitats of the qualifying features
- supporting processes on which the habitats of the qualifying features rely
- populations of each of the qualifying features
- distribution of qualifying features within the site

7.2. Alde-Ore Estuary Ramsar

7.2.1. Qualifying features

- avocet, (wintering)
- lesser black-backed gull (breeding)
- redshank (wintering)
- waterbird assemblage (wintering)
- wetland bird assemblage (breeding)
- wetland invertebrate assemblage
- wetland plant assemblage

7.2.2. Discussion

With the exception of the lesser black-backed gull the rest of the features are estuarine features, and neither the thermal or chemical plume or maximum potential area of organic exceedance will affect the estuary.

7.2.3. Conclusion

We have considered the relevant risks associated with the discharges from SZC that are the subject of this application on the features of the Alde-Ore Estuary Ramsar. There are no separate conservation objectives for the Ramsar site (see Marine site detail (naturalengland.org.uk)), so we will use the relevant conservation objectives from the SAC and SPA.

For the reasons discussed previously in this assessment, we have been able to conclude that there will be no adverse effect on the following features: avocet (wintering), redshank (wintering), waterbird assemblage (wintering), wetland bird assemblage (breeding), wetland invertebrate assemblage, and wetland plant assemblage from the water discharge activities of SZC in terms of maintaining or restoring the:

- extent and distribution of the habitats of the qualifying features
- structure and function of the habitats of the qualifying features
- supporting processes on which the habitats of the qualifying features rely
- populations of each of the qualifying features
- distribution of qualifying features within the site

The breeding lesser black-backed gull feature will be considered further in section 8.

7.3. Alde-Ore Estuary SPA

7.3.1. Qualifying features

- avocet, Recurvirostra avosetta (breeding)
- avocet, Recurvirostra avosetta (non-breeding)
- lesser black-backed gull, Larus fuscus (breeding)
- little tern, Sterna albifrons (breeding)
- marsh harrier, Circus aeruginosus (breeding)
- redshank, Tringa totanus (non-breeding)
- ruff, Philomachus pugnax (non-breeding)
- Sandwich tern, Sterna sandvicensis (breeding)

7.3.2. Discussion

With the exception of little tern, lesser black-backed gull and Sandwich tern, the features for this site are found within the estuary and not offshore within the marine environment.

The site is outside of the ≥2°C thermal uplift (98th percentile) plume from Sizewell C alone, and the chemical plumes and maximum potential area of organic exceedance are shown not to interact with the SPA boundary. Therefore, there is no adverse effect for these features (see section 6, Figure 6, Figure 8, Figure 10, Figure 12, Figure 13, Figure 14).

7.3.3. Conclusion

We have considered the relevant risks associated with the discharges from SZC that are the subject of this application on the features of the Alde-Ore Estuary SPA in light of the designated sites' conservation objectives (with the exception of the breeding little tern, breeding Sandwich tern and breeding lesser black-backed gull features, which will be considered in section 8.

For the reasons discussed previously in this assessment, we have been able to conclude that there will be no adverse effect on the avocet (breeding) and (non-breeding), marsh harrier (breeding), ruff (non-breeding), and redshank (no-breeding) from the water discharge activities of SZC in terms of maintaining or restoring the:

- extent and distribution of the habitats of the qualifying features
- structure and function of the habitats of the qualifying features
- supporting processes on which the habitats of the qualifying features rely
- populations of each of the qualifying features
- distribution of qualifying features within the site

Little tern, Sandwich tern and lesser black-backed gull will be considered further within section 8.

7.4. Minsmere-Walberswick SPA and Ramsar

7.4.1. Minsmere-Walberswick SPA features

- avocet, Recurvirostra avosetta (breeding)
- bittern, Botaurus stellaris
- gadwall, Anas strepera (breeding)
- gadwall, Anas strepera (non-breeding)
- greater white-fronted goose, Anser albifrons albifrons (non-breeding)
- hen harrier, Circus cyaneus (non-breeding)
- little tern, Sterna albifrons (breeding)
- marsh harrier, Circus aeruginosus (breeding)
- nightjar, Caprimulgus europaeus (breeding)

7.4.2. Minsmere-Walberswick Ramsar features

- mosaic of marine, freshwater, marshland and associated habitats
- wetland bird assemblage - breeding
- wetland invertebrate assemblage

Please note that a number of features have not been considered as limited connectivity between this site and SZC means that there is only potential for impact from the thermal plume.

7.4.3. Conservation objectives

Links to the full conservation objectives for the SPA are provided in Environment Agency, 2022b; Annex 2. The appropriate assessment will be concluded against the relevant conservation objectives provided. The conservation objectives for the SPAs will be used when concluding the assessment for the respective Ramsar site as there aren't any specific conservation objectives for the Ramsar site. See Marine site detail (naturalengland.org.uk).

7.4.4. Discussion

Direct connectivity

Most of the features for these 2 sites are reliant on the freshwater supporting habitats of the SPA. There is no direct connectivity with the marine thermal or chemical plumes offshore or the maximum potential area of organic exceedance shown and described in the appropriate assessment methodology section (section 6).

The exception to this is the little tern (SPA feature), which while nesting on the site will forage offshore, and may come into direct contact with the thermal and chemical plumes. This means there could be direct or indirect effects – these will be considered in detail section 8**.**

Indirect connectivity – marine environment and the site

There is connectivity between the marine environment and the freshwater habitats via the Minsmere Sluice outlet which allows sea water into the freshwater marshes.

The applicant provided the following description of the sluice in its response to our Schedule 5 request Number 5 (NNB GenCo, 2021M, Sch 5. No.5):

> "The sluice is divided into two chambers, each with its own gravity outlet culvert. The northern chamber receives flows from the northern culvert of the Minsmere New Cut, while the southern chamber receives flows from Leiston Drain and Scott's Hall Drain. The southern chamber is also connected to the Minsmere New Cut through its southern culvert, which includes a penstock at its upstream face. The penstock is opened to alleviate high water levels in the catchment. When river levels exceed sea levels, water flows from river to sea. When sea levels exceed river levels, flow will cease, and water stored upstream of the sluice. Some ingress of seawater into the freshwater system has been factored into the design.
>
> ……….. water quality in the surface watercourses is influenced by the input of saline water from Minsmere sluice, which results in elevated salinity and

> sulphate levels in the immediate vicinity of the sluice. This suggests that saline influence is localised to the sluice and/or that saline intrusion is infrequent and does not have a lasting effect on upstream surface water quality."

There is therefore a mechanism for the thermal or chemical plumes or the potential area of nutrient enrichment to reach the freshwater site.

The applicant's modelling of the thermal plume from SZC alone (Figure 6) shows that there is the potential for the thermal plume to interact with the coastline at the location of the Minsmere Sluice. However, this is below the threshold of concern with the annual surface temperature difference at the coast predicted to be less than 1.5^{o}C (98th percentile). There will be no adverse effect from the thermal regime in the vicinity of the sluice.

The modelling of the chemical plumes shows the areas of exceedances are also well offshore and there is therefore no mechanism for chemicals from the operational discharges of SZC to reach the site (Figure 8, Figure 10, Figure 12, Figure 13).

Nutrients/organic enrichment from the STW and FRR systems could reach the intake. However, the increase in nutrient/organic enrichment is not at a level to cause a deterioration in water quality (see Appendix B), therefore there will be no adverse effect (Table 10, Table 11).

Indirect effects – prey species

One of bittern's (SPA and Ramsar) prey species is eel, and these could be affected by marine discharges. The supplementary advice package for the site states:

> "Maintain the distribution, abundance and availability of key food and prey items (for example, eel, rudd, roach, frogs, toads) at preferred sizes (for example, roach of 6-35 cm)"

Of these, only the eel has a marine component to its lifecycle.

Minsmere Sluice is fitted with an eel pass to facilitate migration of eels into the Minsmere marshes. We therefore need to consider if the outlets from the WDA could act as a barrier to eel migration, in terms of entering the sluice and therefore the freshwater marshes. Any effects on entrapment of eel are being considered through the DCO process.

The applicant considered the potential for the thermal and chemical plumes from the operational discharge to provide a barrier to eel passage (NNB GenCo, 2020f; Eels Regulations Compliance Assessment and NNB GenCo, 2021e; Eels Regulations Compliance Assessment Addendum).

The location of the outlet headworks 3km offshore in deep water will allow for initial mixing and minimise intersection with the Suffolk Coast coastline. There will therefore be no overlap of the chemical plumes above EQS/PNEC or thermal plumes with the Minsmere Sluice outlet.

The applicant also considered if the offshore thermal uplift could prove a barrier along the coast. It concluded there was no barrier based on the available evidence for thermal avoidance of migratory species off Sizewell using thermal uplift thresholds applied for glass eel and silver eel (Table 9). Modelling results showed that temperatures in excess of potential avoidance thresholds would exceed 25% of the coastal corridor (a 3km transect from the coast to the SZC outfalls) for less than 5% of the time during their migration periods. Therefore, no occlusion effects were predicted (Table 9, Figure 16). Silver eel are the outward migrating pre-adult life stage and as such would not be available as food to bitterns once they have left freshwater. The thermal uplift threshold the applicant applied to glass eels (>+12°C) is high compared to that used for silver eel (>3°C) (Table 9). However, Figure 6 shows that it is rare for more than 25% of the cross-sectional area of the 3km coastal corridor to experience thermal uplift in excess of 3°C during the glass eel migration period. As such, no occlusion effect would be predicted for glass eel even if applying the thermal uplift threshold used for silver eel.

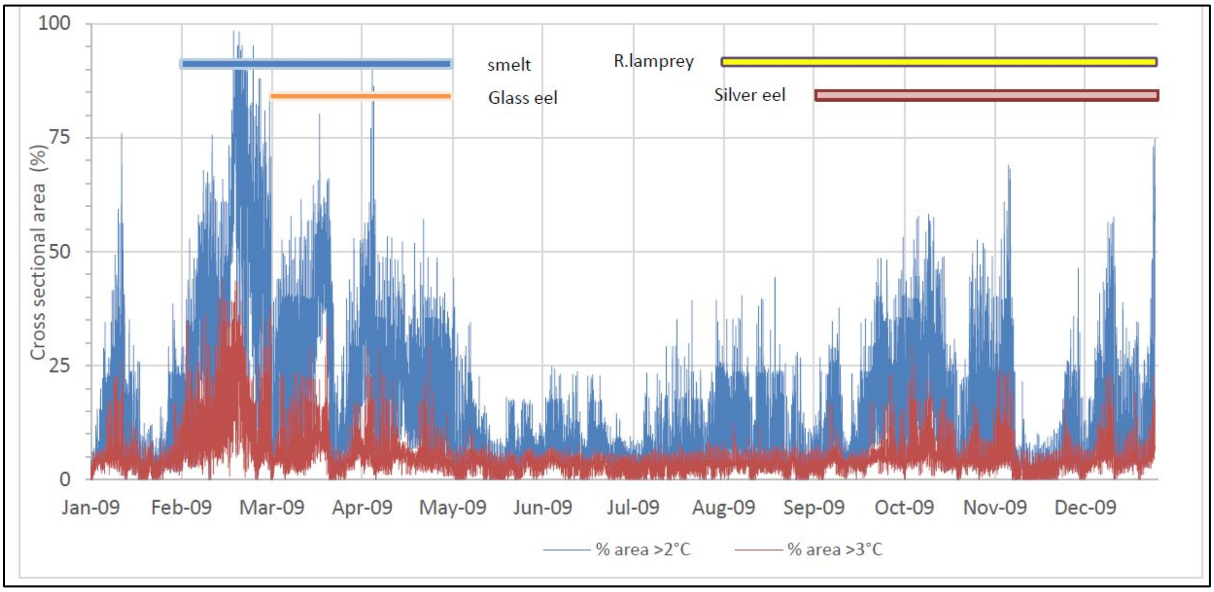

Figure 16: Cross-sectional area of instantaneous plume across the transect with >2°C and >3°C Uplift (reproduced from Figure 16 in NNB GenCo, 2020a; TR302)

Table 9: Percentage of Sizewell C transect experiencing >25% exceedance of thermal thresholds for glass eel and silver eel (Source: NNB GenCo, 2020a; TR302)

Life stage	Assumed thermal threshold	Migration period	Percentage of migration period during which >25% of the 3km migration corridor exceeds the assumed thermal threshold	Conclusion
Glass eel	>+12°C	March – April	0%	Would not experience a barrier to migration in a transect from the coast to the SZC outfalls
Silver eel	3°C	September - December	0.07%	Would not experience a barrier to migration in a transect from the coast to the SZC outfalls

Consideration of the potential for nutrient or organic enrichment from the STW and FRR systems showed that it will be insufficient to lead to increased opportunistic macroalgal or phytoplankton blooms and therefore no effect on eels (section 6.3).

Supporting habitats

Supporting habitats of relevance to the interaction between the freshwater and marine environment include:

- freshwater and coastal grazing marsh
- coastal reedbed
- water column

Table 10 and Table 11 consider the sensitivities of the site's supporting habitats and the outcome of our assessment with regard to the conservation objective targets for the site. We consider that these supporting habitats will support both SPA and Ramsar features.

Table 10: The sensitivities of Minsmere-Walberswick SPA supporting habitats together with the expected effects of SZC

Pressure (from NE advice on operations)	Supporting habitat	Species	Sensitivity	Effect of SZC alone
Temperature increase	Water column Freshwater and coastal Grazing marsh Coastal reedbed	Avocet Bittern Gadwall Greater white-fronted goose Hen harrier Little tern Marsh harrier Shoveler Teal	All supporting habitats are sensitive, Species are not sensitive.	No effect. Pathway for impact for site and features is via the Minsmere Sluice. Site is outside of the thermal plume.
Deoxygenation	Water column Freshwater and coastal Grazing marsh Coastal reedbed	Avocet Bittern Gadwall Greater white-fronted goose Hen harrier Little tern Marsh harrier Shoveler Teal	Only water column is sensitive.	No effect. Deoxygenation could affect the water column as a result of the FRR system. However, the discharge from this system will not be significant enough to impact upon this site and its features.
Introduction of microbial pathogens	Water column Freshwater and coastal Grazing marsh Coastal reedbed	Avocet Bittern Gadwall Greater white-fronted goose Hen harrier	Avocet, bittern, gadwall, greater white-fronted goose, little tern, marsh harrier, shoveler and teal are sensitive.	No effect. Pathogen introduction as a result of CWS will not be at levels significant enough to

Pressure (from NE advice on operations)	Supporting habitat	Species	Sensitivity	Effect of SZC alone
		Little tern Marsh harrier Shoveler Teal	Supporting habitats and hen harrier are not sensitive.	cause an impact upon the supporting habitats or the species they support.
Introduction of other substances	Water column Freshwater and coastal Grazing marsh Coastal reedbed	Avocet Bittern Gadwall Greater white-fronted goose Hen harrier Little tern Marsh harrier Shoveler Teal	Species and supporting habitats are not sensitive.	No effect. Pathway for impact for site and features is via the Minsmere Sluice. Site is outside of the chemical plume.
Nutrient enrichment	Water column Freshwater and coastal Grazing marsh Coastal reedbed	Avocet Bittern Gadwall Greater white-fronted goose Hen harrier Little tern Marsh harrier Shoveler Teal	Only water column is sensitive.	No effect. Nutrient enrichment from SZC alone will be insufficient to lead to opportunistic macroalgal or phytoplankton blooms and the ability of the water column to support the foraging behaviour of the notified bird species will be unaffected.

Pressure (from NE advice on operations)	Supporting habitat	Species	Sensitivity	Effect of SZC alone
Organic enrichment	Water column Freshwater and coastal Grazing marsh Coastal reedbed	Avocet Bittern Gadwall Greater white-fronted goose Hen harrier Little tern Marsh harrier Shoveler Teal	Only water column is sensitive.	No effect. Organic enrichment from SZC alone will not be sufficient to lead to significant alteration to the water column and will therefore not affect the bird species the habitat supports.

Table 11: The outcome of our appropriate assessment of the impact of water discharge activities from the operation of SZC on conservation targets for Minsmere-Walberswick SPA

Attribute/sub-attribute	Target	Target information and site-specific detail	Outcome of SZC alone assessment
Supporting habitat			
Food availability - Bittern			Food availability - Bittern
	Maintain the distribution, abundance and availability of key main food and prey items (for example, eel, rudd, roach, frogs, toads) at preferred sizes (for example, roach of 6-35 cm).	The availability of an abundant food supply is critically important for successful breeding, adult fitness and survival and the overall sustainability of the population. As a result, inappropriate management and direct or indirect impacts which may affect the distribution, abundance and availability of prey may adversely affect the population and alter the distribution of birds. Main food sources can be found within freshwater marsh and reedbed. During severe winter weather Minsmere-Walberswick can assume even greater national and international importance as wildfowl and waders from many other areas arrive, attracted by relatively mild climate, compared with continental areas, and the abundant food resources available. More frequent coastal inundation, and increased ingress of saline water due to reductions in inputs of freshwater will reduce the biomass of freshwater fish, which are the main prey by breeding bitterns.	It isn't considered that SZC WDA will affect food availability as the discharges will not cause a barrier to eel migration in the marine environment. Within the freshwater environment neither the thermal nor chemical plumes from SZC will reach Minsmere Sluice and it is considered that the discharges will not increase nutrient or organic enrichment.

Attribute/sub-attribute	Target	Target information and site-specific detail	Outcome of SZC alone assessment
		Increased turbidity is likely to reduce habitat quality for herons, egrets and bitterns, which detect fish visually and are therefore thought to require fairly clear water. The RSPB, Suffolk Wildlife Trust and Natural England manage their respective land to improve food availability for the SPA species through effective habitat and water management. The RSPB manages water levels on its Minsmere and Dingle Marshes Reserves for optimal feeding and breeding for the SPA features. Natural England manages Westwood Marshes to create a range of different habitats. When the reeds are cut, the cleared areas provide pools for birds to feed within. The undisturbed areas provide nesting sites and insects for food. The target has been set using expert judgement based on knowledge of the sensitivity of the feature to activities that are occurring/have occurred on the site.	
Water quality			
Contaminants – all freshwater wetland features	Restrict aqueous contaminants to levels equating to 'high status' according to Annex VIII and 'good status'	Contaminants may have a range of biological effects on different species within the supporting habitat, depending on the nature of the contaminant. This, in turn, can adversely affect	There will be mixing zones in which the EQS/PNEC values for TRO, bromoform and hydrazine will be exceeded. However, these are far

Attribute/sub-attribute	Target	Target information and site-specific detail	Outcome of SZC alone assessment
	according to Annex X of the Water Framework Directive, avoiding deterioration from existing levels.	the availability of bird breeding, rearing, feeding and roosting habitats, and potentially bird survival. The target has been set using expert judgement based on knowledge of the sensitivity of the feature to activities that are occurring/have occurred on the site.	enough off shore that they will not reach the Minsmere intake or cause a barrier to eel movement in the marine environment.
Dissolved oxygen (DO) - all freshwater wetland features	Maintain the dissolved oxygen (DO) concentration at levels equating to high ecological status (specifically ≥ 5.7mg/l (at 35 salinity) for 95% of the year), avoiding deterioration from existing levels.	Dissolved oxygen (DO) levels affect the condition and health of supporting habitats. Excessive nutrients and/or high turbidity can lead to a drop in DO, especially in warmer months. Low DO can have sub-lethal and lethal impacts on fish and infauna and epifauna communities and therefore can adversely affect the availability and suitability of bird breeding, rearing, feeding and roosting habitats. However, there is a significant amount of natural variation that should be considered. The target has been set using expert judgement based on knowledge of the sensitivity of the feature to activities that are occurring/have occurred on the site.	The decay of biota discharged by the FRR system will not lead to a deterioration from existing levels of DO concentration even though there is potential connectivity with Minsmere Sluice and therefore pathway into the freshwater.
Nutrients – all freshwater wetland features	Maintain water quality at mean winter dissolved inorganic nitrogen levels where biological indicators of eutrophication (opportunistic	High concentrations of nutrients in the water column can cause phytoplankton and opportunistic macroalgae blooms, leading to reduced dissolved oxygen availability. This can impact sensitive fish, epifauna and infauna communities and therefore adversely affect the availability and suitability of bird breeding, rearing,	Discharges from the cooling water system and FRR system will not lead to increases in dissolved inorganic nitrogen levels to the extent that indicators of

Attribute/sub-attribute	Target	Target information and site-specific detail	Outcome of SZC alone assessment
	macroalgal and phytoplankton blooms) do not affect the integrity of the site and features, avoiding deterioration from existing levels.	feeding and roosting habitats. The aim is to seek no further deterioration or improve water quality. The risk of eutrophication across the site has been assessed as low using the Environment Agency's Weight of Evidence approach. This takes into account assessments of the Water Framework Directive opportunistic macroalgae and phytoplankton quality elements using the respective assessment tools. Adverse effects to integrity should be avoided. Therefore, opportunistic macroalgal levels should be maintained so there is no adverse effect to the feature through limited algal cover (<15%) and low biomass (< 500g/m²) of macroalgal blooms in the available intertidal habitat, with area of available intertidal habitat affected by opportunistic macroalgae less than 15%. There should also be limited (<5%) entrainment of algae in the underlying sediment (all accounting for seasonal variations and fluctuations in growth). Phytoplankton levels should be maintained above a WFD assessment tool score of 0.6, where there is only a minor (a) decline in species richness, and (b) disturbance to the diatom-dinoflagellate succession in the spring bloom compared to reference conditions. The target has been set using expert judgement based on knowledge of the sensitivity of the	eutrophication affect the integrity of the site.

Attribute/sub-attribute	Target	Target information and site-specific detail	Outcome of SZC alone assessment
		feature to activities that are occurring/have occurred on the site.	
Turbidity	Maintain natural levels of turbidity (for example, concentrations of suspended sediment, plankton and other material) across the habitat.	Water turbidity is a result of material suspended in the water, including sediment, plankton, pollution or other matter from land sources. Turbidity levels can rise and fall rapidly as a result of biological (for example, plankton blooms), physical (for example, storm events) or human (for example, development) factors. Prolonged changes in turbidity may influence the amount of light reaching supporting habitats, affecting the primary production and nutrient levels of the habitat's associated communities. Changes in turbidity may also have a range of biological effects on different species within the habitat, for example, affecting their ability to feed or breathe. A prolonged increase in turbidity is indicative of an increase in suspended particulates. This has a number of implications for the aquatic/marine environment, such as affecting fish health, clogging the filtering organs of suspension feeding animals and affecting sedimentation rates. This, in turn, can adversely affect the availability and suitability of bird breeding, rearing, feeding and roosting habitats. The target has been set due to a lack of evidence that the feature is being impacted by any human activities.	Discharges from the cooling water and FRR systems will not lead to significant increases in turbidity.

Conclusion

We have considered the relevant risks associated with the discharges from SZC that are the subject of this application on the features of the Minsmere-Walberswick SPA and Ramsar, in light of the designated sites' conservation objectives (with the exception of the breeding little tern feature which will be considered in section 8).

Although there is connectivity between the sites and the point of discharge via the Minsmere Sluice, the thermal and chemical plumes are located so far offshore that they will not reach the sluice intake. The nutrient and organic enrichment risks from the STW and FRR system discharges will not cause a deterioration in water quality in the marine environment and will therefore not alter the water quality of the freshwater environment. For these reasons, which are discussed in more detail previously in this assessment, we have been able to conclude that there will be no adverse effect on the qualifying features from the water discharge activities of SZC in terms of maintaining or restoring the:

- extent and distribution of the habitats of the qualifying features
- structure and function of the habitats of the qualifying features
- supporting processes on which the habitats of the qualifying features rely
- populations of each of the qualifying features
- distribution of qualifying features within the site

Little tern will be considered further within section 8.

7.5. Orfordness to Shingle Street SAC

7.5.1. Qualifying features

- coastal lagoons
- annual vegetation of drift lines
- perennial vegetation of stony banks; coastal shingle vegetation outside the reach of waves

7.5.2. Discussion

Both the annual vegetation of drift lines and perennial vegetation of stony banks features are located from the eastern (seaward) side approximately 20m inland of mean high water, across the spit to the western saltmarsh transition. Therefore, there is no effect pathway to this feature from the predicted thermal and chemical plumes or area of increased organic enrichment.

Coastal lagoons

The coastal lagoons at this site are not a marine feature as they occur landward of highest astronomical tide. However, the salinity of the lagoons is maintained by percolation through the shingle, while at high tides sea water can overtop the shingle bank so there is potential connectivity.

However, the ≥2°C thermal uplift (98th percentile) plume, chemical plumes and maximum potential area of organic exceedance are shown not to interact with the SAC boundary.

7.5.3. Conclusion

We have considered the relevant risks associated with the discharges from SZC that are the subject of this application on the features of the Orfordness to Shingle Street SAC, in light of the designated sites' conservation objectives.

For the reasons discussed previously in this assessment, we have been able to conclude that there will be no adverse effect on the qualifying features from the water discharge activities of SZC in terms of maintaining or restoring the:

- extent and distribution of the habitats of the qualifying features
- structure and function of the habitats of the qualifying features
- supporting processes on which the habitats of the qualifying features rely
- populations of each of the qualifying features
- distribution of qualifying features within the site

7.6. The Wash and North Norfolk Coast SAC

Appropriate assessment is required for the harbour seal feature of this site due to the potential for thermal or chemical plumes to disrupt the coastal movement of seals between The Wash and North Norfolk Coast SAC and the potentially functionally linked Thames Estuary (section 5.1.3). No potential exists for any direct effects on the SAC itself due to its distance from the Sizewell C main development site.

7.6.1. Conservation objectives

Links to the full conservation objectives for the SAC are provided in Environment Agency (2022b; Annex 2), and the appropriate assessment will be concluded against the relevant conservation objectives provided.

7.6.2. Discussion

No potential exists for any direct effects within the boundaries of the SAC itself due to its distance from the Sizewell C main development site (over 100km). This discussion concentrates on the potential for the water discharge activities of SZC to affect harbour seals from The Wash and North Norfolk Coast SAC when they are at sea.

Both SZB and SZC discharge directly into the coastal movement corridor for harbour seals moving between The Wash and the Thames Estuary. In addition to the effects of SZC alone, effects from SZC and SZB in combination will also be considered within the following discussion.

Risks carried through to appropriate assessment for the harbour seal feature of The Wash and North Norfolk Coast SAC are:

- change in thermal regime

- toxic contamination (chemical)
- nutrient enrichment

Change in thermal regime

There is no potential for harbour seal transiting between The Wash and North Norfolk Coast SAC and the Thames Estuary to be directly harmed by elevated water temperatures from SZC alone or SZC and SZB in combination.

Marine mammals can regulate their body temperature during periods of high activity or when the surrounding/ambient temperature is too warm (NNB GenCo, 2021b; shadow HRA). Marine mammals are also accustomed to changes in water temperatures due to their diving behaviour and vertical movements through the water column. The change in absolute water temperature caused by the thermal discharge would be noticeable to marine mammals, but their biological adaptions will allow them to cope with such a change.

The cooling water discharge from SZC will not exceed the internal body temperature of marine mammals, as it experiences a thermal uplift of 11.15°C, with monthly mean sea temperatures peaking at around 19°C to 20°C during August (see section 6.1.2).
There is also no potential for the movements of harbour seal between The Wash and North Norfolk Coast SAC and the Thames Estuary to be blocked as a result of thermal uplift from SZC alone or SZC and SZB in combination.

In estuaries, the mixing zone is recommended to exceed no more than 25% of the channel width, as a 95th percentile, in order to ensure continued free migration of fish (BEEMS, 2019).

For SZC alone, the map of annual 98th percentile exceedances shows that an area between the coast and the outlets will not exceed 2°C or 3°C uplift for at least 98% of the year (Figure 6); 3°C being the thermal uplift where marine fish species may show avoidance behaviour as discussed in chapter 8. These thermal uplift thresholds are indicative only for harbour seal, which may be more tolerant of this magnitude of thermal uplift due to their ability to regulate their body temperature.

For SZC and SZB in combination, around 50% of the 3km transect length appears to experience thermal uplift ≥3°C as a 98th percentile (Figure 7). However, although the "25% of the channel width as a 95th percentile" recommendation of BEEMS (2019) is exceeded, there remains a gap between the ≥3°C exceedance (98th percentile) plumes for SZC and SZB in combination, through which harbour seals could pass (Figure 7). We do not know how far offshore harbour seals travel when moving between The Wash and the Thames Estuary. Telemetry tracks indicate the movements may be coastal, but harbour seals are certainly capable of travelling further offshore (Figure 5). Transiting harbour seals may potentially also pass any area of thermal uplift on the seaward side of the SZC outlet (Figure 6, Figure 7).

The applicant examined thermal occlusion along a transect from the coast to the SZC outlet, 3km offshore, under the scenario of SZC and SZB in combination (Figure 16). From the data underlying Figure 16, the applicant tells us that for 18.7% of the year, 25% or more of the 3km transect would experience >2°C thermal uplift (NNB GenCo, 2020a; TR302). In other words, for 81.3% of the year, 75% or more of the 3km transect would experience <2°C thermal uplift. From Figure 16, it can be seen that it is rare for more than 25% of the transect to experience a >3°C thermal uplift, with February being the exception. However, even in February, at least 55% of the 3km transect experiences less than 3°C thermal uplift at any point in time.

Consequently, there is little risk of transiting harbour seals being disrupted by thermal uplift from SZC and SZB in combination. If avoidance behaviour were to occur, then the additional length added to the journey between The Wash and the Thames Estuary would be insignificant.

When SZC is operating alone, only the offshore plume from SZC would be present and the risk of harbour seal passage being impeded would be lower still (Figure 6).

Toxic contamination (chemical)

TRO discharged from SZC alone, or SZC and SZB in combination, will not prevent harbour seals from moving between The Wash and North Norfolk Coast SAC and the Thames Estuary.

The use of the TRO ≥ EQS 10μg/l (95th percentile) plume is likely to be very precautionary with regard to any avoidance behaviour by harbour seal (detailed further in section 8.3.2). The SZC outlet is 3km offshore and the TRO ≥ EQS plume from SZC does not reach the coastline (Figure 8). As such, the coastal movements of harbour seals will never be blocked by the TRO ≥ EQS plume from SZC alone. The TRO ≥ EQS plumes from SZB and SZC always remain separate (Figure 9), so the coastal movements of harbour seals will not be blocked by the TRO ≥ EQS plume from SZC and SZB in combination.

Bromoform discharged from SZC alone, or SZC and SZB in combination, will not prevent harbour seals from moving between The Wash and North Norfolk Coast SAC and the Thames Estuary. As is the case for TRO plumes, the bromoform ≥ PNEC 5μg/l (95th percentile) plume from SZC does not reach the coastline (Figure 10) and the bromoform ≥ PNEC plumes from SZB and SZC always remain separate (Figure 11), so coastal movements will not be blocked.

Hydrazine discharged from SZC alone, or SZC and SZB in combination, will not prevent harbour seals from moving between The Wash and North Norfolk Coast SAC and the Thames Estuary. The chronic and acute hydrazine exceedance plumes from SZC alone, are small and extend northwards and southwards from the outlets, parallel to the coastline (Table 5, Table 6, Figure 12, Figure 13) so coastal movements will not be blocked. There is no discharge of hydrazine from SZB and so when both stations are operating, the plume will be as for SZC alone, and there will be no additional potential for coastal movements to be blocked.

Nutrient enrichment

The assessment shows that there is no predicted increase in nutrient enrichment in the Greater Sizewell Bay Area and therefore there will be no associated effect on water quality which could disrupt the coastal movements of harbour seals.

Although the maximum potential areas of organic exceedance for SZC alone, and for SZC and SZB in combination extend 1.406km and 1.683km offshore respectively (Figure 14), the release of carbon at the proxy EQS rate of 100g carbon/m²/year over this area would not result in changes to water quality sufficient to block the movements of harbour seals. Furthermore, the applicant's particle tracking study (NNB GenCo, 2021d; TR511) suggests that biota will be distributed beyond the boundary of these areas and that consequently the density of organic enrichment will be below the proxy EQS of 100g carbon/m²/year (section 6.3).

Supporting habitats

Potential supporting habitats listed for harbour seal in The Wash and North Norfolk Coast SAC (Marine site detail (naturalengland.org.uk)) are:

- coastal lagoons
- intertidal coarse sediment
- intertidal mixed sediments
- intertidal mud
- intertidal sand and muddy sand
- water column

Of these, only the water column is of relevance to harbour seals moving past Sizewell, and this is outside of The Wash and North Norfolk Coast SAC itself. The NE Advice on Operations for the SAC lists the water column supporting habitat for harbour seal as being sensitive to the pressure 'barrier to species movement'. Our assessment has shown that no barrier will be formed that would affect the movements of harbour seals between The Wash and North Norfolk Coast SAC and the Thames Estuary.

Conclusion

We have considered the relevant risks associated with the discharges, from SZC alone, and from SZC and SZB in combination, that are the subject of this application, on the harbour seal feature of The Wash and North Norfolk Coast SAC, in light of the designated sites' conservation objectives and supplementary advice on conservation objectives (Table 12).

Natural England's Advice on Operations lists 'Barrier to species movement' as a pressure for the harbour seal feature associated with the maintenance, construction and usage of outlets. This assessment has considered the potential for the water discharge activities of SZC to impede movement of harbour seals between The Wash and North Norfolk Coast SAC and the potentially functionally linked Thames Estuary.

The operation of SZC alone will not lead to a barrier to species movement for the harbour seal feature of The Wash and North Norfolk Coast SAC. So, we can conclude that there will be no adverse effect on this qualifying feature from the water discharge activities of SZC alone, in terms of maintaining or restoring the:

- extent and distribution of the habitats of the qualifying features
- structure and function of the habitats of the qualifying features
- supporting processes on which the habitats of the qualifying features rely
- populations of each of the qualifying features
- distribution of qualifying features within the site

SZB is expected to continue to operate until 2035, although there is potential for an extension of SZB's operational lifetime by 20 years to 2055 at the latest. Consequently, SZC and SZB may be operating in combination for between 2 and 22 years. However, the operation of SZC and SZB in combination will not lead to a barrier to species movement for the harbour seal feature of The Wash and North Norfolk Coast SAC. So, we can conclude that (irrespective of the date of SZB decommissioning) there will be no adverse effect on this qualifying feature from the water discharge activities of SZC and SZB in combination, in terms of maintaining or restoring the:

- extent and distribution of the habitats of the qualifying features
- structure and function of the habitats of the qualifying features
- supporting processes on which the habitats of the qualifying features rely
- populations of each of the qualifying features
- distribution of qualifying features within the site

Table 12: The outcome of our appropriate assessment of the impact of water discharge activities from the operation of SZC alone, and SZC and SZB in combination, on targets contained within Natural England's Supplementary Advice on Conservation Objectives for the harbour seal feature of The Wash and North Norfolk Coast SAC (the table only shows targets which may be affected by water discharge activities)

Attribute	Sub-attribute	Target	Outcome of assessment: SZC alone	Outcome of assessment: SZC and SZB
Population	Population size	Maintain the population size within the site.	None of the attributes below will be adversely affected and so there will be no effect on the ability of the population size to be maintained.	As for SZC alone.
Population	Recruitment and reproductive capability	Maintain the reproductive capability of the species.	None of the attributes below will be adversely affected and so the reproductive capability of the species will be maintained.	As for SZC alone.
Presence and spatial distribution of the species	Presence and spatial distribution of the species	Maintain the presence and spatial distribution of the species and their ability to undertake key life cycle stages and behaviours.	The water discharge activities of SZC alone will not affect the SAC directly due to its distance from the outlets. The ability of harbour seals to move between The Wash and the Thames Estuary will be maintained.	As for SZC alone.
Structure and function	Biological connectivity	Maintain connectivity of the habitat within sites and the wider environment to allow	The water discharge activities of SZC alone will not affect the SAC directly due to its distance from the outlets. Movements of harbour seals between	As for SZC alone.

Attribute	Sub-attribute	Target	Outcome of assessment: SZC alone	Outcome of assessment: SZC and SZB
		movement of migratory species.	The Wash and the Thames Estuary will not be impeded by the water discharge activities and so connectivity with the wider environment will be maintained.	
Supporting habitat	Extent and distribution	Maintain the extent and spatial distribution of the following supporting habitats: foraging and haul-out sites.	The water discharge activities of SZC alone will allow the extent and spatial distribution of foraging sites to be maintained. This is due to the distance of Sizewell from the SAC, the low proportion of the harbour seals' foraging area that would be affected, and the precautionary nature of threshold values used in the assessment of risk from toxic contamination (chemical). Haul-out sites within the SAC will be unaffected due to their distance from Sizewell.	As for SZC alone.
Supporting habitat	Food availability	Maintain the abundance of preferred food items required by the species.	The abundance of preferred food items will be maintained and not altered by the water discharge activities of SZC alone. Any prey that were displaced would remain within the foraging range of harbour seals from the SAC.	As for SZC alone.

Attribute	Sub-attribute	Target	Outcome of assessment: SZC alone	Outcome of assessment: SZC and SZB
Supporting processes	Physico-chemical properties (species)	Maintain the natural physico-chemical properties of the water	The natural physico-chemical properties of the water will be unaffected by the water discharge activities of SZC alone.	As for SZC alone.
Supporting processes	Water quality – contaminants (species)	Restrict aqueous contaminants to levels equating to high status according to Annex VIII and good status according to Annex X of the Water Framework Directive, avoiding deterioration from existing levels.	Although there will be a small mixing zone within which the EQS will be exceeded, the discharge of TRO will not lead to deterioration from existing levels at a scale that would affect the harbour seal feature of the SAC. There will be a release of un-ionised ammonia from the decay of biota discharged by the FRR system, but this will not be of a scale such that there would be any deterioration from existing levels. There will be small mixing zones where PNECs for bromoform and hydrazine will be exceeded, but these will not lead to deterioration from existing levels at a scale that would affect the harbour seal feature of the SAC.	As for SZC alone.

Attribute	Sub-attribute	Target	Outcome of assessment: SZC alone	Outcome of assessment: SZC and SZB
Supporting processes	Water quality - nutrients (species)	Maintain water quality to mean winter dissolved inorganic nitrogen levels where biological indicators of eutrophication (opportunistic macroalgal and phytoplankton blooms) do not affect the integrity of the site and features, avoiding deterioration from existing levels.	Nutrient input from the water discharge activities of SZC alone will not lead to deterioration from existing levels.	As for SZC alone.
Supporting processes	Water quality – turbidity (species)	Maintain natural levels of turbidity (for example, suspended concentrations of sediment, plankton and other material) in areas where this species is or could be present.	Natural levels of turbidity will not be altered by the water discharge activities of SZC alone.	

8. Seabird and harbour porpoise features: Appropriate assessment

8.1. Method

Our appropriate assessment will assess the potential for an adverse effect on breeding seabird features, non-breeding red-throated divers and harbour porpoise from the cooling water system and fish recovery and return systems (FRR) discharges of SZC alone, and will compare this to the baseline. Coastal waters are currently receiving thermal and chemical inputs from the cooling water system discharges of the existing SZB power station, as well as organic input from the FRR discharge at SZB. The baseline is therefore referred to as SZB alone, in the assessment that follows.

SZB is expected to continue to operate until 2035, although there is potential for an extension of SZB's operational lifetime by 20 years to 2055 at the latest. There will therefore be a period of overlap when both stations are operating, with SZC Unit 1 programmed to begin hot functional testing and become operational in 2033, while SZC Unit 2 is programmed to begin hot functional testing and become operational in 2034. Therefore, in addition to assessing the potential for an adverse effect from the cooling water and FRR system discharges of SZC alone, this chapter will also assess the potential for an adverse effect on seabird and harbour porpoise features from the cooling water and FRR system discharges of SZC and SZB in combination and compare this to the baseline (SZB alone).

Once the operation of SZB has ceased, the environmental effects will be those arising from the operation of SZC alone, barring any residual effects from SZB.

We will assess the potential for adverse effects on the breeding seabird features of the following sites:

- Outer Thames Estuary SPA – as the WDA discharges directly into the site

For the following sites the breeding seabird features are considered functionally linked:

- Alde-Ore Estuary SPA
- Alde-Ore Estuary Ramsar
- Benacre to Easton Bavents SPA
- Minsmere-Walberswick SPA

We will assess the potential for adverse effects on the harbour porpoise feature of the following site:

- Southern North Sea SAC

Risks associated with the current application and relevant features are:

- change in thermal regime arising from the discharge of cooling water
    - direct effects may occur through the feature coming into contact with heated water
    - indirect effects may occur if prey avoid areas of heated water, leading to a reduction in prey availability, or an increase in energy expenditure required to locate displaced prey

- toxic contamination (chemical) arising from the discharge of chemicals within the cooling water system
    - direct effects may occur through the feature coming into contact with toxic chemicals
    - indirect effects may occur if toxic contamination alters communities in supporting habitats
    - indirect effects may occur through prey coming into contact with toxic chemicals, and the prey fish then being eaten by the feature (bioaccumulation)
    - indirect effects may occur if prey avoid areas of toxic contamination, leading to a reduction in prey availability

- changes in nutrients/eutrophication arising from sewage discharge and from the discharge of dead and moribund biota from the FRR system
    - indirect effects may occur if the integrity of the site is affected by changes in water quality. Our assessment considers:
        - nutrient concentrations
        - un-ionised ammonia
        - dissolved oxygen
        - phytoplankton production
        - organic enrichment

The applicant has modelled absolute surface temperatures, thermal uplift plumes and chemical exceedance plumes created by the discharge from cooling water systems from SZC and SZB in combination using the validated Sizewell General Estuarine Transport Model (GETM) (sections 6.1.1 and 6.2.1).

In our appropriate assessment, for each breeding seabird feature, we will assess the potential for adverse impact from change in thermal regime and toxic contamination by considering the percentage overlap between generic foraging ranges for breeding seabirds provided in Woodward and others (2019) (Table 13) and the thermal uplift and chemical exceedance plumes calculated by the applicant.

For breeding seabird features, 3 descriptions of foraging areas are referred to in the following assessment, these being the:

- mean maximum + standard deviation (SD) foraging area
- mean maximum foraging area
- mean foraging area

The mean maximum foraging area is the area within an arc centred on the colony location, with a radius equivalent to the mean maximum foraging range for the feature. The mean maximum foraging area describes the usual maximum extent of the foraging area for the breeding seabird feature.

The mean maximum + SD foraging area is the area within an arc centred on the colony location, with a radius equivalent to the mean maximum foraging range for the feature, plus its standard deviation (SD). This too is a description of the usual maximum extent of the foraging area for the breeding seabird feature, but with an added allowance for the variability within the datasets considered by Woodward and others (2019).

The mean foraging area is the area within an arc centred on the colony location, with a radius equivalent to the mean foraging range for the feature. In the assessment that follows, the mean foraging area is used as a proxy for areas of concentrated foraging, closer to the colony. The mean foraging area is the smallest of the foraging areas for which overlaps have been calculated and, as such, is the most precautionary of the foraging areas to use in the assessment.

We cannot know where breeding seabird colonies may establish in future and so in addition to current (or historic) colony locations within SPAs/Ramsars, we have also examined overlaps between plumes and foraging ranges centred on the closest coastal point to the SZC main development site, within each SPA/Ramsar. Foraging areas centred on the closest coastal point will not necessarily show the greatest overlap within all plumes, as each plume will have a different shape. However, considering overlaps between plumes and foraging ranges centred on the closest coastal point does provide a useful approximation to a worst-case scenario.

While foraging areas are used to investigate the potential for adverse effects, we recognise that breeding seabirds do not in fact have an equal probability of foraging at any point within the area. Foraging range is a reasonable proxy for a likely zone of occurrence of those birds, while acting as central place foragers tied to a colony location. But, if preferred feeding locations occur within thermal or chemical mixing zones, then the birds' degree of exposure may be greater than indicated by the percentage overlap between the thermal or chemical plume and the foraging area. Conversely, if preferred feeding locations lie outside of the mixing zones, then the birds' degree of exposure may be less than indicated. In order to address this to some degree, our assessment refers to information supplied by the applicant regarding preferred foraging locations recorded during visual surveys. Preferred foraging locations may vary over time due to, for example, changes in seabed altering local current patterns, or fluctuations in the availability of prey species with different habitat preferences and behaviours. However, as it is not possible to predict precise foraging areas that may be preferred over the whole operational period of SZC, the use of foraging areas, backed by information on preferred foraging locations where available, is an acceptable proxy for assessing the potential for adverse effects on breeding seabird features.

Localised areas of upwelling can sometimes be attractive to fish and seabirds, such as can be seen at the shallow, nearshore SZB cooling water outfall (which also discharges fish from the stations FRR system). A similar situation occurred at the Dungeness power stations, where the area around the cooling water discharge was known as ‘the patch’ to birders or ‘the boil’ to anglers. The outlet at Dungeness is close to shore and in shallow water, whereas at SZC the outlets will be 3.0 to 3.5km offshore and around 16m deep. This is deep enough so that, while there will be a discharge plume, we don’t expect to see a surface boil from the cooling water discharge. The SZC inlets are a similar distance offshore and slightly shallow. The water column in Greater Sizewell Bay is well mixed, and the SZC intake heads and outlets are close enough together, so that SZC will not be drawing in nutrient rich water and discharging into relatively nutrient-depleted surface waters. Prey will not be concentrated in the cooling water – plankton density will be no higher in the discharged water than at the point of abstraction (the FRR systems have their own separate discharge points closer inshore). As such, it is unlikely that the cooling water discharge from SZC will be as attractive to fish and seabirds as the SZB cooling water outlet, or as ‘the patch’ was at Dungeness.

For the non-breeding red-throated diver feature, we will assess the potential for these adverse impacts by considering the percentage of the Outer Thames Estuary SPA that is within the thermal uplift and chemical exceedance plumes.

For the harbour porpoise feature, the potential for adverse impacts will be assessed by considering the size, location, and potential for direct harm of the thermal uplift and chemical exceedance plumes calculated by the applicant, compared to the distribution and movements of harbour porpoises.

Table 13: Mean maximum + standard deviation (SD), mean maximum, and mean foraging ranges, in kilometres, for the lesser black-backed gull, Sandwich tern, little tern and common tern, from Woodward and others (2019). For the lesser black-backed gull, the generic mean has been used, rather than the larger site-specific mean of 49.9km given in the same paper for the Alde-Ore SAC Orfordness colony. The use of the generic mean (43.3km) is precautionary, and is consistent with the use of generic foraging ranges for the other seabird features. Woodward and others (2019) does not provide a standard deviation for the mean maximum foraging range of little tern

Breeding seabird feature	Mean maximum + SD km	Mean maximum km	Mean km
Lesser black-backed gull	236.0	127.0	43.3
Sandwich tern	57.5	34.3	9.0
Little tern	-	5.0	3.5
Common tern	26.9	18.0	6.4

8.1.1. Change in thermal regime

Absolute water temperature

For seabird features and harbour porpoise, the direct effects of change in thermal regime will be assessed by reference to modelled absolute water temperatures at the sea surface, above the point of discharge.

While the Habitats Directive has no specific temperature requirements, the UK Technical Advisory Group on Water Quality (WQTAG) for the Water Framework Directive recommended temperature thresholds for assessing the impact of thermal discharges on SPAs. This includes a maximum temperature of 28°C (as a 98th percentile) as the edge of the mixing zone (WQTAG sub-group, 2006). The following assessment will refer to this threshold. A maximum temperature of 28°C as a 98th percentile means that, within the mixing zone, sea surface temperatures will exceed 28°C for 2% or more of a year.

Similarly, WQTAG sub-group (2006) recommended temperature thresholds for assessing the impact of thermal discharges on SACs, which include a maximum temperature threshold of 21.5°C (as a 98th percentile) as the edge of the mixing zone. However, this threshold is set to protect salmonid fish, considered the most sensitive organisms to thermal impacts (WQTAG sub-group, 2006) and is therefore not appropriate for use in examining impacts on harbour porpoise or their prey in Greater Sizewell Bay. Salmonids are not abundant here. Only one sea trout (Salmo trutta) was recorded in 9 years of impingement monitoring, and no Atlantic salmon (Salmo salar) (NNB GenCo, 2020c; TR406). Salmonids therefore do not form important prey for marine mammal features in this location. Instead, this assessment will refer to the maximum temperature threshold applied to SPAs for harbour porpoise, this being 28°C (as a 98th percentile) as the edge of the mixing zone (WQTAG sub-group, 2006).

The mixing zone is defined as the predicted area of the receiving waterbody that is expected to contain concentrations of these substances above the relevant EQS or PNEC value as a result of the discharge.

Thermal uplift

Indirect effects of change in thermal regime on seabird and harbour porpoise features may occur if prey avoid areas of thermal uplift, leading to reduced prey availability, or an increase in energy expenditure required to locate displaced prey.

The Habitats Directive has no specific water temperature requirements. However, the UK Technical Advisory Group on Water Quality for the Water Framework Directive recommended temperature thresholds for assessing the impact of thermal discharges on SPAs and SACs, which included a 2°C deviation from ambient as a maximum allowable concentration as the edge of the mixing zone (as a 100th

percentile) (WQTAG sub-group, 2006). The maximum allowable concentration is another way of describing a 100th percentile. The annual 100th percentile plume describes the area within which thermal uplift greater than the specified value is exceeded at any point during the year. Thermal uplift of 2°C is not considered to have any link to specific ecological effects, but serves as a precautionary threshold to trigger further investigation (NNB GenCo, 2021b; shadow HRA).

In the following assessment, the size and location of the annual ≥2°C thermal uplift (100th percentile) plume will be discussed in relation to the potential for effects on the harbour porpoise feature of the Southern North Sea SAC.

The use of the annual 100th percentile, however, would be a highly precautionary approach to assessing the foraging area that is potentially 'lost' to seabirds due to thermal uplift. The applicant's GETM model predicts that the surface area of the 2°C (100th percentile) thermal uplift plume from SZC alone, would be 16,775ha (167.75km²), and 22,460ha (224.6km²) for SZC and SZB (NNB GenCo, 2021b; shadow HRA). The foraging areas of some of the breeding seabird features would lie entirely within this plume, but due to there being no link between thermal uplift of 2°C and specific ecological effects, comparison of foraging areas and 2°C (100th percentile) thermal uplift plumes would not, by themselves, help assess potential impacts. Figure 17 shows the 2°C (100th percentile) thermal uplift plume for SZC and SZB, as modelled by the applicant, extending to the north and south of the SZC main development site, and up to around 7.5km offshore.

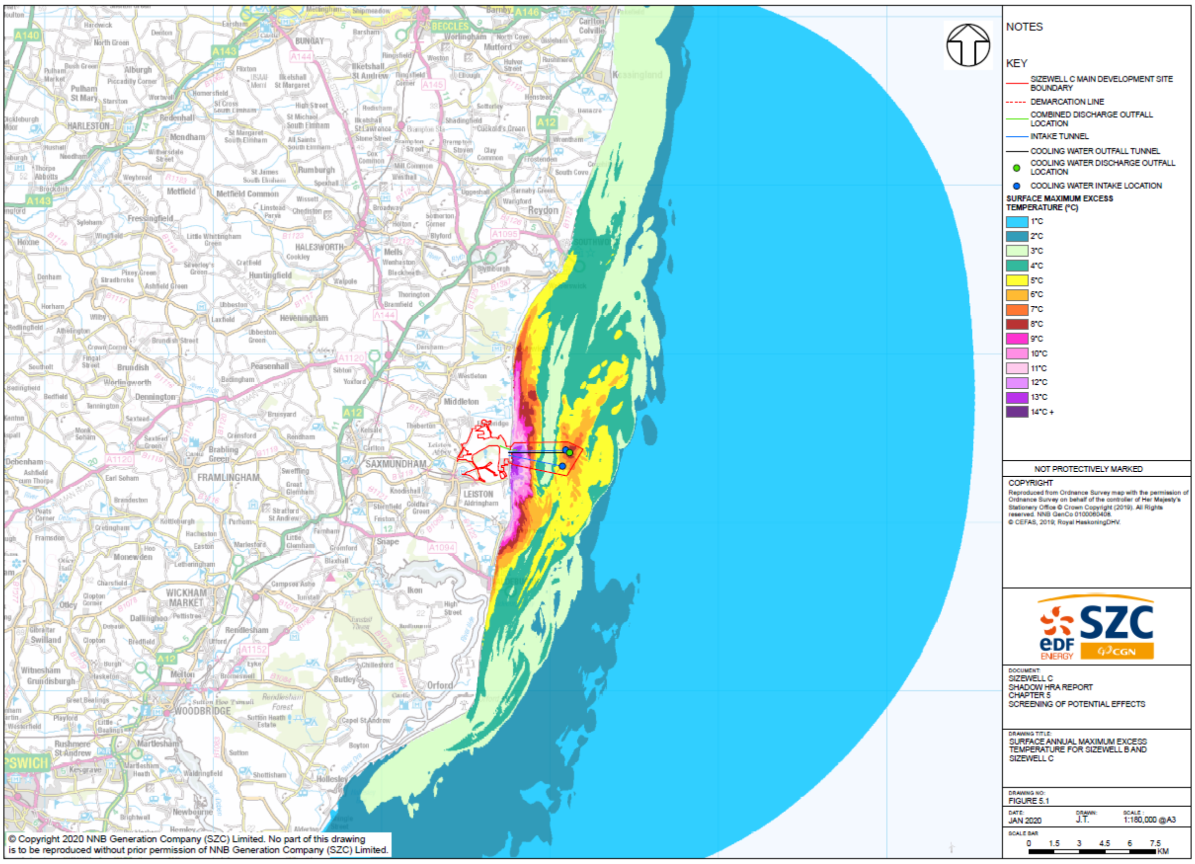

Figure 17: Annual thermal uplift (100th percentile) plumes for SZC and SZB in combination. Reproduced from Figure 5.1 in applicant's sHRA (NNB GenCo, 2021b; shadow HRA)

In addition to the thermal standards just described, the UK Technical Advisory Group on the Water Framework Directive (UKTAG, 2008) proposed standards to ensure that a step rise in temperature, or a sharp gradient, would not create a thermal barrier to fish movement. UKTAG (2008) referred to the Freshwater Fish Directive, which preceded the Water Framework Directive and included a standard such that the temperature measured downstream of a point of discharge (at the edge of the mixing zone) could not exceed the unaffected temperature by more than 1.5°C (for salmonid waters), or 3°C (for cyprinid waters). UKTAG (2008) was unable to find good evidence of the reality of such thermal barriers in rivers and estuaries, except with temperature rises of more than 3°C or near the lethal limit of temperatures. It therefore proposed that a 3°C uplift should be used for the same purpose under the Water Framework Directive (WFD).

Pelagic fish species (notably sprat and herring) will be the most important prey of breeding Sandwich, little and common tern in the waters around Sizewell, with breeding lesser black-backed gull having a more generalist diet (NNB GenCo, 2021b; shadow HRA). Sprat, herring, whiting and seabass form important prey items for non-breeding red throated diver (NNB GenCo, 2021b; shadow HRA), while the diet of harbour porpoise consists of a wide variety of fish, including pelagic schooling fish, as well as demersal and benthic species, especially Ammodytidae (sandeels), gadoids (cod family) and clupeids (herring family) (NNB GenCo, 2021b; shadow HRA). We have not found evidence to support the use of a more precautionary thermal uplift value (that is, less than 3°C thermal uplift) to assess where avoidance behaviour might occur for these fish species (Environment Agency, 2022e: TBS009).

For each breeding seabird feature, the following assessment initially examines the overlap between foraging areas and the ≥2°C and ≥3°C thermal uplift (98th percentile) plumes, calculated over the months when breeding seabird features are present, for each of the mean maximum + SD, mean maximum and mean foraging areas.

The 98th percentile plume describes the area within which thermal uplift, greater than the specified value, is exceeded for at least 2% of the time steps modelled during the months when the seabird feature is present. Conversely, outside of the 98th percentile plume, thermal uplift is less than the specified value for 98%, or more, of the time steps modelled during the months when the seabird feature is present.

There is uncertainty over fish behaviour in response to thermal uplift, and the pattern of seabird foraging is also complex with, for example, intense foraging activity potentially occurring in areas of high flows (Eglington and Perrow, 2014). Consequently, there are no set thresholds for the percentage of a seabird's foraging area over which thermal uplift of 3°C, or more, could indirectly lead to an adverse effect in terms of food availability.

In the absence of firm evidence, the following assessment considers that there will be no adverse effect on a breeding seabird feature (alone) where the percentage of the mean foraging area, which serves as a proxy for areas of concentrated feeding activity close to the colony, that exceeds 3°C thermal uplift (as a 98th percentile) is less than 1%. Although there is no evidence that an overlap of more than 1% would lead to an adverse effect on a breeding seabird feature, in such instances further investigation is triggered, and overlaps with instantaneous thermal plumes are examined.

The 3°C thermal uplift (98th percentile) plume is in effect a summary of thermal uplift conditions over the entirety of the period that seabirds are present. It does not describe the area ≥3°C that might be encountered by a breeding seabird as it leaves its nest on any particular foraging trip, or that a red-throated diver might encounter at any given point in time. The overlap between foraging area and the area of water experiencing ≥3°C thermal uplift, at any single time step of the applicant's GETM model, best represents conditions a seabird might encounter if it were foraging during that time step. This is the overlap between the foraging area and the instantaneous ≥3°C thermal uplift plume.

For any single time step, the area of the instantaneous 3°C thermal uplift plume is likely to be smaller than the area of the 3°C thermal uplift (98th percentile) plume. This can be understood by imagining a thermal plume that extend northwards from the discharge point on flood tides, and southwards on ebb tides. The 3°C thermal uplift plume (98th percentile) will consider all time steps over the months a seabird feature is present and so will consider both the northerly and southerly extents of the plumes, as well as the plume location over all stages in between the flood and ebb tides. The instantaneous plume will only consider a single time step, so may only show the northerly or southerly extent, rather than the combined extent across all tidal stages.

In the following assessment, the pattern of overlaps between a foraging area and the instantaneous 3°C thermal uplift plumes across the months that the breeding seabird feature is present, are illustrated using various graphs, and described by statistics, including the median and inter-quartile range. The median is the middle number in a set of numbers arranged in order of magnitude. The median was chosen over the mean as it is less affected by outliers and skewed data, making the median a better descriptor of the ‘average’ conditions that a foraging seabird would encounter. Half of all observations will be below the median, and half will be above it. The interquartile range describes the range in values of the middle 50% of the data.

In assessing the potential for adverse effect, the median and the range of overlap values are taken into consideration, along with the applicant’s information on preferred feeding locations, where available. For seabird features with a number of colonies within a particular designated site, our conclusion regarding the potential for an impact on the feature considers the site as a whole. Frequent, high percentage overlaps between the mean foraging range and instantaneous ≥3°C thermal uplift plumes at one colony location would not automatically lead to us being unable to conclude no adverse effect on the feature in that site as a whole. For example, there may be a lesser degree of overlap at the site’s other colonies and the behaviour of the feature under consideration (for example, the transitory nesting habits of little tern) may also reduce the features’ dependence upon any one particular colony. While the overlaps between the mean foraging area and the instantaneous ≥3°C thermal uplift plumes may be described in relation to being above or below 1%, this does not imply that we are regarding 1% as a level above which adverse effect cannot be ruled out beyond reasonable scientific doubt. Due to the absence of evidence on the level of effect which may be harmful, our assessment is based on a combination of quantitative (for example, percentage overlap) and qualitative information (for example, seabird behaviour).

Non-breeding red-throated diver are present in the Outer Thames Estuary SPA from September to March (inclusive). Over the winter period, ≥2°C and ≥3°C thermal uplift (98th percentile) plumes are little different to those calculated for the whole annual period (NNB GenCo, 2021b; shadow HRA). Shape files for the September to March thermal uplift plumes were not available and so the proportion of the Outer Thames Estuary SPA covered by the annual ≥2°C and ≥3°C thermal uplift (98th percentile) plumes has been calculated for this assessment. This is a precautionary approach as the annual plume is likely to be larger than a seasonal plume due to the greater time period over which it is generated. The Outer Thames Estuary SPA is comprised of 3 separate sections and so percentages have been calculated both for the SPA as a whole (that is, the sum of the areas of the 3 sections, 3,924.5km²) and for the north-western section alone (1,212.5km²), this being the section into which SZC discharges (Figure 4 in Environment Agency (2022a; Annex 1)). The applicant has calculated summary statistics illustrating the proportion of the total area of the Outer Thames Estuary SPA (all sections combined) covered by instantaneous ≥3°C thermal uplift plumes over the September to March period.

For harbour porpoise, the use of the annual 2°C thermal uplift (100h percentile) plume is a highly precautionary approach to assessing the foraging area that is potentially 'lost' to marine mammals due to thermal uplift, given the absence of evidence for avoidance behaviour in prey species at this temperature threshold. In addition to using a temperature threshold lower than 3°C, the use of the 2°C thermal uplift (100h percentile) plume is precautionary for harbour porpoise because it is a summary of thermal uplift conditions over the entire year. It does not describe the area ≥2°C that might be encountered by a marine mammal within Greater Sizewell Bay at any given point in time. This would instead be represented by the instantaneous thermal uplift plume – the plume calculated for each individual time step within the model.

Should the scale of the 2°C thermal uplift (100h percentile) plume be a cause for concern, when compared to the distribution and behaviour of the harbour porpoise feature, then it would be possible to examine thermal uplift in more detail by considering 3°C thermal plumes and instantaneous overlaps, similar to the method followed for seabird features.

8.1.2. Toxic contamination (chemical)

The following assessment considers the potential effects of total residual oxidants (TRO), bromoform and hydrazine discharged by SZC, following the applicant's conclusion that discharges of these chemicals will exceed the acute EQS or PNEC values (section 5).

The applicant's modelling of these chemical discharges was undertaken using the GETM as validated for Sizewell (section 6.2.1). Chemical discharges were modelled for one month only (May) because the dispersion of chemical discharges is related to the hydrodynamics of the spring neap tidal cycle, which does not change significantly with each month. May was chosen for modelling chemical discharge, as this is the month with the highest phytoplankton growth.

Chemical plumes were modelled with reference to an environmental quality standard (EQS) or a predicted no effect concentration (PNEC) (section 3)). The EQS or PNEC does not specifically consider the direct impact on seabirds or harbour porpoise from physical contact with the discharge. However, EQSs/PNECs for chemicals discharged into the marine environment are set at levels to protect the most sensitive species from acute and/or chronic effects of continuous exposure. Our permitting approach is based on meeting the EQS (or PNEC) and ensuring no significant deterioration. This is sufficiently environmentally protective because in addition to being derived from toxicology data from the most sensitive species, EQSs and PNECs also include safety factors to account for uncertainty in the toxicity data.

When SZC is operating alone, its FRR system returns will lie outside of the mixing zones for TRO, bromoform and hydrazine (Figure 2, Figure 8, Figure 10, Figure 12, Figure 13). This means that, should scavenging seabirds be attracted to the SZC FRR outlets, they will not be within the area within which EQS or PNEC values are met or exceeded. The discharge of cooling water from SZC is unlikely to be attractive to seabirds (section 8.1). However, when SZC and SZB are operating in combination, the FRR system returns of SZC will be close to, or within, the mixing zones for TRO and bromoform discharged from the SZB cooling water outlet (Figure 2, Figure 9, Figure 11). The potential for breeding seabird features to be attracted to the SZC FRR system outlets and thereby exposed to toxic contamination is discussed within the in-combination section of our assessment (section 9.5.3).

Total residual oxidants (TRO)

TRO originates from the combination of chlorine and organic material during chlorination of the cooling water system. Chlorination deters settling of biofouling organisms and is only anticipated to be needed when temperatures are 10°C or higher, not year-round (section 6.2.2). Consequently, there will not be a year-round discharge of TRO, but discharge can be expected during the months when breeding seabirds are present. Non-breeding red-throated diver are present in the Outer Thames Estuary SPA from September through to March. Chlorination is unlikely to occur throughout the entirety of this period – mean monthly temperatures being below 10°C in December, January, February and March (Table 2).

Of the chemical plumes considered in the assessment, the TRO plume is the largest. Model cells within the TRO ≥ EQS 10μg/l (95th percentile) plume are those for which TRO exceeds 10μg/l for at least 5% of the time. Outside of the 10μg/l (95th percentile) plume, model cells are below 10μg/l for 95% of the time, or more.

For breeding seabird features, percentage overlaps have been calculated between their foraging ranges and the TRO ≥ EQS exceedance plumes for SZB alone, SZC alone, and SZC and SZB in combination. The percentage of the Outer Thames Estuary SPA within the various TRO ≥ EQS 10μg/l (as a 95th percentile) plumes has also been calculated, to assess potential impacts on non-breeding red-throated diver. The size and location of the TRO ≥ EQS exceedance plumes will be considered in order to assess potential impacts on the harbour porpoise feature of the Southern North Sea SAC.

For breeding seabird features, where the TRO ≥ EQS exceedance plume overlaps with greater than 1% of the mean foraging area, the pattern of overlaps is examined further by considering overlaps between the mean foraging area and the instantaneous 10µg/l TRO plumes, at every (hourly) time step. The pattern of overlaps between mean foraging area and the instantaneous 10µg/l TRO plumes, across the months that the breeding seabird feature is present, are illustrated using a variety of graphs, and described by statistics, including the median and inter-quartile range (as described previously for thermal uplift). As is the case for thermal uplift, there are no set thresholds for the percentage of a seabird's foraging area over which a concentration of TRO ≥ 10µg/l could indirectly lead to an adverse effect on a breeding seabird feature. There is no evidence that an overlap of more than 1% would lead to an adverse effect. Similarly, while the overlaps between the mean foraging area and the instantaneous TRO ≥ 10µg/l plumes may be described in relation to being above or below 1%, this does not imply that we are regarding 1% as a level above which adverse effect cannot be ruled out beyond reasonable scientific doubt. Due to the absence of evidence on the level of effect which may be harmful, as for thermal uplift, our assessment is based on a combination of quantitative (for example, percentage overlap) and qualitative information (for example, seabird behaviour).

The EQS value comprises both a concentration (10µg/l) and a frequency of occurrence (95th percentile). Without the frequency of occurrence, the concentration of 10µg/l, as considered in the instantaneous plumes, has no regulatory meaning. However, overlaps between the mean foraging area and the instantaneous 10µg/l TRO plumes can still help to describe conditions that a breeding seabird may expect to encounter when leaving the nest on a foraging trip, in the same way as described previously for instantaneous thermal uplift.

Chlorinated by-products (CBP) in particular bromoform

The applicant has calculated a PNEC of 5µg/l (95 percentile), which we have accepted as fit for purpose (section 6.2).

Model cells within the bromoform ≥ PNEC 5µg/l (95th percentile) plume are those for which bromoform exceeds 5µg/l for at least 5% of the time. Outside of the 5µg/l (95th percentile) plume, model cells are below 5µg/l for 95% of the time, or more.

As with TRO, breeding seabird foraging areas have been overlaid on the bromoform ≥ PNEC exceedance plumes for SZB alone, SZC alone, and SZC and SZB in combination, and overlaps calculated. For non-breeding red-throated diver, the percentage of the Outer Thames Estuary SPA within the bromoform ≥ PNEC plume has also been calculated. For harbour porpoise, the size and location of the bromoform ≥ PNEC plumes will be considered in order to assess potential impacts.

The area of the TRO ≥ EQS plume will always be greater than the area of the bromoform ≥ PNEC plume, as the amount of bromoform that is discharged is dependent upon the amount of chlorine that is added to control biofouling. The following assessment does not investigate instances where >1% of the mean foraging area lies within the bromoform ≥ PNEC plume. In such instances, the overlap with the larger TRO plume is examined as this represents a worst-case scenario for considering potential direct and indirect effects.

Hydrazine

The applicant has calculated a chronic PNEC value of 0.4ng/l (calculated as a mean) and an acute PNEC value of 4ng/l (as a 95th percentile). We have accepted these as fit for purpose (section 6.2.4 and Appendix A).

Overlaps have been calculated between the foraging areas of breeding seabird features and the hydrazine mixing zone for the chronic PNEC, and between the same foraging areas and the hydrazine mixing zone for the acute PNEC plume discharged by SZC. No hydrazine is released by SZB, and so the plume areas for SZC and SZB in combination, are the same as for SZC alone.

For non-breeding red-throated diver, the percentage of the Outer Thames Estuary SPA within the chronic and acute hydrazine plumes has been calculated.

The size and location of the hydrazine plumes for SZC alone will also be considered in relation to the potential for direct and indirect effects on the harbour porpoise feature of the Southern North Sea SAC.

The applicant informs us that overlaps between foraging areas with hydrazine exceedance plumes are based on the 69ng/l discharge scenario: a hydrazine discharge of 69ng/l in daily pulses of 2.32 hours (2 hours 18 minutes) starting at 12pm (section 6.2.4). Under the alternative 34ng/l release scenario, the acute plume (17.38ha, 0.17km²) is slightly larger than the acute plume under the 69ng/l scenario (13.79ha, 0.14km²) and may therefore have greater overlap with foraging ranges. The difference between acute plumes is slight though (3.59ha, 0.036km²) and given the small size of the plumes compared to seabird foraging areas in the Outer Thames Estuary SPA and the Southern North Sea SAC, use of either the 69ng/l release scenario or the 34ng/l scenario will not alter our conclusions. For the chronic exceedance plume, the surface plume is slightly larger under the 69ng/l release scenario, being 158.11ha (1.58km²) as opposed to 156.88ha (1.56km²) under the 34ng/l release scenario. The use of the 69ng/l release scenario is therefore the more precautionary figure for calculating overlap with the chronic hydrazine exceedance plume.

8.1.3. Changes in nutrients/eutrophication

For breeding seabird features, non-breeding red throated diver, and harbour porpoise, the potential for adverse impact from changes in nutrients/eutrophication will be assessed by considering inputs from sewage discharge and inputs from the discharge of dead and moribund biota via the FRR systems.

Calculations of inputs from the FRR systems are based on the upper 95% confidence limit of the mean of our 'precautionary worst-case scenario with invertebrates' scenario – a rate of input which we do not typically expect to be exceeded during operation of SZC (Appendix B).

Organic enrichment

Organic enrichment refers to carbon released by the decomposition of dead fish and invertebrates discharged from the FRR systems. As a proxy for an EQS, 100g organic carbon/m^2/year has been used to assess the negative impacts of organic enrichment (Appendix B).

In the following assessment, the potential impact of organic enrichment on breeding seabird features is examined by calculating the overlap between foraging areas and the maximum potential area of organic exceedance for SZB alone, SZC alone, and SZC and SZB in combination. These are the areas the annual FRR discharge could theoretically be spread over to achieve an even thickness that will release carbon at the proxy EQS rate over the whole area (in the manner of spreading fish paste on toast, to an even thickness). Tidal parameters from the thermal plume have been used to scale the area of organic exceedance into a shape which approximates a plume. This method produces plume based on a reasonable worst-case impingement scenario and provides a 'ballpark' figure for examining potential impacts.

For the non-breeding red-throated diver feature and the harbour porpoise feature, the maximum potential areas of organic exceedance are compared to the surface area of the Outer Thames Estuary SPA and the Southern North Sea SAC, respectively.

For further detail on the method used, please see Appendix B.

Nutrient enrichment, un-ionised ammonia and dissolved oxygen

The inputs of additional nutrients (N and P), un-ionised ammonia or decrease in dissolved oxygen have been assessed in terms of the surface area required to dilute the input to the EQS, with the input from the FRR systems being based on our 'reasonable worst case with invertebrates' scenario (see section 6.3). This surface area is then related to the size of Greater Sizewell Bay and its tidal excursion, to inform predictions of the potential indirect effects on breeding seabird, non-breeding red-throated diver and harbour porpoise features.

Because the estimates of organic enrichment due to the SZC FRR system discharge resulted in the largest surface area required to dilute the input to the EQS, similar plumes have not been derived and mapped for nutrient enrichment, un-ionised ammonia or dissolved oxygen as they would be smaller.

8.2. Results

8.2.1. General summary

Breeding seabird features

Table 19 to Table 26 contain the percentage overlap values between mean maximum + SD, mean maximum, and mean foraging areas, for breeding seabird features with the plumes for:

- ≥2°C thermal uplift (98th percentile)
- ≥3°C thermal uplift (98th percentile)
- instantaneous ≥3°C thermal uplift
- TRO ≥ EQS 10μg/l (95th percentile)
- instantaneous TRO ≥ 10μg/l
- bromoform ≥ PNEC 5μg/l (95th percentile)
- hydrazine ≥ chronic PNEC 0.4ng/l (as a mean)
- hydrazine ≥ acute PNEC 4ng/l hydrazine (95th percentile)
- maximum potential area of organic exceedance

The mean foraging area is used as a proxy for areas of more intense foraging, and is the smallest of the foraging areas for which overlaps have been calculated.

Considering the mean foraging area for all breeding seabird features, overlaps with thermal and chemical plumes are generally higher for birds nesting within the Minsmere-Walberswick SPA than for birds nesting in the Alde-Ore SPA. This is as expected due to the Alde-Ore Estuary SPA being further away from the main development site (see Figure 2 and Figure 6 in Environment Agency (2022a; Annex 1)). The Benacre to Easton Bavents SPA is further away still, and there are no overlaps between the mean foraging areas of breeding little tern in Benacre to Easton Bavents SPA and any of the thermal or chemical plumes, or the maximum potential area of organic exceedance for SZB alone, SZC alone, and SZC and SZB in combination (Figure 18) (see also Figure 11 in Environment Agency (2022a; Annex 1).

The SZC cooling water outlets lie further offshore than the SZB outlet and the percentage overlap between the mean foraging areas of breeding seabird features with thermal and chemical plumes is generally reduced for SZC alone, as compared to SZB alone. However, the FRR system discharge of SZC is greater than that of SZB, and the FRR system outlet is not as far offshore as the SZC cooling water outlets (Figure 2). This results in greater overlaps between mean foraging areas of breeding seabird features and the maximum potential area of organic exceedance for SZC alone, as compared to SZB alone (Figure 18).

The maximum potential area of organic exceedance for SZC and SZB results from the biota being discharged from both stations. As such, where overlaps occur between mean foraging areas of breeding seabird features and the maximum potential area of organic exceedance for SZC and SZB in combination, these are generally greater percentage values than for either SZB alone, or SZC alone.

Non-breeding red-throated diver feature

Table 27 shows the percentage of the total surface area of the Outer Thames Estuary SPA covered by the following plumes:

- annual ≥2°C thermal uplift (98th percentile)
- annual ≥3°C thermal uplift (98th percentile)
- instantaneous ≥3°C thermal uplift (September to March)
- TRO ≥ EQS 10μg/l (95th percentile)
- bromoform ≥ PNEC 5μg/l (95th percentile)
- hydrazine ≥ chronic PNEC 0.4ng/l (as a mean)
- hydrazine ≥ acute PNEC 4ng/l hydrazine (95th percentile)
- maximum potential area of organic exceedance

All of the plumes encompass only a small percentage of the total surface area of the Outer Thames Estuary SPA, with only the annual ≥2°C thermal uplift (98th percentile) plume exceeding 1% of the SPA. Instantaneous overlaps with TRO ≥ 10μg/l have not been calculated, as the TRO ≥ EQS 10μg/l (95th percentile) forms such a small percentage of the total surface area of the SPA (<0.2% for SZB alone, SZC alone, and SZC and SZB in combination) (Table 27).

Harbour porpoise feature

Table 28 shows the percentage of the total surface area of the Southern North Sea SAC covered by the following plumes:

- annual ≥2°C thermal uplift (98th percentile)
- annual ≥3°C thermal uplift (98th percentile)
- instantaneous ≥3°C thermal uplift (September to March)
- TRO ≥ EQS 10μg/l (95th percentile)
- bromoform ≥ PNEC 5μg/l (95th percentile)
- hydrazine ≥ chronic PNEC 0.4ng/l (as a mean)

- hydrazine ≥ acute PNEC 4ng/l hydrazine (95th percentile)
- maximum potential area of organic exceedance

All of the plumes encompass only a small percentage (<1%) of the total surface area of the Outer Thames Estuary SPA.

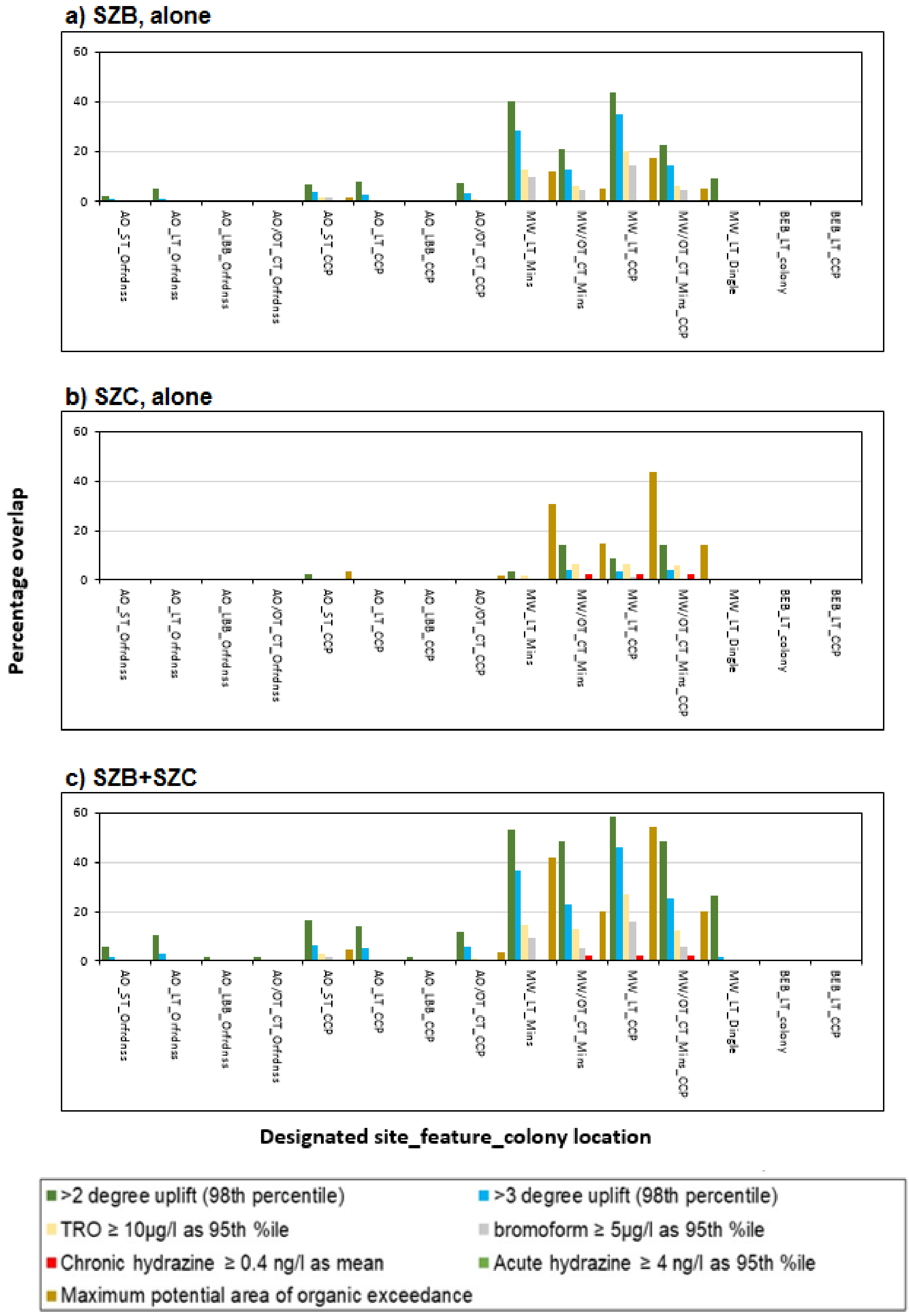

Figure 18: Percentage overlaps between mean foraging areas of breeding seabird features and thermal (98th percentile) and chemical plumes, as well as with the maximum potential area of organic exceedance

AO = Alde-Ore Estuary SPA, **OT** = Outer Thames Estuary SPA, **MW** = Minsmere-Walberswick SPA, **BEB** = Benacre to Easton Bavents SPA, **ST** = Sandwich tern, **LT** = little tern, **LBB** = lesser black-backed gull, **CT** = common tern, **Orfdnss** = Orfordness colony, **Mins** = Minsmere colony, **Dingle** = Dingle colony, **CCP** = closest coastal point.

8.2.2. Change in thermal regime

Absolute water temperature

Sea water will reach a maximum temperature of around 31°C as it passes through the SZC cooling water system (section 6.1.2). The sea surface will not be exposed to temperatures in excess of 28°C as a 98th percentile under baseline conditions, or when SZC is operating alone. When SZC and SZB are operating in combination, 0.11ha (0.0011km²) of the sea surface will be exposed to temperatures in excess of 28°C as a 98th percentile (section 6.1.2).

However, at the immediate point of discharge, the maximum predicted temperatures at the surface will not exceed 8°C above ambient (NNB GenCo, 2021M, Sch 5. No.5).

Thermal uplift

When SZC and SZB are operating in combination, there is a synergistic effect between thermal uplift plumes such that the area of the sea surface experiencing ≥2°C or ≥3°C thermal uplift is greater for SZC and SZB in combination, than would be the case if the surface area of the SZB thermal uplift plume were simply added to that of the SZC thermal uplift plume (section 6.1.2).

For breeding seabird features, when the overlap between the mean foraging area and the ≥3°C thermal uplift (98th percentile) plume exceeded 1%, further investigation was triggered, and overlaps with instantaneous thermal plumes were examined (section 8.1.1). Statistics describing the overlaps between foraging areas and the instantaneous ≥3°C thermal uplift plumes are presented in Table 19 to Table 26 (for completeness) and discussed for individual features, where the overlap between the mean foraging area and the ≥3°C thermal uplift (98th percentile) plume exceeds 1% (sections 8.4 to 8.7).

For the non-breeding red-throated diver feature, the ≥3°C thermal uplift (98th percentile) plume never exceeds 1% of the area of the Outer Thames Estuary SPA (Table 14 and Table 27). However, the applicant has provided statistics describing the percentage of the Outer Thames Estuary SPA covered by instantaneous ≥3°C thermal uplift plumes and these are included for completeness (Table 27).

For the harbour porpoise feature, the ≥2°C thermal uplift (100th percentile) plume never exceeds 1% of the area of the Southern North Sea SAC (Table 28).

For the times of year relevant to each of the features under consideration, generally, the ≥2°C thermal uplift (98th percentile) plume from SZC alone, is around half to two-thirds of the size of the equivalent plume from SZB alone, and the plume from SZC and SZB in combination is around 2 to 3 times the size of the plume from SZB alone (Table 14). Similarly, the ≥3°C thermal uplift (98th percentile) plume from SZC alone, is around a quarter the size of the equivalent plume from SZB alone, and the plume from SZC and SZB in combination, is around 1.6 to 1.7 times the size of the plume from SZB alone (Table 14).

Table 14: The surface area of 2°C and 3°C thermal uplift (98th percentile) plumes during months when breeding seabird features are present. Annual 98th percentile plumes are also presented as these are used in assessing impacts on the non-breeding red-throated diver feature

	SZB ha (km²)	SZC ha (km²)	SZC+SZB ha (km²)
April – August (breeding lesser black-backed gull and Sandwich tern)			
2°C thermal uplift (98th %ile) plume	1,860 (18.6)	980 (9.8)	5,130 (51.3)
3°C thermal uplift (98th %ile) plume	1,050 (10.5)	280 (2.8)	1,770 (17.7)
May – August (breeding little tern and common tern)			
2°C thermal uplift (98th %ile) plume	1,660 (16.6)	900 (9)	3,690 (36.9)
3°C thermal uplift (98th %ile) plume	940 (9.4)	250 (2.5)	1,530 (15.3)
Annual (non-breeding red-throated diver)			
2°C thermal uplift (98th %ile) plume	2433 (24.3)	1551 (15.5)	7899 (79.0)
3°C thermal uplift (98th %ile) plume	1263 (12.6)	306 (3.1)	2200 (22.0)

8.2.3. Toxic contamination (chemical)

Total residual oxidants (TRO)

The applicant's GETM model predicts that the surface area of the TRO ≥ EQS 10µg/l (95th percentile) plume from SZC alone will be slightly smaller than the equivalent plume from SZB alone, whereas with SZC and SZB operating in combination the plume will be 1.9 times the size of the SZB plume (Table 15).

There is no interaction between chemical plumes from SZC and SZB in combination, but when both plumes lie within the mean foraging area of a breeding seabird feature, there will be an increase in the area of exceedance for TRO for SZC and SZB in combination, as compared to SZB alone, or SZC alone (Figure 18).

The percentage overlap between foraging areas for breeding seabird features and the TRO exceedance plume are shown in Table 19 to Table 26. For non-breeding red-throated diver, the percentage of the Outer Thames Estuary SAC within the TRO exceedance plume is shown in Table 27. For harbour porpoise, the percentage of the Southern North Sea SAC within the TRO exceedance plume is shown in Table 28.

For breeding seabird features, where the TRO exceedance plume overlapped with greater than 1% of the mean foraging area, the pattern of overlaps was considered further by examining descriptive statistics for all overlaps between the mean foraging area and the instantaneous 10µg/l TRO plumes at every (hourly) time step. Statistics describing the overlaps between foraging areas and the instantaneous ≥10µg/l TRO plume are presented in Table 19 to Table 26 and discussed for individual features, where relevant (sections 8.4 to 8.7).

For the non-breeding red-throated diver feature and harbour porpoise feature, the TRO exceedance plume never exceeded 1% of the surface areas of the Outer Thames Estuary SPA or Southern North Sea SAC, respectively, and so overlaps with instantaneous 10µg/l TRO plumes have not been calculated (Table 27, Table 28).

Table 15: The surface area of TRO exceedance for SZB alone, SZC alone, and SZC and SZB in combination (from Table 25 in NNB GenCo, 2020b; TR306)

	Surface area of TRO ≥ EQS 10µg/l (95th percentile) plume
SZC alone	337.56ha (3.4km²)
SZB alone	388.56ha (3.9km²)
SZC and SZB in combination	726.21ha (7.3km²)

Chlorinated by-products (CBP) in particular bromoform

The applicant's GETM model predicts that the surface area of the bromoform ≥ PNEC 5µg/l (95th percentile) plume from SZC alone will be 17% of the size of the equivalent plume from SZB alone, whereas with SZC and SZB operating in combination the plume will be 1.2 times the size of the SZB plume (Table 16).

The percentage overlaps between foraging areas for breeding seabird features and the bromoform exceedance plume are shown in Table 19 to Table 26.

For the non-breeding red-throated diver and harbour porpoise features, the percentages of the Outer Thames Estuary SPA and Southern North Sea SAC covered by the bromoform exceedance plumes are shown in Table 27 and Table 28.

Chlorinated by-products result from the breakdown of chemicals used in the chlorination process, and so the bromoform exceedance plume will only be present in the months of the year when chlorination is required. The bromoform exceedance plume is smaller than the TRO exceedance plume and so generally, the percentage overlap between foraging areas (or designated areas) and the bromoform exceedance plume is less than that with the TRO exceedance plume (Figure 18, Table 19 to Table 28).

As with the TRO exceedance plumes there is no interaction between the 2 plumes when SZC and SZB are operating in combination.

Table 16: The surface area of bromoform exceedance for SZB alone, SZC alone, and SZC and SZB in combination (from Table 27 in NNB GenCo, 2020b; TR306)

	Surface area of bromoform ≥ PNEC 5µg/l (95^{th} percentile) plume
SZC alone	52.14ha (0.5km²)
SZB alone	305.80ha (3.1km²)
SZC and SZB in combination	357.94ha (3.6km²)

Hydrazine

The surface area of the chronic hydrazine exceedance plume for SZC alone is very small, being predicted as just 1.6km² by the applicant's GETM model (Table 17). The acute hydrazine exceedance plume for SZC alone is even smaller, at just 0.1km² (Table 17). No hydrazine is released by SZB and so the plume sizes for SZC and SZB in combination are as shown in Table 17.

The percentage overlap between foraging areas for breeding seabird features and chronic and acute hydrazine exceedance plumes are shown in Table 19 to Table 26.

For the non-breeding red-throated diver and harbour porpoise features, the percentages of the Outer Thames Estuary SPA and Southern North Sea SAC covered by the hydrazine exceedance plumes are shown in Table 27 and Table 28, respectively.

Table 17: The surface area of hydrazine exceedance for SZC alone based on 69ng/l of hydrazine discharged in daily pulses of 2.32 h duration starting at midday (from Table to the surface area of the Southern North Sea SAC

	Hydrazine ≥ chronic PNEC 0.4ng/l (as a mean)	Hydrazine ≥ acute PNEC 4ng/l (95^{th} percentile)
SZC alone	158.11ha (1.56km²)	13.79ha (0.14km²)

8.2.4. Results: Changes in nutrients/eutrophication

Organic enrichment

The maximum potential areas of organic exceedance for SZB alone, SZC alone and SZC and SZB in combination are shown in Figure 14.

For SZB alone, the maximum potential area of organic exceedance is 3.97km² and approximates to an ellipse 5.46km long by 0.92km wide (Figure 14). This is equivalent to 0.10% of total area of the Outer Thames Estuary SPA and 0.01% of the area of the Southern North Sea SAC.

For SZC alone, the maximum potential area of organic exceedance is greater than that of SZB alone, at 9.16km² and approximates to an ellipse 8.296km long by 1.406km wide (Figure 14). This is equivalent to 0.21% of total area of the Outer Thames Estuary SPA and 0.02% of the area of the Southern North Sea SAC.

For SZC and SZB, the maximum potential area of organic exceedance is 13.19km² and approximates to an ellipse 9.932km long by 1.683km wide (Figure 14). This is equivalent to 0.34% of total area of the Outer Thames Estuary SPA and 0.04% of the area of the Southern North Sea SAC.

Nutrient enrichment, un-ionised ammonia and dissolved oxygen

Based on the upper 95% confidence level of the mean of our 'reasonable worst-case with invertebrates' impingement scenario, the mean daily loading of impinged biota (upper 95% confidence interval) from SZB alone, is not typically expected to exceed 1,763kg/day, while for SZC this loading will increase, being not expected to exceed 4,083kg/day (Appendix B). For SZC and SZB in combination, the daily loading is the sum of the daily loading from SZC plus SZB and is not typically expected to exceed 5,846kg/day (Appendix B).

The discharge from the sewage treatment works during the operation of SZC alone, will not significantly add to the nutrient input due to the relatively low volumes discharged and the very high dilution this input receives when discharged via the cooling water system (section 6.3).

The surface area required to dilute un-ionised ammonia to the EQS, and the surface area needed to meet oxygen demand through re-aeration all show the same general pattern, with inputs/areas higher for SZC alone, than for SZB alone, and higher still for SZC and SZB (Table 18). This is due to the greater volume of biota discharged from the FRR system of SZC alone, as compared to SZB alone, and the effects of SZC and SZB in combination being based on the sum of the biota from both stations.

Table 18: Summary of FRR system discharge loading estimates for SZC alone, SZB alone, and SZC and SZB in combination, based on the upper 95% confidence limit of the mean of the Environment Agency's 'reasonable worst-case with invertebrates' scenario

		SZC alone	SZB alone	SZC+SZB
Nutrient input	Max daily P content (kg)	20.4	8.8	29.2
	Max daily N content (kg)	142.9	61.7	204.6
Un-ionised ammonia	Area required to dilute to the EQS (21µg/l as an annual mean) with temperature uplift (m^2)	428.3	185.6	613.9
Influence on dissolved oxygen	Area needed to meet oxygen demand through reaeration (km^2)	1.056	0.458	1.514

Table 19: Percentage overlaps between foraging areas for lesser black-backed gull nesting in the Alde-Ore Estuary SPA and the thermal plumes, chemical plumes, and maximum potential area of organic exceedance from SZB alone, SZC alone, and SZC and SZB in combination. Data supplied by the applicant

Alde Ore Estuary SPA – lesser black-backed gull			Orfordness colony			Closest coastal point		
Plume (Apr-Aug)	Foraging area		SZB	SZC	SZC+SZB	SZB	SZC	SZC+SZB
>2°C uplift (98th %ile)	mean max + SD		0.021	0.011	0.059	0.021	0.011	0.058
	mean max		0.060	0.032	0.165	0.059	0.031	0.163
	mean		0.530	0.281	1.462	0.548	0.290	1.512
>3°C uplift (98th %ile)	mean max + SD		0.012	0.003	0.022	0.012	0.003	0.022
	mean max		0.034	0.009	0.062	0.033	0.009	0.061
	mean		0.300	0.080	0.545	0.311	0.083	0.564
Instantaneous > 3°C uplift	mean	Mean	0.05	0.01	0.08	0.05	0.01	0.08
		Q1	0.02	0.00	0.04	0.02	0.00	0.04
		Median	0.04	0.00	0.07	0.04	0.00	0.07
		Q3	0.06	0.01	0.11	0.06	0.01	0.11
		Max	0.23	0.08	0.39	0.24	0.08	0.41
TRO ≥ 10μg/l as 95th %ile	mean max + SD		0.005	0.004	0.009	0.005	0.004	0.009
	mean max		0.013	0.012	0.026	0.013	0.012	0.025
	mean		0.119	0.107	0.226	0.123	0.111	0.234
Instantaneous TRO > 10μg/l	mean	Mean	0.03	0.02	0.05	0.03	0.02	0.05
		Q1	0.02	0.01	0.04	0.02	0.01	0.04
		Median	0.03	0.02	0.05	0.03	0.02	0.05
		Q3	0.03	0.03	0.06	0.03	0.03	0.06
		Max	0.08	0.08	0.12	0.08	0.08	0.13
bromoform ≥ 5μg/l as 95th %ile	mean max + SD		0.004	0.001	0.004	0.004	0.001	0.004
	mean max		0.010	0.002	0.012	0.010	0.002	0.011
	mean		0.088	0.140	0.103	0.091	0.015	0.106
Chronic hydrazine ≥ 0.4ng/l as mean	mean max + SD		n/a	0.002	n/a	n/a	0.002	n/a
	mean max		n/a	0.005	n/a	n/a	0.005	n/a
	mean		n/a	0.045	n/a	n/a	0.047	n/a
Acute hydrazine ≥ 4ng/l as 95th %ile	mean max + SD		n/a	0.000	n/a	n/a	0.000	n/a
	mean max		n/a	0.000	n/a	n/a	0.000	n/a
	mean		n/a	0.004	n/a	n/a	0.004	n/a
Maximum potential area of organic exceedance	mean max + SD		0.004	0.010	0.015	0.004	0.010	0.015
	mean max		0.011	0.029	0.042	0.011	0.029	0.041
	mean		0.095	0.259	0.370	0.098	0.267	0.383

Table 20: Percentage overlaps between foraging areas for Sandwich tern nesting in the Alde-Ore Estuary SPA and the thermal uplift plumes, chemical plumes, and the maximum potential area of organic exceedance from SZB alone, SZC alone, and SZC and SZB in combination. Data supplied by the applicant

Alde Ore Estuary SPA Sandwich tern			Orfordness colony			Closest coastal point		
Plume (Apr-Aug)	**Foraging area**		SZB	SZC	SZC+SZB	SZB	SZC	SZC+SZB
>2°C uplift (98^{th} %ile)	mean max + SD		0.303	0.161	0.837	0.309	0.164	0.853
	mean max		0.840	0.445	2.319	0.870	0.461	2.403
	mean		2.211	0.000	5.809	7.122	2.057	16.597
>3°C uplift (98^{th} %ile)	mean max + SD		0.172	0.046	0.312	0.175	0.047	0.318
	mean max		0.476	0.127	0.865	0.494	0.132	0.896
	mean		1.027	0.000	1.661	4.203	0.301	6.446
Instantaneous > 3°C uplift	mean	Mean	0.08	0.00	0.17	0.72	0.03	1.11
		Q1	0.00	0.00	0.00	0.28	0.00	0.42
		Median	0.00	0.00	0.00	0.52	0.00	0.81
		Q3	0.01	0.00	0.13	0.96	0.00	1.51
		Max	1.84	0.01	2.59	5.33	1.66	7.11
TRO ≥ 10µg/l as 95^{th} %ile	mean max + SD		0.068	0.061	0.130	0.070	0.062	0.132
	mean max		0.189	0.170	0.359	0.196	0.176	0.372
	mean		0.032	0.000	0.032	1.896	0.746	2.642
Instantaneous TRO > 10µg/l	mean	Mean	0.01	0.00	0.01	0.51	0.13	0.64
		Q1	0.00	0.00	0.00	0.23	0.00	0.23
		Median	0.00	0.00	0.00	0.52	0.01	0.61
		Q3	0.00	0.00	0.00	0.74	0.16	0.95
		Max	0.31	0.03	0.30	1.39	1.88	2.75
bromoform ≥ 5µg/l as 95^{th} %ile	mean max + SD		0.050	0.008	0.059	0.051	0.008	0.060
	mean max		0.140	0.023	0.163	0.145	0.024	0.169
	mean		0.059	0.000	0.059	1.461	0.000	1.461
Chronic hydrazine ≥ 0.4ng/l as mean	mean max + SD		n/a	0.026	n/a	n/a	0.026	n/a
	mean max		n/a	0.072	n/a	n/a	0.074	n/a
	mean		n/a	0.000	n/a	n/a	0.308	n/a
Acute hydrazine ≥ 4ng/l (95^{th} %ile)	mean max + SD		n/a	0.002	n/a	n/a	0.002	n/a
	mean max		n/a	0.006	n/a	n/a	0.007	n/a
	mean		n/a	0.000	n/a	n/a	0.000	n/a
Maximum potential area of organic exceedance	mean max + SD		0.054	0.148	0.212	0.055	0.151	0.216
	mean max		0.150	0.410	0.588	0.156	0.425	0.609
	mean		0.000	0.000	0.037	1.418	3.414	4.834

Table 21: Percentage overlaps between foraging areas for little tern nesting in the Alde-Ore Estuary SPA and the thermal uplift plumes, chemical plumes, and the maximum potential area of organic exceedance from SZB alone, SZC alone, and SZC and SZB in combination. Data supplied by the applicant

Alde Ore Estuary SPA little tern			Slaughden Beach colony			Closest coastal point		
Plume (May-Aug)	Foraging area		SZB	SZC	SZC+SZB	SZB	SZC	SZC+SZB
>2°C uplift (98th %ile)	mean max + SD		n/a	n/a	n/a	n/a	n/a	n/a
	mean max		6.492	0.000	10.094	8.249	0.000	12.278
	mean		5.461	0.000	10.392	8.127	0.000	13.906
>3°C uplift (98th %ile)	mean max + SD		n/a	n/a	n/a	n/a	n/a	n/a
	mean max		2.892	0.000	4.708	3.558	0.000	5.998
	mean		0.845	0.000	3.021	2.833	0.000	5.347
Instantaneous > 3°C uplift	mean	Mean	0.08	0.00	0.19	0.16	0.00	0.36
		Q1	0.00	0.00	0.00	0.00	0.00	0.00
		Median	0.00	0.00	0.00	0.00	0.00	0.00
		Q3	0.00	0.00	0.00	0.00	0.00	0.00
		Max	7.94	0.00	9.80	9.71	0.00	11.33
TRO ≥ 10µg/l as 95th %ile	mean max + SD		n/a	n/a	n/a	n/a	n/a	n/a
	mean max		0.115	0.000	0.115	0.368	0.000	0.368
	mean		0.000	0.000	0.000	0.000	0.000	0.000
Instantaneous TRO > 10µg/l	mean	Mean	0.00	0.00	0.00	0.00	0.00	0.00
		Q1	0.00	0.00	0.00	0.00	0.00	0.00
		Median	0.00	0.00	0.00	0.00	0.00	0.00
		Q3	0.00	0.00	0.00	0.00	0.00	0.00
		Max	0.00	0.00	0.00	0.40	0.06	0.39
bromoform ≥ 5µg/l as 95th %ile	mean max + SD		n/a	n/a	n/a	n/a	n/a	n/a
	mean max		0.211	0.000	0.211	0.000	0.453	0.453
	mean		0.000	0.000	0.000	0.000	0.000	0.000
Chronic hydrazine ≥ 0.4ng/l as mean	mean max + SD		n/a	n/a	n/a	n/a	n/a	n/a
	mean max		n/a	0.000	n/a	n/a	0.000	n/a
	mean		n/a	0.000	n/a	n/a	0.000	n/a
Acute hydrazine ≥ 4ng/l as 95th %ile	mean max + SD		n/a	n/a	n/a	n/a	n/a	n/a
	mean max		n/a	0.000	n/a	n/a	0.000	n/a
	mean		n/a	0.000	n/a	n/a	0.000	n/a
Maximum potential area of organic exceedance	mean max + SD		n/a	n/a	n/a	n/a	n/a	n/a
	mean max		0.000	0.000	0.100	0.000	0.007	1.075
	mean		0.000	0.000	0.000	0.000	0.000	0.000

Table 22: Percentage overlaps between the foraging areas for little tern nesting in the Benacre to Easton Bavents SPA and the thermal uplift plumes, chemical plumes, and the maximum potential area of organic exceedance from SZB alone, SZC alone, and SZC and SZB in combination. Data supplied by the applicant

Benacre to Easton Bavents SPA little tern			Closest coastal point		
Plume (May-Aug)	**Foraging area**		SZB	SZC	SZC+SZB
>2°C uplift (98th %ile)	mean max + SD		n/a	n/a	n/a
	mean max		0.000	0.000	0.000
	mean		0.000	0.000	0.000
>3°C uplift (98th %ile)	mean max + SD		n/a	n/a	n/a
	mean max		0.000	0.000	0.000
	mean		0.000	0.000	0.000
Instantaneous > 3°C uplift	mean	Mean	0.00	0.00	0.00
		Q1	0.00	0.00	0.00
		Median	0.00	0.00	0.00
		Q3	0.00	0.00	0.00
		Max	0.00	0.89	1.69
TRO ≥ 10µg/l as 95th %ile	mean max + SD		n/a	n/a	n/a
	mean max		0.000	0.000	0.000
	mean		0.000	0.000	0.000
Instantaneous TRO > 10µg/l	mean	Mean	0.00	0.00	0.00
		Q1	0.00	0.00	0.00
		Median	0.00	0.00	0.00
		Q3	0.00	0.00	0.00
		Max	0.00	0.00	0.00
bromoform ≥ 5µg/l as 95th %ile	mean max + SD		n/a	n/a	n/a
	mean max		0.000	0.000	0.000
	mean		0.000	0.000	0.000
Chronic hydrazine ≥ 0.4ng/l as mean	mean max + SD		n/a	n/a	n/a
	mean max		n/a	0.000	n/a
	mean		n/a	0.000	n/a
Acute hydrazine ≥ 4ng/l as 95th %ile	mean max + SD		n/a	n/a	n/a
	mean max		n/a	0.000	n/a
	mean		n/a	0.000	n/a
Maximum potential area of organic exceedance	mean max + SD		n/a	n/a	n/a
	mean max		0.000	0.000	0.000
	mean		0.000	0.000	0.000

Table 23: Percentage overlaps between the foraging areas for little tern centred on the Minsmere colony and the closest coastal point in the Minsmere-Walberswick SPA and the thermal uplift plumes, chemical plumes, and the maximum potential area of organic exceedance from SZB alone, SZC alone, and SZC and SZB in combination. Data supplied by the applicant

Minsmere-Walberswick SPA little tern			Minsmere colony			Closest coastal point		
Plume (May-Aug)	Foraging area		SZB	SZC	SZC+SZB	SZB	SZC	SZC+SZB
>2°C uplift (98th %ile)	mean max + SD		n/a	n/a	n/a	n/a	n/a	n/a
	mean max		27.922	17.527	57.479	30.170	20.700	62.586
	mean		40.323	3.431	53.495	43.643	8.731	58.428
>3°C uplift (98th %ile)	mean max + SD		n/a	n/a	n/a	n/a	n/a	n/a
	mean max		18.027	5.855	31.695	21.307	6.430	37.152
	mean		28.820	0.000	36.417	35.305	3.629	45.918
Instantaneous > 3°C uplift	mean	Mean	4.39	0.03	6.08	6.16	0.40	8.71
		Q1	1.09	0.00	1.47	3.36	0.00	4.98
		Median	2.76	0.00	4.19	4.88	0.00	7.02
		Q3	6.15	0.00	8.82	7.63	0.63	10.81
		Max	30.25	1.72	33.35	33.18	3.44	37.24
TRO ≥ 10µg/l as 95th %ile	mean max + SD		n/a	n/a	n/a	n/a	n/a	n/a
	mean max		9.132	7.995	17.126	10.748	9.648	20.396
	mean		12.843	1.864	14.707	20.575	6.553	27.128
Instantaneous TRO > 10µg/l	mean	Mean	3.14	0.22	3.36	5.05	1.19	6.23
		Q1	0.93	0.00	0.93	3.96	0.53	4.79
		Median	2.82	0.01	3.03	4.77	0.81	5.87
		Q3	4.95	0.21	5.29	5.82	1.59	7.22
		Max	13.50	3.41	13.74	14.18	5.52	15.38
bromoform ≥ 5µg/l as 95th %ile	mean max + SD		n/a	n/a	n/a	n/a	n/a	n/a
	mean max		6.814	1.280	8.094	7.864	1.307	9.171
	mean		9.638	0.000	9.638	14.839	1.182	16.021
Chronic hydrazine ≥ 0.4ng/l as mean	mean max + SD		n/a	n/a	n/a	n/a	n/a	n/a
	mean max		n/a	3.542	n/a	n/a	4.069	n/a
	mean		n/a	0.101	n/a	n/a	2.196	n/a
Acute hydrazine ≥ 4ng/l as 95th %ile	mean max + SD		n/a	n/a	n/a	n/a	n/a	n/a
	mean max		n/a	0.357	n/a	n/a	0.365	n/a
	mean		n/a	0.000	n/a	n/a	0.351	n/a
Maximum potential area of organic exceedance	mean max + SD		n/a	n/a	n/a	n/a	n/a	n/a
	mean max		8.347	19.999	26.763	8.538	23.320	33.208
	mean		12.228	30.700	41.826	17.542	43.648	54.218

Table 24: Percentage overlaps between the foraging areas for little tern centred on the Dingle colony in the Minsmere-Walberswick SPA and the thermal uplift plumes, chemical plumes, and the maximum potential area of organic exceedance from SZB alone, SZC alone, and SZC and SZB in combination. Data supplied by the applicant

Minsmere- Walberswick SPA little tern			Dingle colony		
Plume (May-Aug)	**Foraging area**		SZB	SZC	SZC+SZB
>2°C uplift (98th %ile)	mean max + SD		n/a	n/a	n/a
	mean max		8.245	0.000	19.769
	mean		9.022	0.000	26.741
>3°C uplift (98th %ile)	mean max + SD		n/a	n/a	n/a
	mean max		1.451	0.000	3.553
	mean		0.000	0.000	1.866
Instantaneous > 3°C uplift	mean	Mean	0.02	0.00	0.11
		Q1	0.00	0.00	0.00
		Median	0.00	0.00	0.00
		Q3	0.00	0.00	0.00
		Max	3.56	0.16	6.91
TRO ≥ 10µg/l as 95th %ile	mean max + SD		n/a	n/a	n/a
	mean max		0.000	0.000	0.000
	mean		0.000	0.000	0.000
Instantaneous TRO > 10µg/l	mean	Mean	0.00	0.00	0.00
		Q1	0.00	0.00	0.00
		Median	0.00	0.00	0.00
		Q3	0.00	0.00	0.00
		Max	0.00	0.00	0.00
bromoform ≥ 5µg/l as 95th %ile	mean max + SD		n/a	n/a	n/a
	mean max		0.000	0.000	0.000
	mean		0.000	0.000	0.000
Chronic hydrazine ≥ 0.4ng/l as mean	mean max + SD		n/a	n/a	n/a
	mean max		n/a	0.000	n/a
	mean		n/a	0.000	n/a
Acute hydrazine ≥ 4ng/l as 95th %ile	mean max + SD		n/a	n/a	n/a
	mean max		n/a	0.000	n/a
	mean		n/a	0.000	n/a
Maximum potential area of organic exceedance	mean max + SD		n/a	n/a	n/a
	mean max		0.000	0.017	1.439
	mean		0.000	0.000	0.000

Table 25: Percentage overlaps between foraging areas for common tern centred on the Orfordness colony and the closest coastal point in the Alde-Ore Estuary SPA and the thermal uplift plumes, chemical plumes, and the maximum potential area of organic exceedance from SZB alone, SZC alone, and SZC and SZB in combination. Data supplied by the applicant

Outer Thames Estuary SPA common tern			Orfordness colony			Closest coastal point		
Plume (May-Aug)	Foraging area		SZB	SZC	SZC+SZB	SZB	SZC	SZC+SZB
>2°C uplift (98th %ile)	mean max + SD		1.221	0.661	2.704	1.283	0.694	2.840
	mean max		2.267	1.454	4.795	2.871	1.554	6.354
	mean		0.460	0.000	1.682	7.745	0.000	11.515
>3°C uplift (98th %ile)	mean max + SD		0.691	0.183	1.245	0.726	0.193	1.307
	mean max		1.492	0.410	2.605	1.625	0.431	2.926
	mean		0.000	0.000	0.114	3.438	0.000	5.563
Instantaneous > 3°C uplift	mean	Mean	0.01	0.00	0.01	0.33	0.00	0.63
		Q1	0.00	0.00	0.00	0.00	0.00	0.00
		Median	0.00	0.00	0.00	0.03	0.00	0.19
		Q3	0.00	0.00	0.00	0.33	0.00	0.81
		Max	0.80	0.00	1.41	4.07	0.95	5.82
TRO ≥ 10µg/l as 95th %ile	mean max + SD		0.307	0..275	0.582	0.323	0.289	0.611
	mean max		0.686	0.614	1.301	0.722	0.647	1.368
	mean		0.000	0.000	0.000	0.963	0.000	0.963
Instantaneous TRO > 10µg/l	mean	Mean	0.00	0.00	0.00	0.18	0.00	0.18
		Q1	0.00	0.00	0.00	0.00	0.00	0.00
		Median	0.00	0.00	0.00	0.00	0.00	0.00
		Q3	0.00	0.00	0.00	0.31	0.00	0.31
		Max	0.00	0.00	0.00	1.39	0.16	1.38
bromoform ≥ 5µg/l as 95th %ile	mean max + SD		0.227	0.037	0.264	0.238	0.039	0.277
	mean max		0.506	0.083	0.589	0.533	0.088	0.620
	mean		0.000	0.000	0.000	0.641	0.000	0.641
Chronic hydrazine ≥ 0.4ng/l as mean	mean max + SD		n/a	0.116	n/a	n/a	0.122	n/a
	mean max		n/a	0.259	n/a	n/a	0.273	n/a
	mean		n/a	0.000	n/a	n/a	0.000	n/a
Acute hydrazine ≥ 4ng/l as 95th %ile	mean max + SD		n/a	0.010	n/a	n/a	0.011	n/a
	mean max		n/a	0.023	n/a	n/a	0.024	n/a
	mean		n/a	0.000	n/a	n/a	0.000	n/a
Maximum potential area of organic exceedance	mean max + SD		0.243	0.665	0.953	0.256	0.698	1.001
	mean max		0.544	1.485	2.095	0.572	1.563	2.239
	mean		0.000	0.000	0.000	0.068	1.652	3.274

Table 26: Percentage overlaps between the foraging areas for common tern centred on the Minsmere colony and the closest coastal point in the Minsmere-Walberswick SPA and the thermal uplift plumes, chemical plumes, and the maximum potential area of organic exceedance from SZB alone, SZC alone, and SZC and SZB in combination. Data supplied by the applicant

Outer Thames Estuary SPA common tern			Minsmere colony			Closest coastal point		
Plume (May-Aug)	Foraging area		SZB	SZC	SZC+SZB	SZB	SZC	SZC+SZB
>2°C uplift (98th %ile)	mean max + SD		1.464	0.793	3.242	1.417	0.767	3.138
	mean max		3.407	1.844	7.543	3.268	1.770	7.237
	mean		20.895	14.336	48.759	22.981	13.983	48.346
>3°C uplift (98th %ile)	mean max + SD		0.829	0.220	1.492	0.802	0.213	1.444
	mean max		1.928	0.511	3.472	1.850	0.491	3.331
	mean		12.762	4.010	23.173	14.503	3.877	25.528
Instantaneous > 3°C uplift	mean	Mean	2.04	0.37	3.31	2.12	0.36	3.50
		Q1	1.08	0.00	1.78	1.07	0.00	1.95
		Median	1.61	0.02	2.65	1.71	0.02	2.98
		Q3	2.52	0.66	4.21	2.74	0.64	4.44
		Max	11.75	2.73	15.21	11.77	2.84	14.71
TRO ≥ 10µg/l as 95th %ile	mean max + SD		0.368	0.330	0.698	0.356	0.319	0.676
	mean max		0.857	0.767	1.624	0.822	0.736	1.558
	mean		6.520	6.214	12.735	6.495	5.817	12.312
Instantaneous TRO > 10µg/l	mean	Mean	1.58	1.16	2.74	1.56	1.13	2.69
		Q1	1.27	0.62	2.10	1.24	0.61	2.12
		Median	1.52	0.96	2.53	1.53	0.93	2.49
		Q3	1.80	1.48	3.21	1.81	1.45	3.10
		Max	4.30	4.51	7.00	4.16	4.36	6.77
bromoform ≥ 5µg/l as 95th %ile	mean max + SD		0.272	0.045	0.316	0.263	0.043	0.306
	mean max		0.632	0.104	0.736	0.606	0.100	0.706
	mean		4.702	0.815	5.520	4.791	0.788	5.580
Chronic hydrazine ≥ 0.4ng/l as mean	mean max + SD		n/a	0.139	n/a	n/a	0.135	n/a
	mean max		n/a	0.324	n/a	n/a	0.310	n/a
	mean		n/a	2.538	n/a	n/a	2.453	n/a
Acute hydrazine ≥ 4ng/l as 95th %ile	mean max + SD		n/a	0.012	n/a	n/a	0.012	n/a
	mean max		n/a	0.029	n/a	n/a	0.028	n/a
	mean		n/a	0.228	n/a	n/a	0.220	n/a
Maximum potential area of organic exceedance	mean max + SD		0.292	0.797	1.142	0.283	0.772	1.106
	mean max		0.679	1.855	2.657	0.651	1.779	2.550
	mean		5.324	14.529	19.888	5.148	14.060	20.147

Table 27: Percentage overlaps between the Outer Thames Estuary SPA, as occupied by non-breeding red-throated diver and the thermal uplift plumes, chemical plumes, and the maximum potential area of organic exceedance from SZB alone, SZC alone, and SZC and SZB in combination. Data supplied by the applicant

Outer Thames Estuary SPA / red-throated diver	**Outer Thames Estuary SPA**				
Plume (May-Aug)			SZB	SZC	SZC+SZB
Annual >2°C uplift (98th %ile)	Outer Thames Estuary SPA		0.620	0.395	2.013
Annual >3°C uplift (98th %ile)	Outer Thames Estuary SPA		0.322	0.078	0.561
Instantaneous > 3°C uplift (Sep – Mar)	Outer Thames Estuary SPA	Mean	0.07	0.01	0.11
		Q1	0.04	0.00	0.06
		Median	0.06	0.00	0.09
		Q3	0.09	0.01	0.14
		Max	0.27	0.14	0.64
TRO ≥ 10µg/l as 95th %ile	Outer Thames Estuary SPA		0.10	0.09	0.19
bromoform ≥ 5µg/l as 95th %ile	Outer Thames Estuary SPA		0.08	0.01	0.09
Chronic hydrazine ≥ 0.4ng/l as-mean	Outer Thames Estuary SPA		n/a	0.04	0.04
Acute hydrazine ≥ 4ng/l as 95th %ile	Outer Thames Estuary SPA		n/a	<0.01	<0.01
Maximum potential area of organic exceedance	Outer Thames Estuary SPA		0.101	0.233	0.336

Table 28: Percentage overlaps between the Southern North Sea SAC, as utilised by the harbour porpoise feature and the thermal uplift plumes, chemical plumes, and the maximum potential area of organic exceedance from SZB alone, SZC alone, and SZC and SZB in combination. Also shown are percentage overlaps with the area of the Southern North Sea SAC of particular importance to the harbour porpoise feature during winter months (see section 8.9.1). Data supplied by the applicant

Southern North Sea SAC / harbour porpoise	**Southern North Sea SAC**			
Plume		SZB	SZC	SZC+SZB
Annual >2°C uplift (100th %ile)	Total area (36,951km²)	0.25%	0.45%	0.61%
TRO ≥ 10µg/l as 95th %ile	Winter area (12,697km²)	0.7%	1.3%	1.8%
	Total area (36,951km²)	0.01%	0.01%	0.02%
bromoform ≥ 5µg/l as 95th %ile	Winter area (12,697km²)	0.03%	0.03%	0.06%
	Total area (36,951km²)	0.01%	< 0.01%	0.01%
Chronic hydrazine ≥ 0.4ng/l as mean	Winter area (12,697km²)	0.02%	<0.01%	0.03%
	Total area (36,951km²)	n/a	<0.01%	<0.01%
Acute hydrazine ≥ 4ng/l as 95th %ile	Winter area (12,697km²)	n/a	0.01%	0.01%
	Total area (36,951km²)	n/a	<0.01%	<0.01%
Maximum potential area of organic exceedance	Winter area (12,697km²)	n/a	<0.01%	<0.01%
	Total area (36,951km²)	0.01%	0.02%	0.04%
	Winter area (12,697km²)	0.03%	0.07%	0.10%

8.3. Overarching discussion

8.3.1. Change in thermal regime

Absolute water temperature

There will be no adverse effects on any of the breeding seabird features considered in this assessment from a change in thermal regime due to increased absolute water temperatures as a result of the operation of SZC alone, or SZC and SZB in combination.

Change in thermal regime, due to increased absolute water temperatures as a result of the operation of SZC alone, or SZC and SZB in combination, will not result in an adverse effect on the non-breeding red-throated diver feature of the Outer Thames Estuary SPA.

There is no potential for harbour porpoise to be directly harmed by elevated water temperatures when SZC is operating alone, or when SZC and SZB are operating in combination, and therefore no potential for absolute water temperatures to have an adverse effect on the harbour porpoise feature of the Southern North Sea SAC.

WQTAG guidance for thermal discharges into SPAs will not be exceeded when SZC is operating alone – the sea's surface will not experience temperatures in excess of 28°C (as a 98th percentile) (WQTAG sub-group, 2006). When SZC and SZB are operating in combination, the mixing zone is extremely small, and at just 0.11ha (0.0011km^2) will not be large enough to have an adverse effect on breeding seabird features, the non-breeding red-throated diver feature or the harbour porpoise feature.

For SZB alone, SZC alone, and SZC and SZB in combination, surface water temperatures will not exceed the internal body temperature of seabirds and none of the breeding seabird features (lesser black-backed gull, Sandwich tern, little tern, common tern) dive deeper than 2m when feeding (Furness and others, 2012). Red-throated divers can descend as far as 10m below the surface to catch small fish (NNB GenCo, 2021b; shadow HRA). The cooling water outlets for SZC will be around 12 to 15m below the surface (NNB GenCo, 2020b; TR306), with the actual outlet raised above the seabed. So, it is possible for red-throated divers to swim down as deep as the discharge point. However, as the cooling water process raises water temperatures by around 11.15°C (NNB GenCo, 2020b; TR306) even at the discharge point itself, temperatures would still be below the bird's internal body temperature. The chances of significant numbers of red-throated divers diving so close to the outlet would be extremely small, and even were they to do so they would experience a thermal gradient as they approached the outlet which would allow time for avoidance behaviour to take place.

Marine mammals can regulate their body temperature during periods of high activity or when the surrounding/ambient temperature is too warm (NNB GenCo, 2021b; shadow HRA). Marine mammals are also accustomed to changes in water temperatures due to their diving behaviour and vertical movements through the water column. The change in absolute water temperature caused by the thermal discharge would be noticeable to harbour porpoises, but their biological adaptions will allow them to cope with such a change. The cooling water discharge from SZC will not exceed the internal body temperature of marine mammals.

Thermal uplift

Where the percentage of the mean foraging area experiencing ≥ 3°C thermal uplift (as a 98th percentile) is less than 1%, there will be no adverse effect on a breeding seabird feature, due to change in thermal regime resulting from thermal uplift. This is due to the small proportion of the mean foraging area that will be affected, which is itself only a part of the wider potential foraging area for the feature.

Where the percentage of the Outer Thames Estuary SPA experiencing ≥ 3°C thermal uplift (as a 98th percentile) is less than 1%, there will be no adverse effect on the non-breeding red-throated diver feature, due to change in thermal regime resulting from thermal uplift. This is due to the small proportion of the SPA that will be affected.

There is no potential for an adverse effect on the harbour porpoise feature of the Southern North Sea SAC through thermal uplift from SZC alone, or SZC and SZB in combination due to the low proportion of the Southern North Sea SAC that is affected. Furthermore, due to the thermal plume lying entirely within the Southern North Sea SAC, any prey displaced would still be available to foraging harbour porpoise.

For breeding seabird features, this assessment considers the overlap between thermal uplift and the mean foraging range as a ‘worst-case’. The mean foraging area, the smallest of the foraging areas, is used as a proxy for areas of concentrated foraging activity. Foraging trips may extend beyond this mean area, and so the true impact may be somewhat less than indicated.

Where the percentage of the mean foraging area that exceeds 3°C thermal uplift (as a 98th percentile) is greater than 1%, the potential impact of thermal uplift on each breeding seabird feature is considered further for each individual breeding seabird feature in sections 8.4 to 8.7.

For the non-breeding red-throated diver feature, this assessment considers the percentage of the entire area of the Outer Thames Estuary SPA that experiences in excess of the thermal uplift exceedance criteria. Where the percentage of Outer Thames Estuary SPA experiencing ≥3°C thermal uplift (as a 98th percentile) is greater than 1%, the potential impact of thermal uplift on the non-breeding red-throated diver feature is considered further in section 8.8.

With regard to the harbour porpoise feature, the annual ≥2°C thermal uplift (100th percentile) plumes for SZC alone, and SZC and SZB in combination, form only 0.45% and 0.61% of the surface area of the Southern North Sea SAC respectively, or 0.74%, 1.32%, and 1.77% of its winter area. The potential impact of thermal uplift on the harbour porpoise feature of the Southern North Sea SAC is considered further in section 8.9.

8.3.2. Toxic contamination (chemical)

Total residual oxidants (TRO)

TRO may adversely affect breeding seabird features through direct contact, or through indirect effects, such as prey fish avoiding areas of increased TRO concentrations.

As for thermal uplift, for breeding seabird features, this assessment considers the overlap between thermal uplift and the mean foraging range, as a 'worst-case', using the mean foraging area, the smallest of the foraging areas, as a proxy for areas of concentrated foraging activity. Foraging trips may extend beyond this mean area and so the true impact may be somewhat less than indicated.

Similarly, toxic contamination may have both direct and indirect effects on harbour porpoises. Direct effects may occur due to individuals coming into contact with the toxic chemicals. Indirect effects may occur via toxic contamination altering communities in supporting habitats, or through prey fish being affected by the toxic chemicals and the fish then being eaten by porpoises (bioaccumulation). An additional indirect effect would be if the prey fish avoided areas with elevated levels of chemicals, leading to a reduction in prey availability and potentially forcing the porpoises to travel farther than usual and therefore expend increased amounts of energy in order to find new prey.

Direct effects

For breeding seabird features, where the percentage of the mean foraging area experiencing EQS ≥ 10µg/l TRO (as a 95th percentile) is less than 1%, there will be no adverse effect due to toxic effects (chemical) resulting from direct contact with TRO. This is due to both the small proportion of the mean foraging area that will be affected (itself only a part of the wider potential foraging area for the feature), and the precautionary nature of the EQS with regard to direct toxicity on seabirds.

Where the percentage of the Outer Thames Estuary SPA experiencing EQS ≥ 10µg/l TRO (as a 95th percentile) is less than 1%, there will be no adverse effect on the non-breeding red-throated diver feature due to toxic effects (chemical) resulting from direct contact with TRO. This is due to both the small proportion of the SPA that will be affected, and the precautionary nature of the EQS with regard to direct toxicity on seabirds.

There is no potential for a direct adverse effect on the harbour porpoise feature of the Southern North Sea SAC through toxic contamination (chemical) caused by the discharge of TRO from SZC alone, or SZC and SZB in combination. This is due to the low proportion of the Southern North Sea SAC that is affected, the low concentrations of TRO that are being released, and the mobility of harbour porpoise, which would result in any time spent within an exceedance plume to be low, were a porpoise to enter.

Referring to a value of 10µg/l TRO when considering the likelihood of direct effects on seabirds is precautionary, whether for the 95th percentile plume, or the instantaneous >10µg/l plumes.

Results available from toxicity trials of 3 marine fish species occurring in the North Sea, Atlantic herring (Clupea harengus), European plaice (Pleuronectes platessa) and European Dover sole (Solea solea) show that LC50s for continuous exposure to TRO for these species are 65µg/l for herring and 28µg/l for both plaice and sole, with 96 hours continuous exposure (Sorokin and others, 2007). The LC50 is the concentration that kills 50% of the animals.

Seabirds would be expected to display lower levels of sensitivity to these chemicals in the water column than fish which have more direct contact with seawater via the skin and across the gill surface. Furthermore, exposure of seabirds to TRO would be expected to be of a short duration when diving for food, or in the case of lesser black-backed gull and red-throated diver potentially also when loafing on the sea surface.

For breeding seabirds, where the percentage of the mean foraging area that exceeds TRO > EQS 10µg/l (as a 95th percentile) is greater than 1%, the potential impact of direct toxicity on each breeding seabird feature is described further for each individual feature in sections 8.4 to 8.7. For the non-breeding red-throated diver feature, this assessment considers the percentage of the entire area of the Outer Thames Estuary SPA experiencing in excess of the TRO exceedance criteria. The potential impact of direct toxicity on the non-breeding red throated diver feature is described further in section 8.8.

For harbour porpoise, direct contact with chlorine and its by-products can be problematic, as they can irritate the animal’s skin.

In the information submitted to support the HRA (NNB GenCo, 2021b; shadow HRA), the applicant states that there is very little information available about the potential effects of chlorinated discharges, TROs (and bromoform) on marine mammals in the wild, but that skin infections have been observed in captivity, during continuous exposure to chlorine concentrations regularly exceeding 2.5mg/l (NNB GenCo, 2021b; shadow HRA). The infections result from chlorination destroying beneficial microflora and the inactivation of antimicrobial substances secreted by the skin (NNB GenCo, 2021b; shadow HRA). These levels are far higher than those expected from the operation of the SZC power station where chlorination would be applied at a dose level to produce 0.2mg/l TRO after the drum screens (section 6.2.2), and are also far higher than the EQS value of 10µg/l TRO (as a 95th percentile). Any effects shown in captive mammals are highly unlikely to be replicated in those exposed to the SZC chemical discharges.

The TRO ≥ EQS 10µg/l (95th percentile) plumes for SZB alone, SZC alone, and SZC and SZB in combination form only 0.01%, 0.01% and 0.02% of the surface area of the Southern North Sea SAC respectively, or 0.03%, 0.03%, and 0.06% of the area of particular importance to porpoise in the winter (Table 27). At any one time, the instantaneous plume size will generally be smaller than the 95th percentile plume and so the chances of porpoises encountering the plume are low. Due to their mobility, harbour porpoise would also not be expected to remain within the plume for prolonged periods of time. The potential impact of direct toxicity on the harbour porpoise feature is described further in section 8.9.

Indirect effects

Prey fish avoidance behaviour due to toxic effects (chemical) will not result in indirect effects on breeding seabird features where less than 1% of the mean foraging area lies within the EQS ≥ 10µg/l TRO (95th percentile) plume. This is due to the low proportion of the overall foraging area that would be affected.

Prey fish avoidance behaviour due to toxic effects (chemical) will not result in indirect effects on the non-breeding red-throated diver feature where less than 1% of the Outer Thames Estuary SPA lies within the EQS ≥ 10µg/l TRO (95th percentile) plume. This is due to the low proportion of the overall foraging area that would be affected.

Due to the low proportion of the Southern North Sea SAC that would be affected, and the precautionary nature of the EQS value, prey fish avoidance behaviour or changes to the biological community due to toxic effects (chemical) resulting from the discharge of TRO will not result in indirect effects on harbour porpoise. Furthermore, due to the TRO exceedance plume lying entirely within the Southern North Sea SAC, any prey displaced would still be available to foraging harbour porpoise.

There will be no effects of bioaccumulation of TRO on the seabird or harbour porpoise features due to toxic effects (chemical). This is due to the high solubility and rapid degeneration of chlorine species.

Seabird and harbour porpoise features may be indirectly adversely affected if prey species avoid areas of increased TRO concentration. As with direct toxic effects, referring to a value of 10µg/l TRO when considering the likelihood of fish avoidance behaviour is precautionary, whether for the 95th percentile plume, or the instantaneous ≥ 10µg/l plumes.

Davis and others (2021) cite a range of studies supporting an assumption that fish can detect and avoid chlorinated effluent, at concentrations as low as 50µg/l, and that European seabass (Dicentrarchus labrax) populations will move into areas where food is available at mean TRO concentrations of ≤40µg/l, but that the time spent in these areas is likely to be reduced in comparison with unchlorinated water. These higher concentrations will lie within the ≥ 10µg/l plume, and so the use of the greater area of the ≥ 10µg/l plume is a precautionary approach.

In addition to prey avoidance behaviour, indirect effects on the seabird and harbour porpoise features may also occur if toxic contamination alters biological communities in supporting habitats. The overlap between the 10µg/l TRO (95th percentile) plume and a foraging area describes the percentage of the foraging area over which the biological community might be affected due to TRO exceeding the EQS. Indirect effects on seabird features, and on harbour porpoise will be limited though because their primary interaction with the marine biological community is through the consumption of prey. Major prey species, Atlantic herring and European sprat, feed on plankton, particularly copepod crustaceans, which will be produced over a large area of the North Sea. The plankton community upon which the prey fish depend will therefore have limited exposure to EQS ≥ 10µg/l TRO (95th percentile) plumes within Greater Sizewell Bay.

For breeding seabird features, where the percentage of the mean foraging area that exceeds TRO > EQS 10µg/l (as a 95th percentile) is greater than 1%, the potential impact of indirect toxicity on each seabird feature is described further for each individual feature (sections 8.4 to 8.7). The potential indirect effects of TRO on the red-throated diver feature are considered further in section 8.8.

For harbour porpoise, the TRO exceedance plumes for SZB alone, SZC alone, and SZC and SZB in combination, form only 0.01%, 0.01% and 0.02% of the surface area of the Southern North Sea SAC respectively, or 0.03%, 0.03%, and 0.06% of the area of particular importance to porpoise in the winter (Table 28). Due to the TRO plumes being entirely within the Southern North Sea SAC, any displaced fish would continue to be available to harbour porpoises. The potential indirect effects of TRO on the harbour porpoise feature are considered further in section 8.9.

Bioaccumulation of chlorine species will not be significant due to the high solubility of chlorine in water and its rapid degradation in the environment (Sorokin and others, 2007).

Chlorinated by-products (CBP) in particular bromoform

Direct effects

Where the percentage of the mean foraging area experiencing PNEC ≥ 5µg/l bromoform (as a 95th percentile) is less than 1%, there will be no adverse effect on a breeding seabird feature due to toxic effects (chemical) resulting from direct contact with chlorinated by-products. This is due to both the small proportion of the mean foraging area that will be affected (itself only a part of the wider potential foraging area for the feature), and the precautionary nature of the PNEC with regard to direct toxicity on seabirds.

Where the percentage of the Outer Thames Estuary SPA experiencing PNEC ≥ 5µg/l bromoform (as a 95th percentile) is less than 1%, there will be no adverse effect on the non-breeding red-throated diver feature due to toxic effects (chemical) resulting from direct contact with chlorinated by-products. This is due to both the small proportion of the SPA that will be affected, and the precautionary nature of the PNEC with regard to direct toxicity on seabirds.

Due to both the small proportion of the Southern North Sea SAC that will be affected, and the precautionary nature of the PNEC with regard to direct toxicity on marine mammals, there will be no adverse effect on the harbour porpoise feature due to toxic effects (chemical) resulting from direct contact with chlorinated by-products.

Toxicity data for marine organisms shows the lowest reported lethal concentration (LC_{50}) for bromoform as 1mg/L for oyster larvae (Crassostrea virginica) and the lowest non-observable effect concentration (NOEC) as 500µg/l for clam gill tissue (NNB GenCo, 2014c; TR217). Direct toxicity has been observed in sheepshead minnow (Cyprinodon variegates), a North American estuarine and saltmarsh fish at 7.1mg/l (US Environmental Protection Agency ECOTOX database, accessed in 2010).

Although no studies have been conducted looking at the direct effects of bromoform on seabirds, as with TRO, seabirds would be expected to display lower levels of sensitivity than fish, because fish have more direct contact with seawater via the skin and across the gill surface. As such, the bromoform ≥ 5µg/l (95th percentile) plume is considered a precautionary threshold with regard to direct toxic effects on seabirds.

For breeding seabird features, instances where greater than 1% of the mean foraging area overlaps with the PNEC > 5µg/l bromoform (95th percentile) plume will be discussed further in sections 8.4 to 8.7.

For the non-breeding red-throated diver feature, section 8.8 will discuss any instances where bromoform exceedance occurs over greater than 1% of the area of the Outer Thames Estuary SPA.

Similarly, there is little information regarding the direct effects of bromoform on marine mammals, but the air-breathing harbour porpoise would be expected to display lower levels of sensitivity than fish, for which gas exchange takes place across the gill surfaces. As such, the bromoform ≥ PNEC 5µg/l (95th percentile) plume is considered a precautionary threshold with regard to direct toxic effects on the harbour porpoise feature. The potential direct effects of bromoform on the harbour porpoise feature are considered further in section 8.9.

Indirect effects

Prey fish avoidance behaviour due to toxic effects (chemical) will not result in indirect effects on breeding seabird features where less than 1% of the mean foraging area lies within the PNEC ≥ 5µg/l bromoform (95th percentile) plume. This is due to the low proportion of the foraging area that would be affected.

Prey fish avoidance behaviour due to toxic effects (chemical) will not result in indirect effects on the non-breeding red-throated diver feature where less than 1% of the Outer Thames Estuary SAC lies within the PNEC ≥ 5µg/l bromoform (95th percentile) plume. This is due to the low proportion of the SAC that would be affected.

Due to the low proportion of the Southern North Sea SAC that would be affected, and the precautionary nature of the PNEC value, prey fish avoidance behaviour or changes to the biological community due to toxic effects (chemical) resulting from the discharge of chlorinated by-products, particularly bromoform, will not result in indirect effects on harbour porpoise. Furthermore, due to the bromoform exceedance plume lying entirely within the Southern North Sea SAC, any prey displaced would still be available to foraging harbour porpoise.

Due to the low bioaccumulation factor of bromoform, we consider there to be no effects on seabird features due to toxic effects (chemical) resulting from the bioaccumulation of bromoform.

The seabird or harbour porpoise features may be indirectly adversely affected if prey species avoid areas of increased bromoform concentration. However, as the TRO ≥ EQS 10µg/l (95th percentile) plume is larger than the bromoform ≥ PNEC 5µg/l (95th percentile) plume, overlaps between the mean foraging area of breeding seabird features, or the protected area for non-breeding red-throated diver and harbour porpoise, with areas of TRO exceedance are a worst-case scenario regarding prey fish avoidance of chemical plumes.

Indirect effects on seabird features may occur if toxic contamination alters biological communities in supporting habitats.

For breeding seabird features, the overlap between the bromoform ≥ PNEC 5µg/l (95th percentile) plume and a foraging area describes the percentage of the foraging area over which the biological community might be affected due to bromoform exceeding the PNEC. For the non-breeding red-throated diver and the harbour porpoise features the areas over which the biological community might be affected due to bromoform exceeding the PNEC is expressed as a percentage of the Outer Thames Estuary SPA or Southern North Sea SAC, respectively. As with TRO, indirect effects on seabird and harbour porpoise features will be limited as their primary interaction with the marine community is through the consumption of prey. The major prey species, Atlantic herring (Clupea harengus) and European sprat (Sprattus sprattus) feed on plankton, particularly copepod crustaceans, which will be produced over a large area of the North Sea. The plankton community upon which the prey fish depend will therefore have limited exposure to bromoform ≥ PNEC 5μg/l (95^{th} percentile) plumes within Greater Sizewell Bay.

Where greater than 1% of the mean foraging area of a breeding seabird feature overlaps with the bromoform exceedance plume, this will be assessed further. For the red-throated diver feature, further assessment will be carried out if the bromoform exceedance plume extends across greater than 1% of the area of the Outer Thames Estuary SPA. However, assessment will be by reference to overlaps between mean foraging area, or SPA area, and instantaneous ≥ 10μg/l TRO plumes, rather than instantaneous plumes for bromoform. This is because, as TRO exceedance plumes are larger than those of bromoform, referring to instantaneous TRO exceedance plumes represents the worst case. Indirect effects as a result of fish avoiding areas of bromoform exceedance will be no worse than indirect effects as a result of fish avoiding areas of TRO exceedance.

For harbour porpoise, the bromoform exceedance plumes form no greater than 0.01% of the area of the Southern North Sea SAC, or a maximum of 0.03% of the area of the SAC of importance to harbour porpoise during winter months (Table 27).

Bioaccumulation of bromoform will not be significant due to its low bioaccumulation factor and its rapid degradation in the marine environment (Sizewell C Project: Response to Schedule 5 No. 5, paragraph 1.2.11) (NNB GenCo, 2021M, Sch 5. No.5), with long-term studies on sea bass in a fish farm receiving power station cooling water showing that little of the bromoform that was accumulated was ultimately retained in the tissues (NNB Generation Company (HPC) Limited, 2011; TR186).

Hydrazine

Direct effects

There will be no adverse effects on breeding seabird features due to toxic effects (chemical) resulting from direct contact with hydrazine when SZC is operating alone or SZC and SZB are operating in combination. This is due both to the small proportion of the mean foraging area that will be affected (itself only a part of the wider potential foraging area for the feature), and the precautionary nature of the PNECs with regard to direct toxicity on seabirds.

There will be no adverse effects on the non-breeding red-throated diver feature due to toxic effects (chemical) resulting from direct contact with hydrazine when SZC is operating alone or SZC and SZB are operating in combination. This is due both to the small proportion of the Outer Thames Estuary SPA that will be affected, and the precautionary nature of the PNECs with regard to direct toxicity on seabirds.

Due to both the very small proportion of the Southern North Sea SAC that will be affected, and the precautionary nature of the PNECs with regard to direct toxicity on marine mammals, there will be no adverse effects on the harbour porpoise feature due to toxic effects (chemical) resulting from direct contact with hydrazine when SZC is operating alone or SZC and SZB are operating in combination.

The applicant calculated a chronic PNEC value of 0.4ng/l (calculated as a mean) and an acute PNEC value of 4ng/l (as a 95th percentile), values which we have accepted (Appendix A). More recently, assessments used in support of the Canadian Federal Water Quality Guidelines for hydrazine indicate concentrations below 0.2µg/l (200ng/l) have a low probability of adverse effects for marine life (Environment Canada, 2013).

The PNECs used as thresholds within this assessment were derived from data available for a range of species including algae, invertebrates and fish (Appendix A). The applicant calculated PNECs based on data for the most sensitive species, the single-celled marine algae (Dunaliella tertiolecta) following a study which reported an EC50 (median effective concentration) of 0.4µg/l for this species (NNB GenCo, 2021f; TR445). To derive the EC50, cultures of the algae were measured after 6, 8 and 10 days of growth, with the EC50 being defined in this experiment as the concentration that resulted in a 50% reduction in algal biomass as compared to a control (Dixon and others, 1979). The reported EC50 concentration may therefore result from a combination of lethal and sublethal effects, but the mechanisms by which the relative reduction in growth occurred were not studied. The applicant then divided this published EC50 concentration by its assessment (or safety) factor of 100 to derive the acute PNEC of 4ng/l, and by 1,000 to derive the chronic value of 0.4ng/l (Appendix A).

The Canadian Federal Water Quality Guidelines for hydrazine cite LC50 (96h) toxicity endpoints for 5 freshwater fish species (common guppy (Poecilia reticulata), channel catfish (Ictalurus punctatus), golden shiner (Notemigonus crysoleucas), bluegill (Lepomis macrochirus), and fathead minnow (Pimephales promelas)), which range from of 610µg/l for common guppy up to 5,980µg/l for fathead minnow (Environment Canada, 2013). 610µg/l is >150,000 times greater than the acute PNEC (4ng/l) and >1,500,000 times greater than the chronic PNEC (0.4ng/l). Although no studies have been conducted looking at the direct effects of hydrazine on seabirds or marine mammals, these would be expected to be less sensitive than fish, because fish have more direct contact with seawater via the skin and across their gill surfaces. As such, the hydrazine PNECs are considered precautionary regarding the potential for direct toxic effects on the seabird and harbour porpoise features.

For SZC alone (and SZC and SZB in combination), only low percentages of the mean foraging areas of breeding seabird features overlap with the chronic hydrazine ≥ PNEC 0.4ng/l (calculated as a mean) plume, for all breeding seabird features, with overlaps only exceeding 1% for little tern centred on the closest coastal point in the Minsmere-Walberswick SPA (2.2%), common tern centred on the Minsmere colony (2.5%) and common tern centred on the closest coastal point in the Minsmere-Walberswick SPA (2.5%) (Figure 18, Table 19 to Table 26).

Considering the non-breeding red-throated diver feature, the chronic hydrazine plume from SZC (and SZC and SZB in combination) comprises only 0.04% of the area of the Outer Thames Estuary SPA (Table 27). For the harbour porpoise feature, the chronic hydrazine plume from SZC (and SZC and SZB in combination) comprises <0.01% of the area of the Southern North Sea SAC (Table 28).

For SZC alone (and SZC and SZB in combination), percentage overlaps with the acute hydrazine > PNEC plume are even lower, not exceeding 0.5% for any breeding seabird feature (Figure 18, Table 19 to Table 26) and being <0.01% of the area of the Outer Thames Estuary SPA, of which non-breeding red-throated divers are a feature (Table 27) and <0.01% of the area of the Southern North Sea SAC, designated for harbour porpoise (Table 28).

The chronic and acute hydrazine exceedance plumes from SZC alone are extremely small in relation to the area of the Southern North Sea SAC. The hydrazine plume is predicted to be <0.01% of the total area of the Southern North Sea SAC, and 0.01% of the area of particular importance to harbour porpoise during the winter (Table 28). Hydrazine is not discharged by SZB and so the plume size for SZC alone, is the same as will occur when SZC and SZB are operating in combination. The probability of porpoises encountering the intermittent hydrazine discharge is therefore low. Due to their mobility, harbour porpoise would also not be expected to remain within the plume for prolonged periods of time.

Indirect effects

There will be no adverse effects on breeding seabird features due to indirect toxic effects (chemical) resulting from the discharge of hydrazine when SZC is operating alone or SZC and SZB are operating in combination. This is due to the small proportion of the mean foraging area that will be affected (itself only a part of the wider potential foraging area for the feature).

There will be no adverse effects on the non-breeding red-throated diver feature due to indirect toxic effects (chemical) resulting from the discharge of hydrazine when SZC is operating alone or SZC and SZB are operating in combination. This is due to the small proportion of the Outer Thames Estuary SPA that will be affected.

Due to the small proportion of the Southern North Sea SAC that will be affected, there will be no adverse effects on the harbour porpoise feature due to indirect toxic effects (chemical) resulting from the discharge of hydrazine when SZC is operating alone or SZC and SZB are operating in combination.

There will no effects on the seabird or harbour porpoise features due to toxic effects (chemical) resulting from the bioaccumulation of hydrazine discharged with cooling water from SZC alone, or from SZC and SZB in combination, due to its low bioaccumulation factor and rapid natural decay rate.

The seabird and harbour porpoise features may be indirectly adversely affected if prey species avoid areas of increased hydrazine concentration. However, as the TRO ≥ EQS 10µg/l plume is larger than either the chronic or acute PNEC for hydrazine, overlaps between the mean foraging area of breeding seabird features (or area of the SPA) and areas of TRO exceedance are a worst-case scenario regarding prey fish avoidance of chemical plumes.

Indirect effects on seabird features may occur if toxic contamination alters biological communities in supporting habitats. The area within the chronic hydrazine exceedance plume is the area over which the biological community might be affected due to hydrazine.

Indirect effects on the seabird and harbour porpoise features will be limited as their primary interaction with the marine community is through the consumption of prey. The major prey species, Atlantic herring and European sprat, feed on plankton, particularly copepods crustaceans, which will be produced over a large area of the North Sea. The plankton community upon which the prey fish depend will have limited exposure to chronic hydrazine exceedance plumes within Greater Sizewell Bay, which in any event form only a small proportion of mean foraging areas of breeding seabird features, or of the Outer Thames Estuary SPA (for non-breeding red-throated divers).

Bioaccumulation of hydrazine will not be significant due to the rapid natural decay rate of hydrazine, which has a half-life of around 49 minutes in seawater, and its low bioconcentration factor (Environment Canada, 2013; NNB GenCo, 2021g; TR390).

8.3.3. Changes in nutrients/eutrophication

Maximum potential area of organic exceedance

Direct effects

There is no source-receptor pathway by which organic enrichment can have a direct effect on breeding seabird features, the non-breeding red-throated diver feature, or the harbour porpoise feature.

Indirect effects

Particle tracking models indicate that dispersal of dead/moribund biota will be greater than indicated by the maximum potential area of organic exceedance plume approximation, resulting in the contribution of carbon falling below the proxy EQS of 100g carbon/m²/year. This, together with the precautionary nature of both particle tracking modelling and the calculation of the maximum potential area of organic exceedance plume approximation, means that there will be no adverse effect on the breeding seabird, the non-breeding red-throated diver or harbour porpoise features as an indirect result of organic enrichment. Additionally, adverse effects on these features are unlikely due to the pathways by which the dead/moribund biota may affect marine food chains.

Organic enrichment may affect seabird and marine mammal features indirectly, through changes to biological communities or supporting habitats. Tyler-Walters and others (2018) describe how organic enrichment encourages the productivity of suspension and deposit feeding detritivores and allows other species to colonise the affected area to take advantage of the enhanced food supply. Other pressures are exerted on the habitat, such as an accumulation of organic matter on the seabed - smothering organisms - and oxygen depletion (Tyler-Walters and others, 2018). The benthic invertebrate community response is characterised by decreasing numbers of species, total number of individuals, and total biomass and dominance by a few pollution-tolerant annelid worms.

The maximum potential area of organic exceedance is the largest area over which biology could be affected by the FRR discharge. Should biota be dispersed further away from the outlet than the plume approximation indicates, then the release of carbon over that wider area would occur at less than the proxy EQS rate of 100g carbon/m²/year.

The applicant conducted a particle tracking study, which modelled the distribution of sprat-sized particles from the SZC FRR system discharge. We know that these particles will be distributed over at least 32.7km², while the maximum potential area of organic exceedance for SZC alone is 9.16km² (see section 6.3.4, Figure 15 and NNB GenCo, 2021d; TR511). If the biota were distributed over the area identified by the particle tracking studies, the density of enrichment would be 9.16km² / 32.7km² = 0.28 of the proxy EQS of 100g carbon/m²/year. Therefore, it follows that if the biota from the FRR system of SZC alone were spread evenly over the wider 32.7km² area indicated by the particle tracking model, it would contribute 28g carbon/m²/year, rather than 100g carbon/m²/year.

Similarly, the maximum potential area of organic exceedance for SZC and SZB in combination is 13.19km² (section 6.3.4). So, if the biota were distributed over the 32.7km² identified by the particle tracking studies, the density of enrichment would be 13.19km² / 32.7km² = 0.40 of the proxy EQS of 100g carbon/m²/year. This means that if the biota from the FRR systems of both SZC and SZB in combination were spread evenly over the wider 32.7km² area indicated by the particle tracking study, it would be contributing 40g carbon /m²/year, rather than 100g carbon/m²/year.

The applicant's particle tracking model is conservative in that it does not account for resuspension or advection of particles once they have sunk. When they have reached the seabed they remain there and move no further, but they are likely to continue to be resuspended and moved. The decomposition and consumption of organic matter will also aid its dispersal. Estimates of dead/moribund biota are also based on our reasonable worst-case scenario (Appendix B), which represents a level of impingement that we do not expect to be exceeded during the operation of SZC (except in the case of rare, short-term extreme events, such as sprat inundations).

Scavengers, such as crabs, may benefit from the organic input, whereas other species may be detrimentally affected. Responses of animals in mid-trophic levels are difficult to predict, although Crangon crangon (a prey item for common and little terns) would be likely to benefit from the increase in organic matter. Similarly, sand goby (Pomatoschistus minutus) and flatfish may benefit from the increase in organic matter; these being prey items for harbour porpoise (Santos and Pierce, 2003). The predominant prey fish species for breeding seabird features feeding in the Outer Thames Estuary SPA, such as herring and sprat, are highly mobile and planktivorous and are therefore less likely to be affected by organic enrichment.

For breeding seabirds, the greatest overlaps between mean foraging area and the maximum potential area of organic exceedance occur for little tern, centred on the closest coastal point to the main development site, within the Minsmere-Walberswick SPA. The greatest overlap is 54.2% when SZC and SZB are operating in combination (for little tern at the closest coastal point in the Minsmere-Walberswick SPA) (Figure 18, Table 23). However, considering the wider dispersal of biota from the FRR systems, as indicated by the particle tracking modelling, the actual contribution of carbon to the environment is likely to be less than the proxy EQS value over this area. Given also the pathways by which the biota may affect food chains, and the precautionary nature of the particle tracking modelling and organic exceedance calculations, it is unlikely that organic material discharged from the FRR systems of SZC alone, or SZC and SZB in combination will adversely affect the breeding little tern feature of the Minsmere-Walberswick SPA.

Consequently, given that any effect is unlikely for the breeding seabird feature with the greatest overlap between their mean foraging area and the maximum potential area of organic exceedance, we can also conclude that all other breeding seabird features, and the non-breeding red-throated diver feature, will be similarly unaffected by organic enrichment.

Similarly, given the small proportion of the Southern North Sea SAC taken up by the maximum potential area of organic exceedance, the distances over which biota are likely to be dispersed, and the limited potential for adverse indirect impact on harbour porpoise through the food chain, there will be no adverse effect on the harbour porpoise feature of the Southern North Sea SAC as a result of organic enrichment.

Nutrient enrichment, un-ionised ammonia and dissolved oxygen

Direct effects

There are no source-receptor pathways by which nutrient enrichment, un-ionised ammonia or dissolved oxygen levels can directly affect the breeding seabird, non-breeding red throated diver or harbour porpoise features.

Indirect effects

Nutrient enrichment from SZC alone, or SZC and SZB in combination, will not be sufficient to increase phytoplankton production to the extent that there is an increase in turbidity. Consequently, there will be no indirect effects on the seabird or harbour porpoise features due to nutrient enrichment resulting from the operation of SZC alone, or from SZC and SZB in combination.

Seabird and harbour porpoise features may be indirectly affected if:

- nutrient enrichment results in increased phytoplankton production, increasing turbidity (reducing visibility for visual predators) and potentially affecting biological communities
- levels of un-ionised ammonia or dissolved oxygen altered biological communities or caused avoidance behaviour in prey species, leading to reduced prey availability

For nutrient enrichment, based on the upper 95% confidence interval of the mean of our 'reasonable worst-case with invertebrates' scenario, nutrient input from SZC alone, is not expected to exceed 20.4kg of P per day, and 142.9kg of N (Table 8).

The applicant modelled the effect of phosphate and nitrates discharged from SZC alone on phytoplankton productivity, concluding that while there may be an increase in local phytoplankton productivity, the effect of discharged nutrients would be more than offset by entrainment mortality (section 6.3.4).

Our reasonable worst-case scenario for impingement calculates a daily input of N from the FRR system discharge of around 4 times the amount of N input used by the applicant in its modelling assessment, but this higher level of input would also have a negligible impact on phytoplankton growth (section 6.3.4).

In addition to N released into the environment as a result of the decomposition of dead biota from the FRR systems, the decay of hydrazine will also release N to the environment. However, the volumes released will not result in any impact on phytoplankton growth (section 6.3.4).

Un-ionised ammonia resulting from biota discharged from the FRR systems of SZC alone, or SZC and SZB in combination will not be sufficiently concentrated to result in avoidance behaviour by prey species. Consequently, there will be no indirect effects on seabird or harbour porpoise features resulting from un-ionised ammonia levels due to nutrient enrichment from the operation of SZC alone, or from SZC and SZB in combination.

Un-ionised ammonia can be toxic to the fish prey of seabirds and harbour porpoise. However, only 428.3m² (with thermal uplift) is required to dilute the un-ionised ammonia (NH_4) resulting from the FRR system discharge of SZC alone, to its EQS of 21µg/l (as an annual mean), with the equivalent figure for SZC and SZB being 613.9m² (Table 8). This does not mean that fish will encounter an area of exceedance of these dimensions. The actual area of exceedance, if any, will be much smaller as biota are discharged throughout the day and night from 2 outlets (for SZC alone), rather than over one short time period, and all in a single location. Discharges from SZB and SZC outlets will be further dispersed again. Biota will also be dispersed away from the outlets, with a proportion consumed by scavengers, rather than all settling in one place. The particle tracking modelling indicated sprat-like particles may disperse over an area of up to 32.7km² (NNB GenCo, 2020g; TR520). Furthermore, the discharge is taking place in a tidal environment, with a flow of water moving past the discharge points with the tides. The surface area of water required to dilute the un-ionised ammonia (NH_3) resulting from the FRR discharge of SZC alone to its EQS value is slightly below 0.001% of the tidal excursion (43.6km²) (NNB GenCo, 2020b; TR306). For SZC and SZB in combination, the figure is 0.001% (the tidal excursion being the horizontal area over which a particle would be transported through the ebb and flow of a tidal cycle).

The EQS of 21µg/l (as an annual mean) is itself precautionary when it comes to assessing toxic effects on fish. Environment Canada (2010) reports that freshwater rainbow trout (Oncorhynchus mykiss) were tested for sensitivity to un-ionised ammonia (NH_3) concentrations ranging from 0.01 to 0.07mg/l (10 to 70µg/l), with pathological lesions in the gills and extensive tissue degradation in the kidneys being directly correlated with ammonia concentrations above 0.04mg/l (40µg/l), after 4 months of exposure.

While fish can be harmed by un-ionised ammonia and would be expected to avoid exposure to this chemical, the concentrations potentially being released by the FRR system discharge of SZC alone, and SZC and SZB in combination will not be great enough to cause fish avoidance behaviour at such a level that seabird features would be affected. Similarly, the harbour porpoise feature of the Southern North Sea SAC would also not be affected. Furthermore, due to the size of the Southern North Sea SAC, were fish prey to be displaced from around the outlets, they would still remain within the SAC and still be available to harbour porpoises.

Any reduction in dissolved oxygen levels caused by biota discharged from the FRR systems of SZC alone, or SZC and SZB in combination will not be sufficient to result in avoidance behaviour by prey species. Consequently, there will be no indirect effects on seabird or harbour porpoise features resulting from changes in dissolved oxygen levels caused by nutrient enrichment from SZC alone, or from SZC and SZB in combination.

The surface area required to meet the daily oxygen demand of the discharge from the FRR system of SZC alone was calculated as being 1.056km², with the corresponding figure being 1.514km² for SZC and SZB (Table 8). As with un-ionised ammonia, this does not mean that seabird prey species will encounter a de-oxygenated area of this size. The actual areas over which effects on oxygen levels occur will be smaller due to the continuous discharge of biota, from 2 separate outlets, the dispersal of that biota away from the outlets, the consumption of a proportion by scavengers and the tidal movement of water past the outlets. The surface area of water required to meet the daily oxygen demand of the discharge from the FRR system of SZC alone (1.056km²) is just 2.4% of the tidal excursion (43.6km²) (NNB GenCo, 2020b; TR306) and for SZC and SZB in combination, the figure is 3.5%, meaning that the daily oxygen demand can be met without affecting the distribution of prey fish.

8.4. Lesser black-backed gull (breeding)

By reference to its mean maximum + standard deviation foraging range (236km) the following sites with breeding lesser black-backed gull as a qualifying feature have been identified by the applicant and considered appropriate for assessment:

- Alde-Ore Estuary SPA
- Alde-Ore Estuary Ramsar

The information sheet on Ramsar wetlands for the Alde-Ore Estuary Ramsar (available via jncc.gov.uk) lists lesser black-backed gull under Ramsar criterion 6 – species/populations occurring at levels of international importance.

An ecological narrative for the feature is given in Environment Agency (2022c; Annex 3).

The following appropriate assessment will assess the potential for an adverse effect alone on the integrity of the listed sites from direct and indirect effects on breeding lesser black-backed gull, resulting from the cooling water system and FRR system discharges.

8.4.1. Designated sites

The applicant considered that breeding lesser black-backed gull were present in the Alde-Ore Estuary SPA and Ramsar from April to August (NNB GenCo, 2021b; shadow HRA), based on the work of Furness (2015). NE's Senior Specialist in Marine Ornithology confirmed that these months were appropriate for use in our HRAR (NE's Senior Specialist in Marine Ornithology email 2021, personal communication, 9 November).

The information that the applicant provided to support the HRAR (NNB GenCo, 2021b; shadow HRA), and NE's supplementary advice on conservation objectives tell us that:

- Orfordness has historically been the primary breeding colony in the Alde-Ore Estuary SPA (section 8.4.2). This assessment will be carried out using foraging ranges centred on the Orfordness colony location (Table 29). In order to provide a high-level perspective of how percentage overlap may vary with colony location, the assessment will also refer to foraging ranges centred on the closest coastal point to the SZC main development site within the Alde-Ore Estuary SPA (Table 29). The closest coastal point is around 4.5km to the north of the Orfordness colony.

Currently, the main nesting areas are on Havergate Island, but this is further from the main development site and so use of the Orfordness and closest coastal point locations is precautionary

Table 29: National Grid references for the Orfordness lesser black-backed gull colony, together with the closest coastal point to the SZC main development site, within the Alde-Ore Estuary SPA (and Ramsar)

Colony location	Colony grid reference (NGR)
Orfordness	TM454512
Closest coastal point	TM46375559

8.4.2. Species condition summary

As part of the assessment, we will consider the status of the qualifying features of the site, the site condition and the prevailing environmental conditions. We will also consider any threats or degradations of the species and its supporting habitats for the designated sites.

The information that the applicant provided to support the HRAR (NNB GenCo, 2021b; shadow HRA), and NE's supplementary advice on conservation objectives (Marine site detail (naturalengland.org.uk)) tell us that:

- at the time of the site designation in 1996, the SPA population was estimated as 14,070 breeding pairs, representing 12% of the British population and 8% of the world population of the graellsii race, which breeds from Iceland to Portugal and winters to West Africa (Avibase - The World Bird Database). A peak population size of 23,400 pairs was recorded in 2000, since when numbers have reduced substantially and significantly below the target. The mean population estimate for the SPA from 2012 to 2016 is 1,963 pairs and for 2011 to 2015 peak mean counts are 1,940 breeding pairs (Marine site detail (naturalengland.org.uk))
- Although qualifying as a breeding species and recognised to be largely migratory, small numbers of lesser black-backed gull remain in the area over winter. During winter surveys (for red-throated divers and cormorants) the applicant has recorded them commuting, foraging and loafing
- historically, the primary breeding colony in the SPA was on Lantern Marshes at Orfordness (approximately 12.5km south of the main development site) – this is the site used as the 'colony location' in our assessment. Numbers at this colony increased to a peak of approximately 23,000 pairs in the early

2000s, but have decreased substantially since then, with around 550 to 640 pairs during the period 2010 to 2012. The main nesting areas are now on Havergate Island (approximately 17km south of the main development site). Between 2000 and 2007 the number of occupied nests at Havergate Island was around 200 to 800, but since 2008 the number of occupied nests has been over 1,000, with as many as 2,399 in 2015

Due to its extensive foraging range, shore-based surveys are of limited value in determining the key main areas used by lesser black-backed gull. However, vantage point surveys conducted by the applicant from 12 locations along the coastline near Sizewell recorded lesser black-backed gulls resting or foraging at all vantage points. Small groups (fewer than 50 individuals) were seen loafing around the outlets at Sizewell A and B. Large numbers of gulls were reported commuting throughout the area, probably travelling offshore or inland to forage.

8.4.3. Conservation objectives

Links to the full conservation objectives for the SPAs identified here are provided in (Environment Agency, 2022b; Annex 2). The appropriate assessment will be concluded against the relevant conservation objectives provided. The conservation objectives for the SPAs will be used when concluding the assessment for the respective Ramsar site.

8.4.4. Supporting habitats

Thermal and chemical plumes from SZC do not extend into the Alde-Ore Estuary SPA itself (see ‘Alde-Ore Estuary SPA’ sub-section in ‘Discussion of risks for each site’ within the ‘Appropriate assessment’ chapter). The source-receptor pathway for lesser black-backed gulls therefore occurs when they are foraging or loafing within the Outer Thames Estuary SPA. Supporting habitats of importance for lesser black-backed gull in the Outer Thames Estuary SPA include:

- intertidal sand and muddy sand
- intertidal mixed sediments
- intertidal mud
- intertidal rock
- water column

8.4.5. Discussion

Risks carried through to appropriate assessment for the breeding lesser black-backed gull feature of the Alde-Ore SPA are as follows:

- change in thermal regime
- toxic contamination (chemical)
- nutrient enrichment

Change in thermal regime

Absolute water temperatures

There is no potential for lesser black-backed gull to be directly harmed by elevated water temperatures when SZC is operating alone, or when SZC and SZB are operating in combination (section 8.3.1).

Thermal uplift

There is no potential for an adverse effect on lesser black-backed gull of the Alde-Ore Estuary SPA through thermal uplift from SZC alone, or SZC and SZB in combination.

Due to the extensive range of lesser black-backed gull, the overlap between its mean foraging area and the ≥3°C thermal uplift (98th percentile) plume is not of sufficient scale to adversely affect the feature, being below 1% for SZB, SZC and SZC and SZB in combination, whether foraging areas are centred on the Orfordness colony or the closest coastal point (Table 19). Although not calculated, overlaps between the 3°C thermal uplift (98th percentile) and foraging ranges centred on the Havergate colony would show no meaningful difference from the values presented in Table 19. Plotting foraging areas and thermal uplift plumes onto maps illustrates the low potential for impact from thermal uplift (Figure 19, Figure 20).

Lesser black-backed gulls are generalist feeders, foraging in terrestrial as well as marine environments. This further reduces any risk of indirect effects of thermal uplift on lesser black-backed gulls through prey fish avoidance behaviour.

Lesser black-backed gulls have been recorded loafing in the Outer Thames Estuary SPA, but even if the birds were deterred from loafing in warmer water, this would be unlikely to constitute significant disturbance, with a variety of terrestrial and estuarine locations, unaffected by thermal uplift, also being available as loafing areas.

Toxic contamination (chemical)

Direct effects

There are no direct effects of toxic contamination (chemical) on the breeding lesser black-backed gull feature of the Alde-Ore Estuary SPA, from either SZC alone, or SZC and SZB in combination. This is due to the very low proportion of the foraging area within which EQS or PNEC values are exceeded for TRO, bromoform or hydrazine.

None of the overlaps between the mean foraging area (centred on the Orfordness colony or closest coastal point) and either the TRO, bromoform, chronic hydrazine or acute hydrazine exceedance plumes are above 1% (Table 19).

The mean foraging area is used as a proxy for areas of concentrated foraging, closer to the colony. However, seabirds do not have an equal probability of foraging at any point within the defined area. Due to their recorded feeding on fishery discards, the FRR system outfalls might prove attractive to lesser black-backed gulls. However, in the event that the FRR system outfalls did become a preferential foraging area for lesser black-backed gulls, these lie outside of the mixing zones for TRO, bromoform and hydrazine from SZC alone and concentrations are therefore below EQS or PNEC thresholds. The potential for the FRR system outlets to be attractive to lesser black-backed gulls is discussed further in section 9.5.3, with regard to the potential for an in-combination effect between SZC and toxic contamination from the SZB cooling water outlet, when SZC and SZB are both operating.

The discharge plume from the SZC cooling water outlets is unlikely to be attractive to seabirds due to its depth and the absence of a concentration of food (section 8.1).

Indirect effects

There are no indirect effects of toxic contamination (chemical) on the breeding lesser black-backed gull feature of the Alde-Ore Estuary SPA, from either SZC alone, or SZC and SZB in combination. This is due to the very low proportion of the foraging area within which EQS or PNEC values are exceeded for TRO, bromoform or hydrazine (Table 19, section 8.3.2).

There is no potential for bioaccumulation of TRO, bromoform or hydrazine to affect the breeding seabird feature (section 8.3.2).

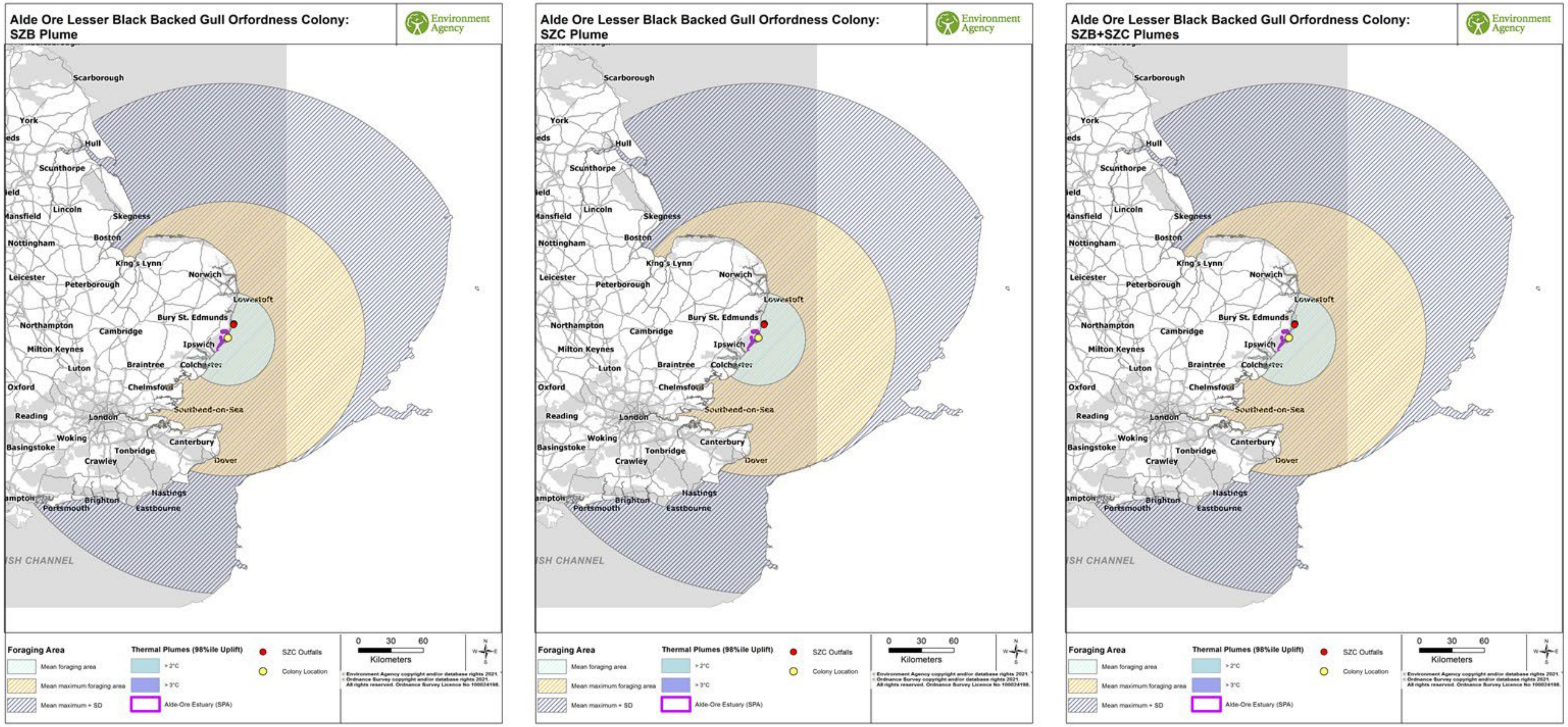

Figure 19: Mean, mean maximum, and mean maximum + SD foraging areas for breeding lesser black-backed gull centred on the Orfordness colony in the Alde-Ore Estuary SPA together with the ≥2°C and ≥3°C thermal uplift (98th percentile) plumes for SZB alone, SZC alone, and SZC and SZB in combination, as calculated by the applicant. Although plotted, the thermal plumes are not visible due to their small size relative to the foraging areas of the breeding seabird feature

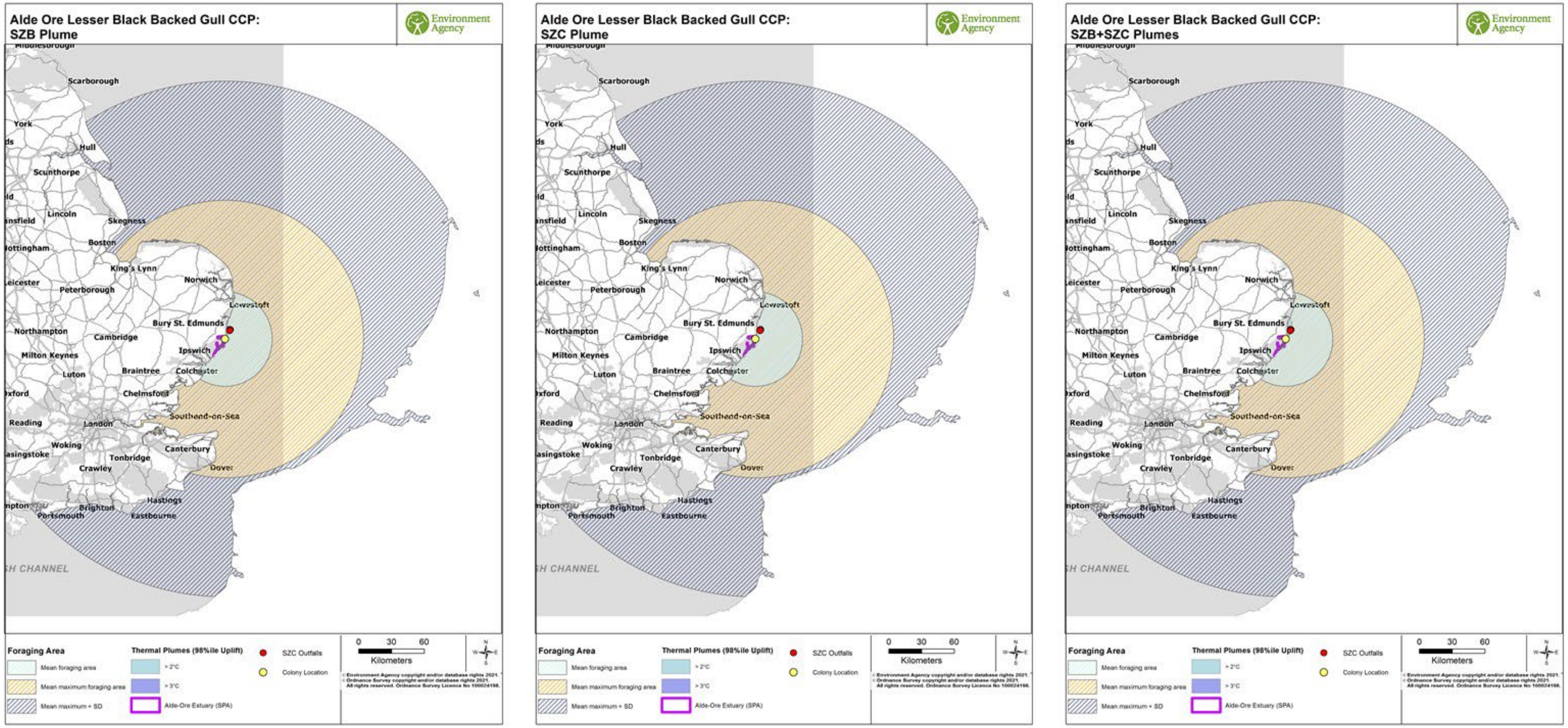

Figure 20: Mean, mean maximum, and mean maximum + SD foraging areas for breeding lesser black-backed gull centred on the closest coastal point to the main development site within the Alde-Ore Estuary SPA, together with the ≥2°C and ≥3°C thermal uplift (98th percentile) plumes for SZB alone, SZC alone, and SZC and SZB in combination, as calculated by the applicant. Although plotted, the thermal plumes are not visible due to their small size relative to the foraging areas of the breeding seabird feature

Changes in nutrients/eutrophication

Direct effects

There are no source-receptor pathways by which organic or nutrient enrichment from SZC alone, or SZB and SZC in combination, can directly affect breeding seabird features (section 8.3.3).

Indirect effects

There are no indirect effects of organic enrichment on the breeding lesser black-backed gull feature of the Alde-Ore Estuary SPA, from either SZC alone, or SZC and SZB in combination (section 8.3.3).

Changes in nutrient enrichment, un-ionised ammonia and dissolved oxygen levels resulting from the operation of SZC alone, or SZC and SZB in combination, will not lead to any indirect effects on breeding seabird features (section 8.3.3).

Supporting habitats

There will be no adverse effects on the supporting habitats of Alde-Ore Estuary lesser black-backed gull feeding in the Outer Thames Estuary SPA as a result of the operation of SZC alone, or SZC and SZB in combination.

Intertidal habitats are primarily used for resting/loafing when the tide is out. Foraging may occur in this habitat at low tide. However, given the generalist nature of the lesser black-backed gulls' diet and their extensive foraging range, this will form only one potential foraging area for these wide-ranging birds. Generally, any effects on the intertidal supporting habitats will only occur when the tide is in. The water discharge activities of SZC alone, or SZC and SZB in combination will not affect the ability of the intertidal sand and muddy sand habitat, the intertidal mixed sediments habitat, the intertidal mud habitat or the intertidal rock habitat to support breeding lesser black-backed gulls.

Foraging takes place in the water column supporting habitat, but given the wide-ranging behaviour of breeding lesser black-backed gulls, any effects on the water column of the Outer Thames Estuary SPA will not adversely affect the breeding seabird feature (Table 30).

Table 30: The sensitivities of the water column supporting habitat for Alde-Ore Estuary SPA lesser black-backed gull foraging in the Outer Thames Estuary SPA, as described in NE Advice on Operations, together with the expected effects as a result of SZC alone, and SZC and SZB

Pressure (from NE advice on operations)	Supporting habitat	Sensitivity	Effect of SZC alone	Effect of SZC and SZB
Increases in temperature	Water column	Sensitive	No effect. While thermal uplift may potentially affect the water column within the Outer Thames Estuary SPA, breeding lesser black-backed gull will be unaffected due to the uplift forming such a small percentage of their potential foraging area (Table 19). The generalist diet of lesser black-backed gulls also means that they are not solely reliant upon the water column supporting habitat for food.	No effect. As for SZC alone.
Other substances (solid, liquid or gas)	Water column	Not assessed	No effect. Lesser black-backed gulls foraging from colonies within the Alde-Ore Estuary SPA would encounter some areas of TRO, bromoform and hydrazine exceedance. However, the area affected is a small percentage of the foraging area of breeding lesser black-backed gull (Table 19) and so the feature will be unaffected.	No effect. As for SZC alone.
Nutrient enrichment	Water column	Sensitive	No effect. Nutrient enrichment, from SZC alone, will be insufficient to lead to opportunistic macroalgal or phytoplankton blooms, and the ability of the water column habitat to support the foraging behaviour of the breeding lesser black-backed gull feature will be unaffected.	No effect. As for SZC alone.

Pressure (from NE advice on operations)	Supporting habitat	Sensitivity	Effect of SZC alone	Effect of SZC and SZB
Changes in suspended solids (water clarity)	Water column	Sensitive	No effect. There is no potential for nutrient enrichment to increase turbidity and the ability of the water column habitat to support the foraging behaviour of breeding lesser black-backed gull feature will be unaffected.	No effect. As for SZC alone.

8.4.6. Conclusion

We have considered the relevant risks associated with the discharges, from SZC alone, and from SZC and SZB in combination, that are the subject of this application, on the lesser black-backed gull (breeding) feature of the Alde-Ore Estuary SPA, in light of the designated sites' conservation objectives and supplementary advice on conservation objectives (Table 31).

Despite the considerable decline in numbers of breeding pairs since the site was designated (from >14,000 to <2,000 breeding pairs), the scale of impacts from the discharges from the cooling water system and the FRR system, compared to the foraging range and generalist diet of the feature, allows us to conclude that there will be **no adverse effect** on this qualifying feature from the water discharge activities of SZC alone, in terms of maintaining or restoring the:

- extent and distribution of the habitats of the qualifying features
- structure and function of the habitats of the qualifying features
- supporting processes on which the habitats of the qualifying features rely
- populations of each of the qualifying features
- distribution of qualifying features within the site

SZB is expected to continue to operate until 2035, although there is potential for an extension of SZB's operational lifetime by 20 years to 2055 at the latest. Consequently, SZC and SZB may be operating in combination for between 2 and 22 years. However, the scale of impacts from the discharges from the cooling water system and the FRR system compared to the foraging range and generalist diet of the breeding lesser black-backed gull feature are such that (irrespective of the decommissioning date of SZB) we conclude that there will be **no adverse effect** on this qualifying feature from the water discharge activities of SZC and SZB in combination, in terms of maintaining or restoring the:

- extent and distribution of the habitats of the qualifying features
- structure and function of the habitats of the qualifying features
- supporting processes on which the habitats of the qualifying features rely
- populations of each of the qualifying features
- distribution of qualifying features within the site

Following the conclusion of no adverse effect on the breeding lesser black-backed gull feature of the Alde-Ore Estuary SPA, we further conclude that the justification of the Alde-Ore Estuary Ramsar will be unaffected by the water discharge activities of SZC alone or SZC and SZB in combination. These activities will not adversely affect the site's ability to support lesser black-backed gull during the breeding season at levels of international importance (Ramsar criterion 6).

Table 31: The outcome of the appropriate assessment of the impact of water discharge activities from the operation of SZC alone, and SZC and SZB in combination, on targets contained within Natural England's Supplementary Advice on Conservation Objectives for the breeding lesser black-backed gull feature of the Alde-Ore Estuary SPA (the table only shows targets which may be affected by water discharge activities)

Attribute	Sub-attribute	Target	Outcome of SZC alone assessment	Outcome of SZC and SZB assessment
Breeding population	Abundance	Restore the size of the breeding population to a level which is above 14,074, while avoiding deterioration from its current level as indicated by the latest mean peak count or equivalent.	None of the attributes below will be adversely affected and so there will be no effect on abundance of the breeding lesser black-backed gull feature.	As for SZC alone.
Connectivity with supporting habitats	Connectivity with supporting habitats	Maintain safe passage of birds moving between nesting, roosting, and feeding areas.	There are no physical obstructions to safe passage associated with the WDA permit. Absolute water temperature and chemical plumes would have no direct effect, but there is also very little overlap between thermal and chemical plumes and the foraging area of breeding lesser black-backed gulls in the Alde-Ore SPA.	As for SZC alone.
Supporting habitat	Extent and distribution of supporting habitat for the breeding season	Maintain the extent, distribution, and availability of suitable habitat (either within or outside the site boundary) which supports the feature for all necessary stages of its breeding cycle (courtship, nesting, feeding).	There will be no effect on the ability of suitable habitats to support breeding lesser black-backed gulls.	As for SZC alone.

Attribute	Sub-attribute	Target	Outcome of SZC alone assessment	Outcome of SZC and SZB assessment
Supporting habitat	Food availability	Maintain the distribution, abundance and availability of key main food and prey items (for example, voles, small seabirds, waders, sandeel, sprat, cod, herring, roach, rudd, beetles, flies, earthworm, shellfish) at preferred sizes.	Due to the small proportion of the foraging area experiencing thermal uplift or chemical exceedance, the distribution, abundance and availability of key main marine food and prey items of lesser black-backed gull will be maintained. There is no source-receptor pathway by which terrestrial or freshwater prey can be affected.	As for SZC alone.
Water quality	Contaminants	Reduce aqueous contaminants to levels equating to high status according to Annex VIII and good status according to Annex X of the Water Framework Directive, avoiding deterioration from existing levels.	There will be mixing zones in which the EQS/ PNEC values for TRO, bromoform and hydrazine will be exceeded. However, these will not be large enough to result in deterioration in water quality at a scale which will affect the breeding lesser black-backed gull feature. The decay of biota discharged by the FRR system will not lead to the release of un-ionised ammonia to the extent that there will be a deterioration in water quality that will affect the breeding lesser black-backed gull feature.	As for SZC alone.

Attribute	Sub-attribute	Target	Outcome of SZC alone assessment	Outcome of SZC and SZB assessment
Water quality	Dissolved oxygen (DO)	Maintain the DO concentration at levels equating to high ecological status, avoiding deterioration from existing levels.	The decay of biota discharged by the FRR system will not lead to a deterioration from existing levels of DO concentration.	
Water quality	Nutrients	Maintain water quality at mean winter dissolved inorganic nitrogen levels where biological indicators of eutrophication (opportunistic macroalgal and phytoplankton blooms) do not affect the integrity of the site and features avoiding deterioration from existing levels.	Discharges from the cooling water system and FRR system will not lead to increases in dissolved inorganic nitrogen levels to the extent that indicators of eutrophication affect the integrity of the site.	As for SZC alone.
Water quality	Turbidity	Maintain natural levels of turbidity (for example, concentrations of suspended sediment, plankton and other material) across the habitat.	Organic enrichment will not lead to any increase in turbidity.	As for SZC alone.

8.5. Sandwich tern (breeding)

By reference to its mean maximum + standard deviation foraging range (57.5km), the following site with breeding Sandwich tern as a qualifying feature has been identified by the applicant and considered appropriate for assessment:

- Alde-Ore Estuary SPA

An ecological narrative for the feature is given in Environment Agency (2022c; Annex 3).

The following appropriate assessment will assess the potential for an adverse effect alone on the integrity of the sites listed above from direct and indirect effects on breeding Sandwich tern, resulting from the cooling water and FRR discharges.

8.5.1. Designated sites

The applicant considered that breeding Sandwich tern were present in the Alde-Ore Estuary SPA from April to August (NNB GenCo, 2021b; shadow HRA), based on the work of Furness (2015). NE's Senior Specialist in Marine Ornithology confirmed that these months were appropriate for use in our HRAR (email dated 9 November, 2021).

The information that the applicant provided to support the HRAR (NNB GenCo, 2021b; shadow HRA), and NE's supplementary advice on conservation objectives tell us that:

- Sandwich terns have been recorded as nesting in the SPA since 1986, primarily at Havergate Island (approximately 17km south along the coast from the main development site redline boundary) where historically there were large aggregations of over 100 birds. However, the colony disappeared in 1997 and since then nesting has only occurred sporadically. The last recorded successful breeding at Havergate Island was in 2004

The applicant supplied information based on foraging areas centred on the Orfordness seabird colony location (Table 32). In order to provide a high-level perspective of how percentage overlap may vary with colony location, this assessment will also refer to foraging ranges centred on the closest coastal point to the SZC main development site, within the Alde-Ore Estuary SPA (Table 32). The closest coastal point is around 4.5km to the north of the Orfordness colony.

Although Sandwich tern have been historically recorded breeding on Havergate Island, which is around 4km to the south-west of the Orfordness seabird colony, the closer the colony is to the SZC cooling water and FRR system outlets, the greater is the potential for overlap with SZC discharge plumes. Considering the overlaps with

SZC discharge plumes, whether or not Sandwich tern should establish a colony at Orfordness or at the closest coastal point is therefore precautionary.

Table 32: National Grid references for a putative Orfordness Sandwich tern colony, together with the closest coastal point to the SZC main development site, within the Alde-Ore Estuary SPA

Colony location	Colony grid reference (NGR)
Orfordness	TM454512
Closest coastal point	TM46375559

8.5.2. Species condition summary

As part of the assessment, we will consider the status of the qualifying features of the site, the site condition and the prevailing environmental conditions. We will also consider any threats or degradations of the species and its supporting habitats for the designated sites.

The information that the applicant provided to support the HRAR (NNB GenCo, 2021b; shadow HRA), and NE's supplementary advice on conservation objectives (Marine site detail (naturalengland.org.uk)) tell us that:

- the SPA's qualifying population of 170 pairs of Sandwich terns constituted 0.1% of the biogeographical (Western Europe/Western Africa) population and 1.2% of the national population. Numbers declined from between 100 to 300 breeding pairs (1993 to 1996) to generally less than 10, and often no breeding pairs per year from 1997 to 2009, with a maximum of 15 pairs in this latter period (2003)

- numbers of pairs attempting to breed fluctuates due to the tendency for mass movements between colonies. A relatively high number of breeding pairs is no guarantee of the colony's success in a particular year. There have been years of complete breeding failure, when Sandwich terns have attempted to breed, notably in 1995 when 250 occupied nests were abandoned, but also more recently in 2005 and 2009. Since 2009, there have been no breeding pairs recorded in the SPA and Sandwich terns have not successfully bred within the SPA since 2004. However, birds are known to 'loaf' in the area towards the end of the breeding season

- given a decline in both breeding numbers and productivity since designation, the breeding population within the SPA has been given a restore objective by Natural England

- surveys carried out between April 2011 and April 2012 (commissioned by the applicant) recorded Sandwich tern sightings at 12 vantage points along the coastline between approximately 0.5km north of the main development site and Orfordness, within the SPA, approximately 2.5km east of Havergate Island. The peak period for observations was July to September, coinciding with the likely occurrence of birds on passage

- during the 2011 to 2012 surveys, small numbers of Sandwich terns were seen foraging offshore or commuting along the coastline, both close inshore and more than 1 to 2 km offshore. Although generally in small groups of one to two birds, occasional groups of up to 10 individuals were seen during peak times in July and August. The favoured feeding areas were over the shallow coastal waters near to the SPA and near to Thorpeness, while resting birds were recorded on lagoons within the SPA and at Slaughden. Sandwich tern activities were also recorded during bi-monthly surveys between May and August 2013 at 15 vantage points along the coastline (12 used in the 2011 surveys plus a further 3 located further north extending coverage up to Dunwich, approximately 6km north of the main development site and approximately 15km north of Alde-Ore Estuary SPA)

- observation of feeding areas over the shallow coastal waters are consistent with the supplementary advice on conservation objectives (Marine site detail (naturalengland.org.uk)), which notes that 'Sandwich tern feed in the shallow waters along the shingle beaches of Orfordness and Havergate'

8.5.3. Conservation objective

Links to the full conservation objectives for the SPAs identified here are provided in Environment Agency (2022b; Annex 2). The appropriate assessment will be concluded against the relevant conservation objectives provided.

8.5.4. Supporting habitats

Thermal and chemical plumes from SZC do not extend into the Alde-Ore Estuary itself (section 7.3). The source-receptor pathway for Sandwich terns therefore occurs when they are foraging within the Outer Thames Estuary SPA. Supporting habitats listed for little tern in Outer Thames Estuary SPA (Marine site detail (naturalengland.org.uk)) are:

- intertidal sand and muddy sand
- water column

8.5.5. Discussion

Risks carried through to appropriate assessment for the breeding Sandwich tern feature of the Alde-Ore SPA are as follows:

- change in thermal regime
- toxic contamination (chemical)
- nutrient enrichment

Change in thermal regime

Absolute water temperatures

There is no potential for breeding Sandwich tern to be directly harmed by elevated water temperatures when SZC is operating alone, or when SZC and +SZB are operating in combination (section 8.3.1).

Thermal uplift

There is no potential for an adverse effect on breeding Sandwich tern of the Alde-Ore Estuary SPA through thermal uplift from SZC alone, or SZC and SZB in combination.

For the Orfordness colony location, there is no overlap between the mean foraging area and the 3°C thermal uplift (98^{th} percentile) plume when SZC is operating alone, a reduction from 1.0% overlap the baseline of SZB alone (Table 20, Figure 21). SZC and SZB in combination shows a slight increase on the baseline, at 1.7% (Table 20, Figure 21).

For the closest coastal point, there is a very slight overlap between the mean foraging area and the 3°C thermal uplift (98^{th} percentile) plume when SZC is operating alone (0.3%), a reduction from 4.2% overlap under baseline conditions (SZB alone) (Table 20, Figure 22). SZC and SZB in combination again show a slight increase on the baseline, at 6.4% (Table 20, Figure 22).

There are no set thresholds that indicate what size of overlap may be problematical for breeding seabirds. However, when the overlap between the ‘mean’ foraging area and the 3°C thermal uplift (98th percentile) plume exceeded 1%, further investigation was triggered, and overlaps with instantaneous thermal plumes were examined (Table 20, Figure 23). There is no discernible pattern as to when higher percentage overlaps occur (Figure 24).

The overlap between foraging area and the area of water experiencing >3°C thermal uplift, at any single (hourly) time step of the model, best represents conditions a seabird might encounter if embarking on a foraging trip during that time step.

Although when SZC and SZB are operating in combination, overlaps between the mean foraging areas of Sandwich tern centred on the Orfordness colony and the ≥3°C thermal uplift (98th percentile) plume exceed 1%, there would be no overlap at all with instantaneous ≥3°C thermal uplift plumes for 57% of the hourly periods during the months the breeding seabird feature is present (Figure 23), with the median overlap also being 0% (Q1 = 0.00%, Q3 = 0.13%) (Table 20).

When SZC and SZB are operating in combination, overlaps between the mean foraging areas of Sandwich tern centred on the closest coastal point and the ≥3°C thermal uplift (98th percentile) plume also exceed 1%. However, while there would be no occasions when there was no overlap at all with instantaneous ≥3°C thermal uplift plumes, generally, overlaps are still low, with the median overlap also being 0.81% (Q1 = 0.42%, Q3 = 1.51%) (Figure 23, Table 20).

With SZC and SZB in combination, Sandwich tern would experience slightly higher overlap more often than baseline (SZB alone) for Orfordness and the closest coastal point. However, colonies further south than Orfordness would be less affected, for example, on Havergate Island.

During the applicant's visual surveys, shallow coastal waters near to the Alde-Ore Estuary SPA and near to Thorpeness were recorded as being the favoured feeding areas for Sandwich tern. This tallies with Natural England's supplementary advice on conservation objectives, which notes feeding in shallow waters off Orfordness and Havergate. The Alde-Ore Estuary itself will be unaffected by thermal uplift and so feeding grounds off Havergate island will also be unaffected. The coastal strip to the northern end of the Alde-Ore Estuary SPA, which is currently affected by elevated temperatures from SZB, will continue to be affected when SZC begins operation (Figure 21, Figure 22). However, when SZB and SZC are operating in combination, a considerable proportion of the mean foraging area will be unaffected, with Sandwich terns also able to venture further afield as indicated by their mean maximum and mean maximum and SD foraging ranges (Figure 21, Figure 22).

Sandwich terns can adapt their foraging behaviour in response to environmental conditions. For example, Eglington and Perrow (2014) report that Sandwich terns feed on food sources that are unpredictable in time and space, which may result in variation in specific foraging locations within colonies between years and seasons. There is also evidence that foraging areas may shift in response to changes in weather conditions (Eglington and Perrow, 2014).

Due to the low percentages of mean foraging areas that will be affected by ≥3°C thermal uplift at any one time, the potential for wide-ranging foraging behaviour and flexibility in foraging location, a small increase in frequency of overlap between mean foraging area and the ≥3°C thermal uplift plume, when SZB and SZC will both be operation, will not adversely affect the breeding Sandwich tern feature. Due to the small scale of the increase in frequency of overlap, there will be no adverse effect from thermal uplift resulting from the operation of SZC and SZB in combination, regardless of whether SZB is decommissioned in 2035 or its operational life is extended (potentially to 2055).

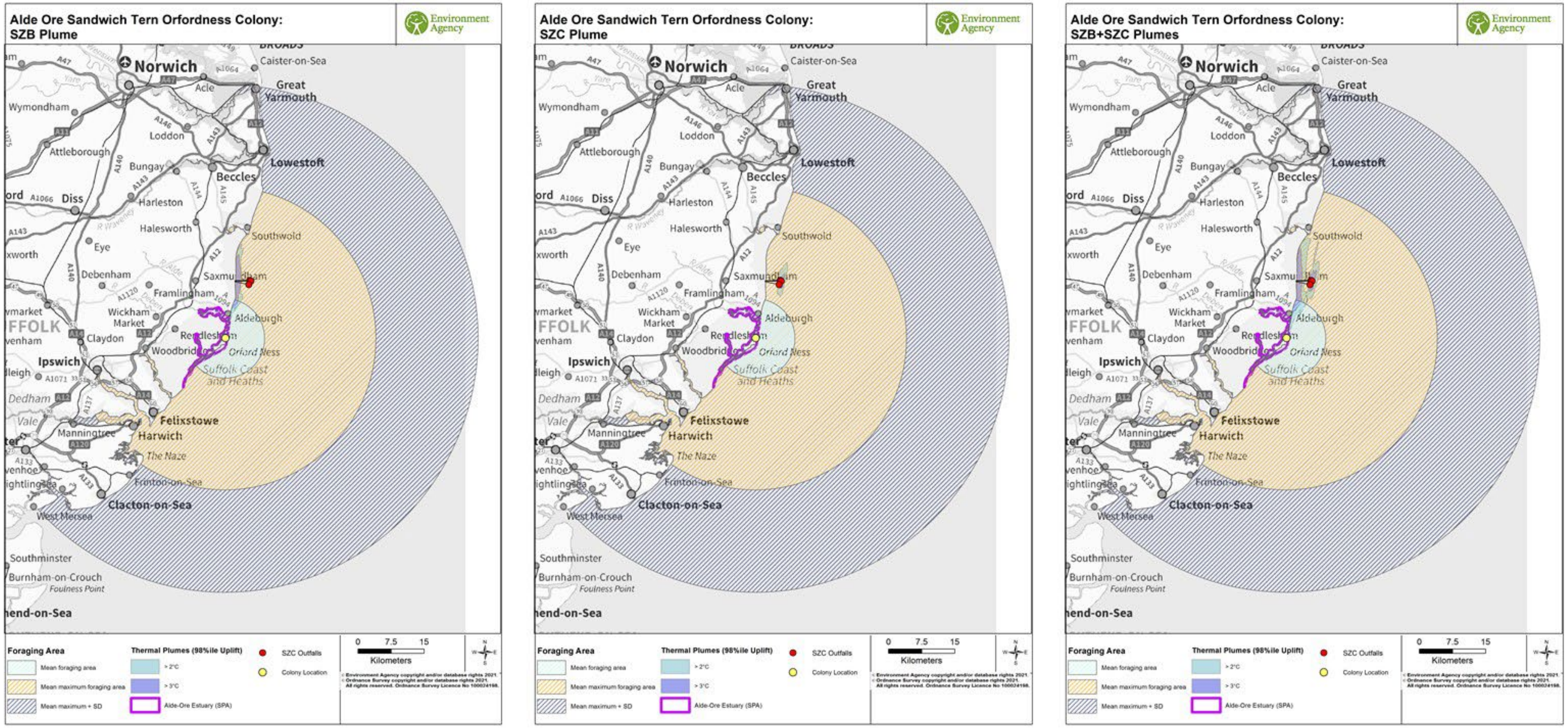

Figure 21: Mean, mean maximum, and mean maximum + SD foraging areas for breeding Sandwich tern centred on the Orfordness colony in the Alde-Ore Estuary SPA, together with the ≥2°C and ≥3°C thermal uplift (98th percentile) plumes for SZB alone, SZC alone, and SZC and SZB in combination, as calculated by the applicant

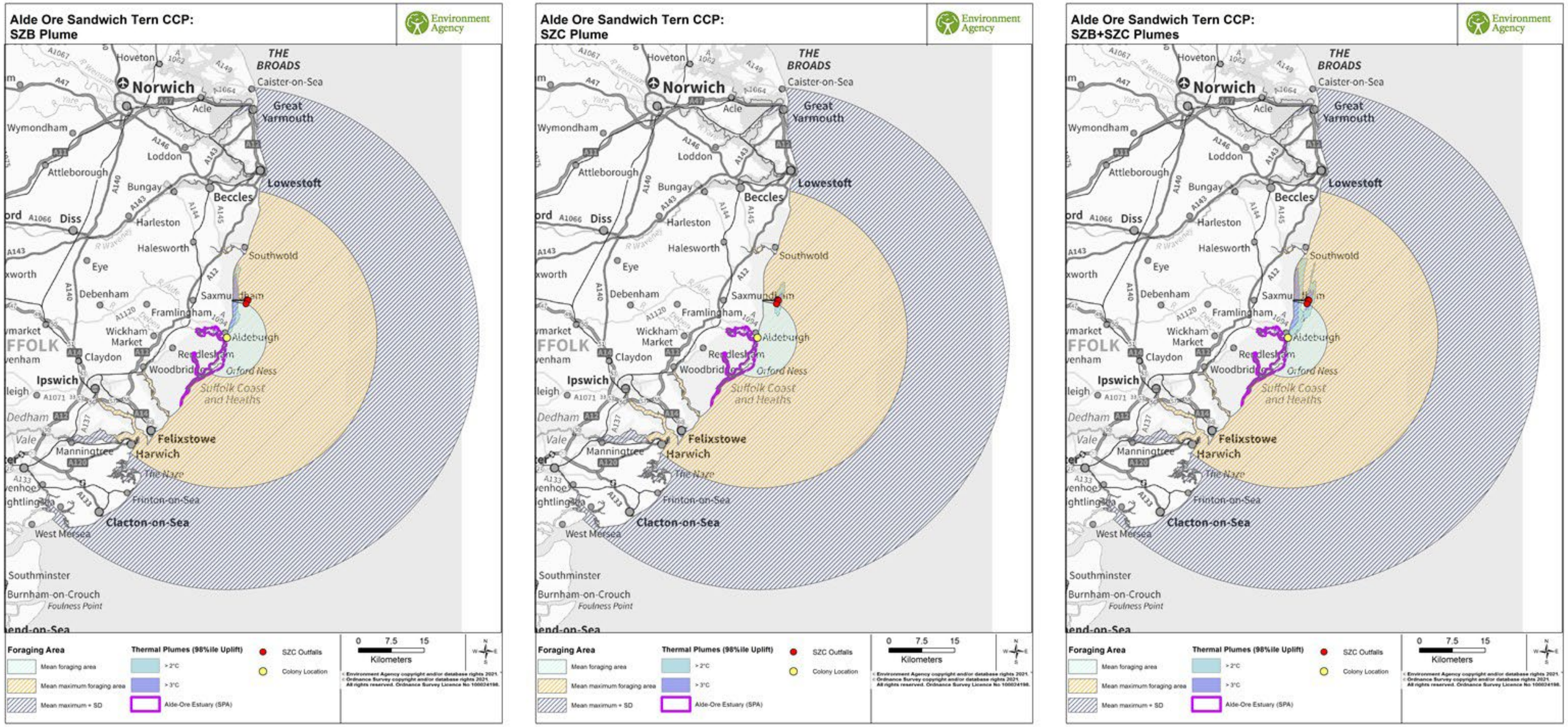

Figure 22: Mean, mean maximum, and mean maximum + SD foraging areas for breeding Sandwich tern centred on the closest coastal point to the SZC main development site within the Alde-Ore Estuary SPA, together with the ≥2°C and ≥3°C thermal uplift (98th percentile) plumes for SZB alone, SZC alone, and SZC and SZB in combination, as calculated by the applicant

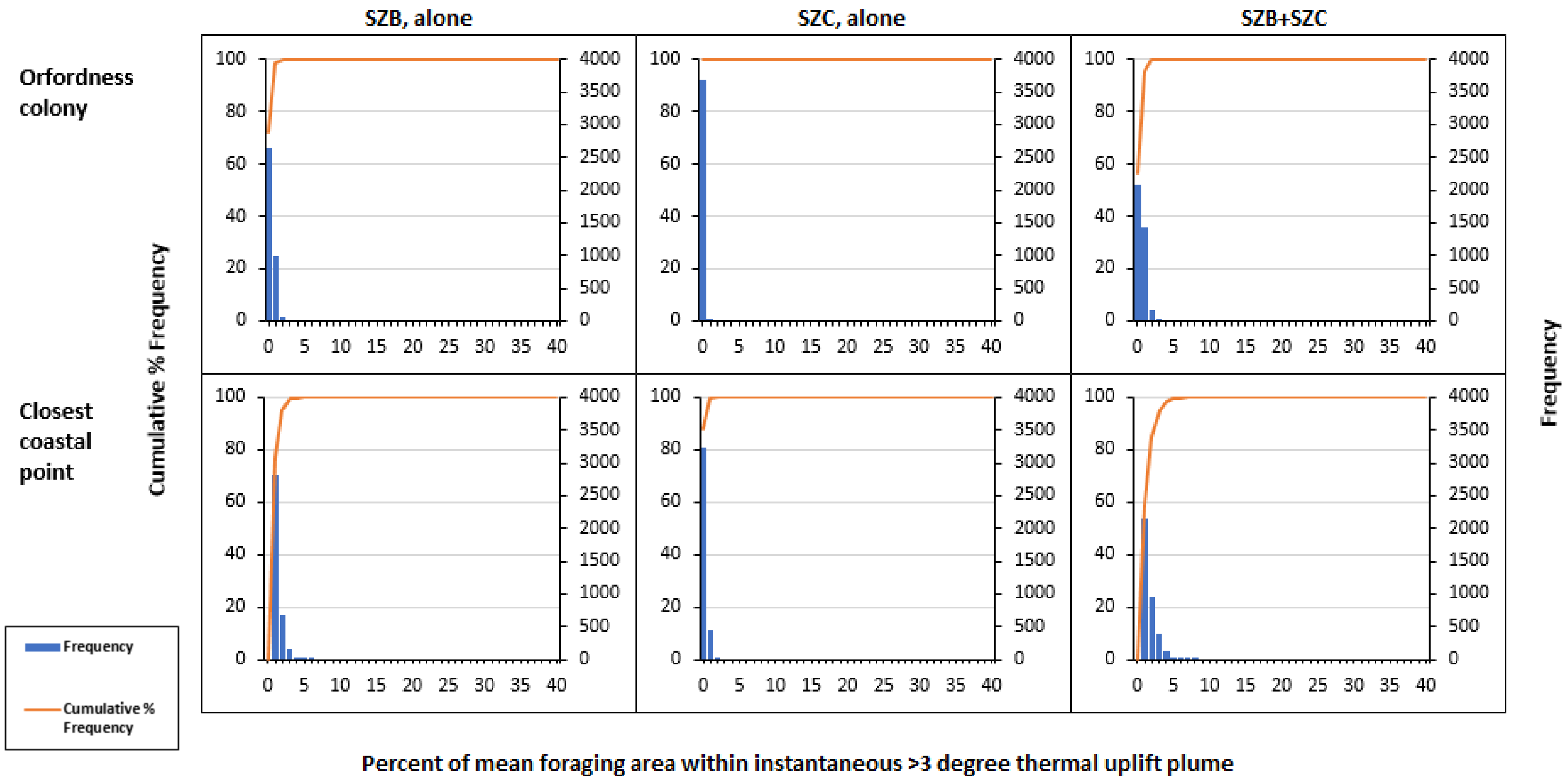

Figure 23: Frequency, and cumulative percentage frequency graphs showing the distribution of percentage overlaps between mean foraging area of Alde-Ore Sandwich terns centred on the Orfordness colony or the closest coastal point, and instantaneous ≥3°C thermal uplift plumes from SZB alone, SZC alone, and SZC and SZB in combination. Although overlap between the mean foraging area and the ≥3°C thermal uplift (98th percentile) plume did not exceed 1% for foraging areas centred on either the Orfordness colony or the closest coastal point when SZC is operating alone, frequency/cumulative percentage frequency graphs are included here for SZC alone, for convenience. Data provided by the applicant

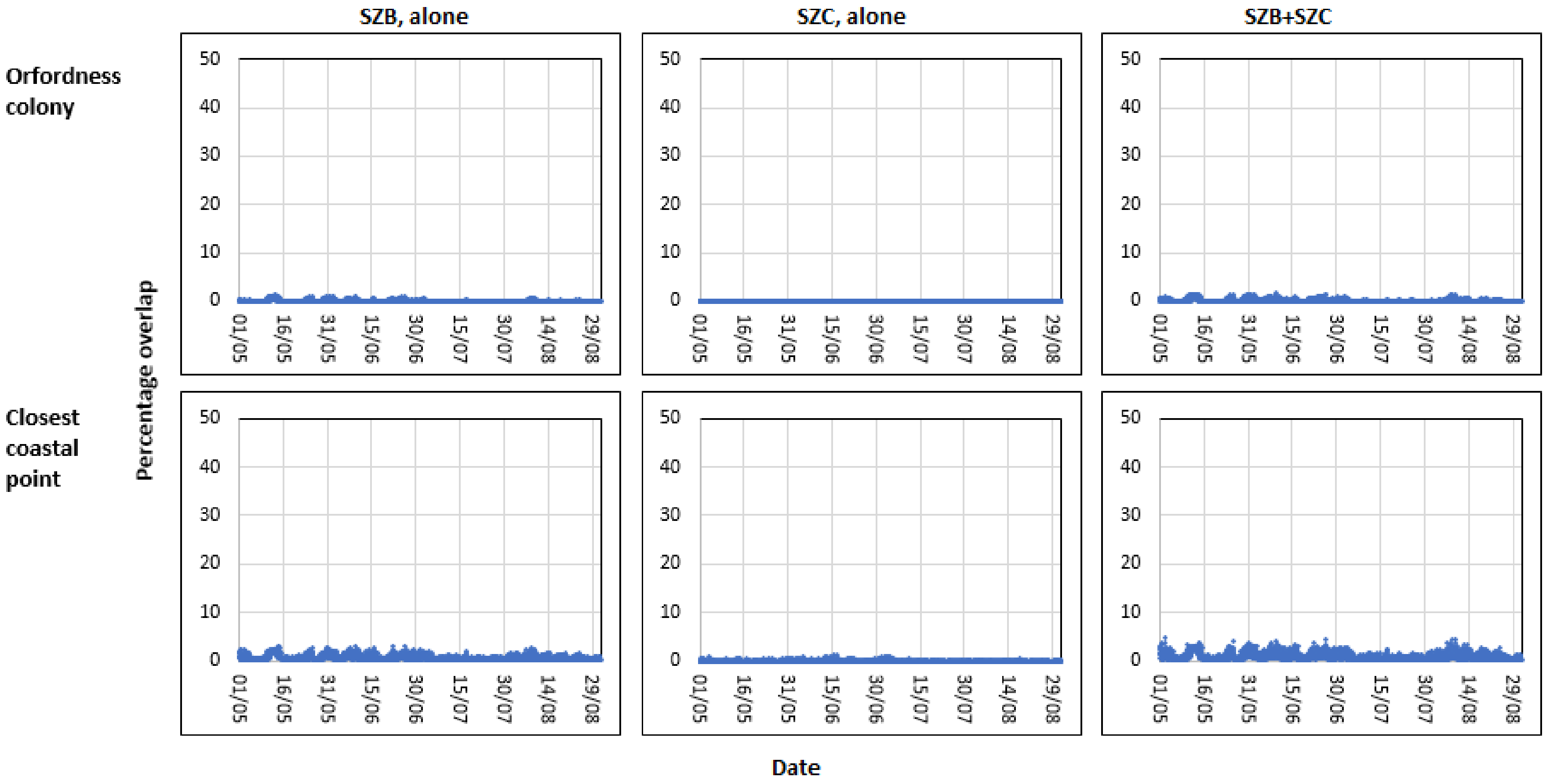

Figure 24: The distribution of percentage overlaps between mean foraging area of Alde-Ore Sandwich terns centred on the Orfordness colony or the closest coastal point, and instantaneous ≥3°C thermal uplift plumes from SZB alone, SZC alone, and SZC and SZB in combination, over the months when the breeding seabird feature is present. Data provided by the applicant

Toxic contamination (chemical)

Direct effects

There will be no direct effects of toxic contamination (chemical) on the breeding Sandwich tern feature of the Alde-Ore Estuary SPA, from either SZC alone, or SZC and SZB in combination.

For SZC alone, there is no overlap between the mean foraging area of Sandwich tern centred on the Orfordness colony and the TRO > EQS 10µg/l (95th percentile) plume, and even when SZB and SZC are both operating together, the overlap is only 0.03% of the foraging range, meaning that the chances of Sandwich terns entering the plume are very low (Table 20).

Similarly, for SZC alone, the overlap between the mean foraging area of Sandwich tern centred on the closest coastal point and the TRO > EQS 10µg/l (95th percentile) plume is just 0.7%, and so there is very little likelihood of the birds entering the plume (Table 20). For SZC and SZB in combination, there is an increase in baseline conditions (1.9%, SZB alone) to 2.6% overlap (Table 20). However, examining overlaps between mean foraging area and instantaneous ≥10µg/l TRO plumes reveals that the percentage of the foraging area experiencing ≥10µg/l TRO is usually low, with around 80% of hourly periods experiencing less than 1% overlap (Q1 = 0.23%, median = 0.61%, Q3 = 0.95%) (Table 20, Figure 25).

For both the Orfordness colony and the closest coastal point, overlaps between mean foraging area and both bromoform ≥ PNEC 5µg/l (95th percentile) and hydrazine plumes are also low, meaning there is low probability of Sandwich terns entering these plumes, which are themselves precautionary with regard to direct effects on seabirds.

Indirect effects

There are no indirect effects of toxic contamination (chemical) on the breeding Sandwich tern feature of the Alde-Ore Estuary SPA, from either SZC alone, or SZC and SZB in combination. This is due to the very low proportion of the foraging area within which EQS or PNEC values are exceeded for TRO, bromoform or hydrazine (Table 20, section 8.3.2).

There is no potential for bioaccumulation of TRO, bromoform or hydrazine to affect the breeding seabird feature (section 8.3.2).

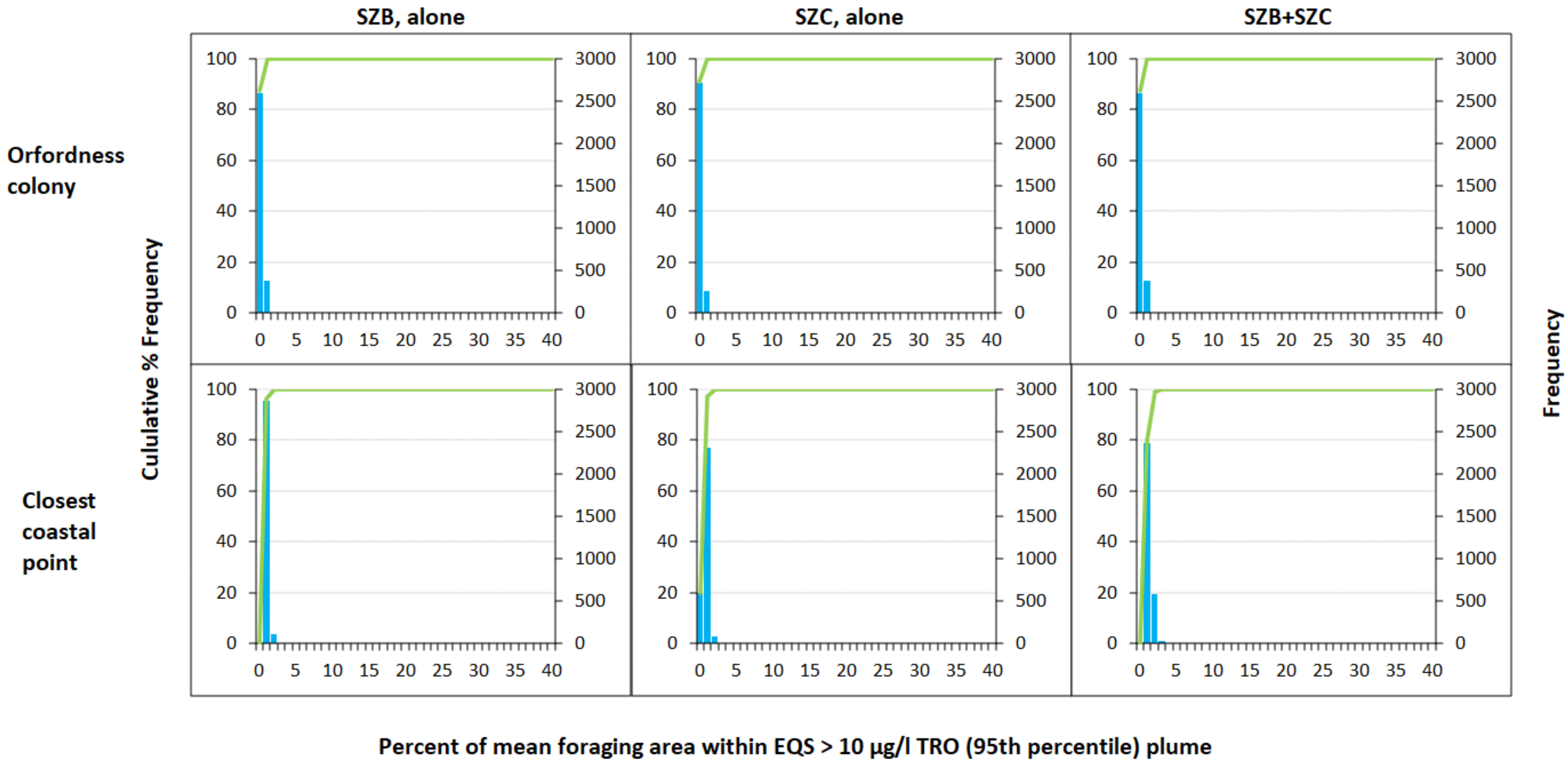

Figure 25: Frequency and cumulative percentage frequency graphs showing the distribution of percentage overlaps between mean foraging area of Alde-Ore SPA Sandwich terns centred on the Orfordness colony or the closest coastal point and instantaneous ≥ 10µg/l TRO thermal uplift plumes from SZB alone, SZC alone, and SZC and SZB in combination. Data provided by the applicant

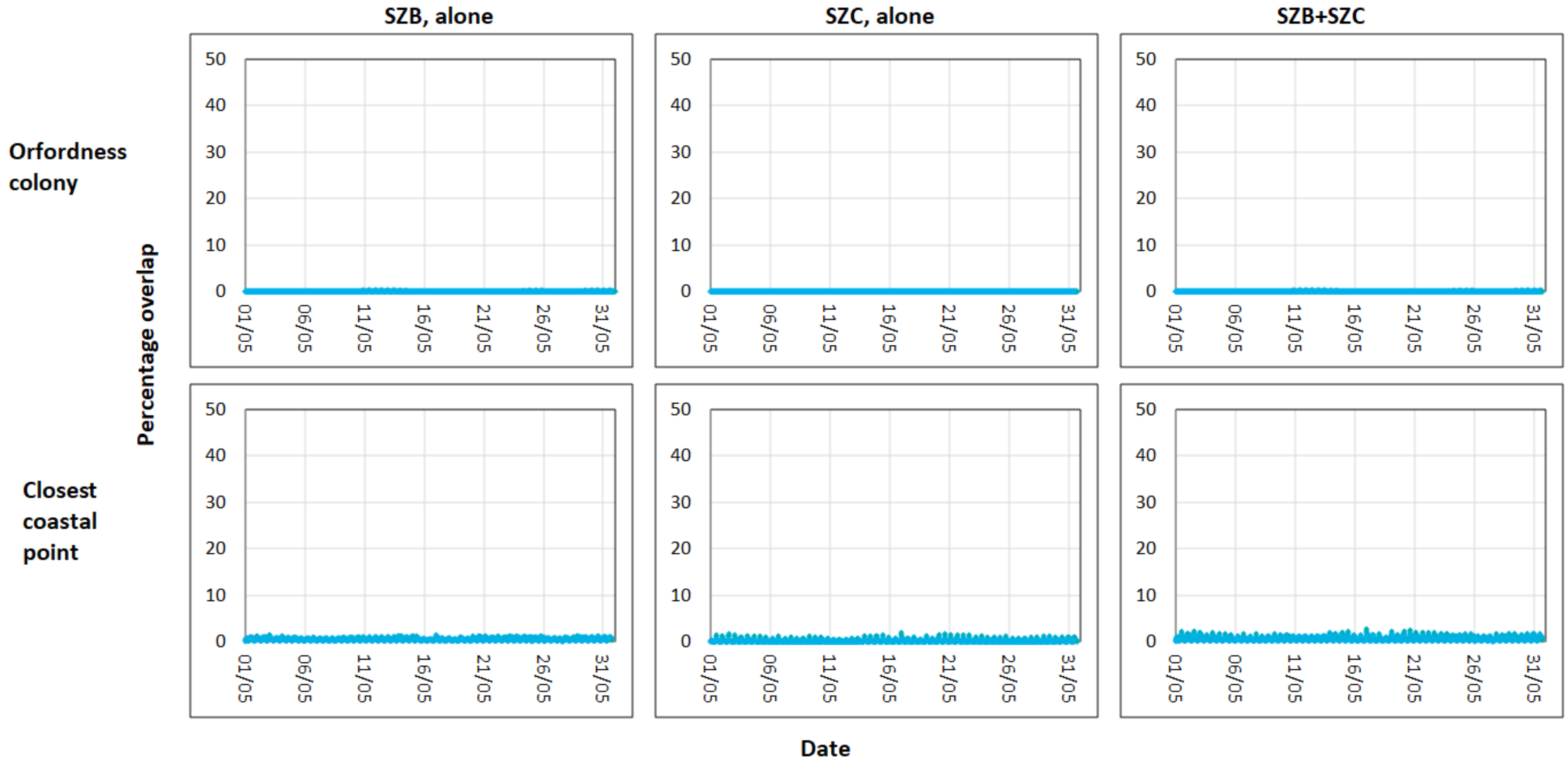

Figure 26: The distribution of percentage overlaps between mean foraging area of Alde-Ore SPA Sandwich terns centred on the Orfordness colony or the closest coastal point, and instantaneous ≥ 10µg/l TRO plumes from SZB alone, SZC alone, and SZC and SZB in combination, over the months when the breeding seabird feature is present. Data provided by the applicant

Changes in nutrients/eutrophication

Direct effects

There are no source-receptor pathways by which organic or nutrient enrichment from SZC alone, or SZC and SZB in combination can directly affect breeding seabird features (section 8.3.3).

Indirect effects

There are no indirect effects of organic enrichment on the breeding Sandwich tern feature of the Alde-Ore Estuary SPA, from either SZC alone, or SZC and SZB in combination (section 8.3.3).

Changes in nutrient enrichment, un-ionised ammonia and dissolved oxygen levels resulting from the operation of SZC alone, or SZC and SZB in combination will not lead to any indirect effects on breeding seabird features (section 8.3.3).

Supporting habitats

There will be no adverse effects on the supporting habitats of Alde-Ore Estuary Sandwich tern feeding in the Outer Thames Estuary SPA as a result of the operation of SZC alone, or SZC and SZB in combination.

Terns use the intertidal sand and muddy sand habitat for resting/loafing when the tide is out. Any effects on the intertidal sand and muddy sand supporting habitat will only occur when the tide is in, and therefore the water discharge activities of SZC alone, or SZC and SZB in combination will not affect the ability of the intertidal sand and muddy sand habitat to support breeding Sandwich terns.

Foraging takes place in the water column supporting habitat in the Outer Thames Estuary SPA. However, given the small size of overlaps between thermal and chemical plumes, and the low level of nutrient input relative to tidal dynamics, any effects on the water column supporting habitat from SZC alone, or SZC and SZB in combination will not adversely affect the breeding seabird feature (Table 33).

Table 33: The sensitivities of the water column supporting habitat for Alde-Ore Estuary SPA Sandwich tern foraging in the Outer Thames Estuary SPA, as described in NE Advice on Operations, together with the expected effects as a result of SZC alone, and SZC and SZB in combination

Pressure (from NE advice on operations)	Supporting habitat	Sensitivity	Effect of SZC alone	Effect of SZC+SZB
Increases in temperature	Water column	Sensitive	No effect. While thermal uplift may potentially affect the water column within the Outer Thames Estuary SPA, breeding Sandwich tern will be unaffected due to flexibility in their foraging behaviour and the area of uplift forming only a small percentage of their potential foraging area. The ability of the water column habitat to support breeding Sandwich terns will be unaffected.	No effect. As for SZC alone.
Other substances (solid, liquid or gas)	Water column	Not assessed	No effect. Sandwich terns foraging from colonies within the Alde-Ore Estuary SPA would encounter some areas of TRO, bromoform and hydrazine exceedance. However, the areas affected are small percentages of the foraging area of breeding Sandwich terns and the threshold values used are precautionary with regard to direct and indirect effects. The ability of the water column habitat to support breeding Sandwich terns will be unaffected.	No effect. As for SZC alone.

Pressure (from NE advice on operations)	Supporting habitat	Sensitivity	Effect of SZC alone	Effect of SZC+SZB
Nutrient enrichment	Water column	Sensitive	No effect. Nutrient enrichment, from SZC alone, will be insufficient to lead to opportunistic macroalgal or phytoplankton blooms and the ability of the water column habitat to support the foraging behaviour of the breeding Sandwich tern feature will be unaffected.	No effect. As for SZC alone.
Changes in suspended solids (water clarity)	Water column	sensitive	No effect. There is no potential for nutrient enrichment to increase turbidity and the ability of the water column habitat to support the foraging behaviour of the breeding Sandwich tern feature will be unaffected.	No effect. As for SZC alone.

8.5.6. Conclusion

We have considered the relevant risks associated with the discharges, from SZC alone, and from SZC and SZB in combination, that are the subject of this application, on the Sandwich tern (breeding) feature of the Alde-Ore Estuary SPA, in light of the designated sites' conservation objectives and supplementary advice on conservation objectives (Table 34).

Despite the considerable decline in numbers of breeding pairs, from 100 to 300 breeding pairs (1993 to 1996) to less than 10, and often no breeding pairs per year from 1997 to 2009, the scale of impacts from the discharges from the cooling water system and the FRR system, together with the flexibility in foraging behaviour of the feature, allows us to conclude that there will be **no adverse effect** on this qualifying feature from the water discharge activities of SZC alone, in terms of maintaining or restoring the:

- extent and distribution of the habitats of the qualifying features
- structure and function of the habitats of the qualifying features
- supporting processes on which the habitats of the qualifying features rely
- populations of each of the qualifying features
- distribution of qualifying features within the site

SZB is expected to continue to operate until 2035, although there is potential for an extension of SZB's operational lifetime by 20 years to 2055 at the latest. Consequently, SZC and SZB may be operating in combination for between 2 and 22 years. However, the scale of impacts from the discharges from the cooling water system and the FRR system, together with the flexibility in foraging behaviour of the feature, allows the Environment Agency to conclude that (irrespective of the date of SZB decommissioning) there will be **no adverse effect** on this qualifying feature from the water discharge activities of SZC and SZB in combination, in terms of maintaining or restoring the:

- extent and distribution of the habitats of the qualifying features
- structure and function of the habitats of the qualifying features
- supporting processes on which the habitats of the qualifying features rely
- populations of each of the qualifying features
- distribution of qualifying features within the site

Table 34: The outcome of the appropriate assessment of the impact of water discharge activities from the operation of SZC alone, and SZC and SZB in combination, on targets contained within Natural England's Supplementary Advice on Conservation Objectives for the breeding Sandwich tern feature of the Alde-Ore Estuary SPA (the table only shows targets which may be affected by water discharge activities)

Attribute	Sub-attribute	Target	Outcome of SZC alone assessment	Outcome of SZC+SZB assessment
Breeding population	Abundance	Restore the size of the breeding population at a level to be agreed*, while avoiding deterioration from its current level as indicated by the latest mean peak count or equivalent. * In the absence of an abundance value from the SPA citation, for information, the JNCC standard data form states there were 170 pairs of breeding Sandwich tern (Joint Nature Conservation Committee (JNCC), 2011). Natural England will consider this value as one option to inform the numerical target in due course.	None of the attributes below will be adversely affected, and so there will be no effect on the restoration of the breeding Sandwich tern feature.	As for SZC alone.
Connectivity with supporting habitats	Connectivity with supporting habitats	Maintain safe passage of birds moving between nesting and feeding areas.	There are no physical obstructions to safe passage associated with the WDA permit. Absolute water temperature and chemical plumes would have no direct effect, but there is also very little overlap	As for SZC alone.

Attribute	Sub-attribute	Target	Outcome of SZC alone assessment	Outcome of SZC+SZB assessment
			between thermal and chemical plumes and the foraging area of breeding Sandwich terns in the Alde-Ore SPA.	
Supporting habitat	Extent and distribution of supporting habitat for the breeding season	Maintain the extent, distribution and availability of suitable habitat (either within or outside the site boundary), which supports the feature for all necessary stages of its breeding cycle (courtship, nesting, feeding).	There will be no effect on the ability of suitable habitats to support breeding Sandwich terns.	As for SZC alone.
Supporting habitat	Food availability	Maintain the distribution, abundance and availability of key food and prey items (for example, sand eel, sprat) at preferred sizes.	Due to the small proportion of the foraging area experiencing thermal uplift or chemical exceedance, the distribution, abundance and availability of key food and prey items of Sandwich tern will be maintained.	As for SZC alone.

Attribute	Sub-attribute	Target	Outcome of SZC alone assessment	Outcome of SZC+SZB assessment
Water quality	Contaminants	Reduce aqueous contaminants to levels equating to high status according to Annex VIII and good status according to Annex X of the Water Framework Directive, avoiding deterioration from existing levels.	There will be mixing zones in which the EQS/PNEC values for TRO, bromoform and hydrazine will be exceeded. However, these will not be large enough to result in deterioration in water quality at a scale which will affect the breeding Sandwich tern feature. The decay of biota discharged by the FRR system will not lead to the release of un-ionised ammonia to the extent that there will be a deterioration in water quality that will affect the breeding Sandwich tern feature.	As for SZC alone.
Water quality	Dissolved oxygen (DO)	Maintain the DO concentration at levels equating to high ecological status, avoiding deterioration from existing levels.	The decay of biota discharged by the FRR system will not lead to a deterioration from existing levels of DO concentration.	
Water quality	Nutrients	Maintain water quality at mean winter dissolved inorganic nitrogen levels where biological indicators of eutrophication (opportunistic macroalgal and phytoplankton blooms) do not affect the	Discharges from the cooling water and FRR systems will not lead to increases in dissolved inorganic nitrogen levels to the	As for SZC alone.

Attribute	Sub-attribute	Target	Outcome of SZC alone assessment	Outcome of SZC+SZB assessment
		integrity of the site and features avoiding deterioration from existing levels.	extent that indicators of eutrophication affect the integrity of the site.	
Water quality	Turbidity	Maintain natural levels of turbidity (for example, concentrations of suspended sediment, plankton and other material) across the habitat.	Organic enrichment will not lead to any increase in turbidity.	As for SZC alone.

8.6. Little tern (breeding)

By reference to its mean maximum foraging range (5km), the following sites with little tern qualifying features have been identified by the applicant and considered appropriate for assessment:

- Alde-Ore Estuary SPA
- Benacre to Easton Bavents SPA
- Minsmere to Walberswick SPA
- Outer Thames Estuary SPA

Sites with breeding seabirds as qualifying features would ordinarily be identified and considered appropriate for assessment if their mean + standard deviation foraging range overlaps with the zone of influence of SZC. However, in the case of little tern, a mean maximum + standard deviation foraging range is not provided in Woodward and others (2019), and so the mean maximum foraging range has instead been used for this purpose.

An ecological narrative for the feature is given in Environment Agency (2022c; Annex 3).

The following appropriate assessment will assess the potential for an adverse effect alone on the integrity of the sites listed above from direct and indirect effects resulting from the cooling water system and FRR system discharges.

8.6.1. Designated sites

The little tern colonies of the Suffolk and Norfolk coastline are functionally linked and all make up a larger meta-population of little tern. These are interlinked populations that will move up and down the coast between colonies following prey species and nesting where their food source is most abundant or nesting habitat is most suitable (Minsmere-Walberswick SPA supplementary advice). As such, little terns are transitory in their nesting habits and may move between different colonies in response to factors, including disturbance and predation (Minsmere-Walberswick SPA supplementary advice).

The applicant considered that breeding little tern were present in the Suffolk and Norfolk colonies from May to August (NNB GenCo, 2021b; shadow HRA), based on the work of Furness (2015). NE's Senior Specialist in Marine Ornithology confirmed that these months were appropriate for use in our HRAR (NE's Senior Specialist in Marine Ornithology email 2021, personal communication, 9 November).

This assessment will be carried out using foraging ranges centred on the colony locations within each designated site (Table 35). However, the assessment will also refer to foraging ranges centred on the closest coastal point to the SZC main development site, within these sites (Table 35). This is to provide a high-level perspective of how percentage overlap may vary with colony location.

Within the Alde-Ore Estuary SPA, the closest coastal point to the SZC main development site is around 0.6km to the north of the Slaughden Beach colony (Table 35). Historically, little terns have also nested at Havergate Island, near the Ore-Butley estuaries confluence (most recently in 2006, when 3 breeding pairs were recorded). Havergate Island is around 7km further south from the main development site than Slaughden Beach, and so use of the Orfordness and closest coastal point locations will be precautionary – there will be less overlap between foraging ranges and plumes from SZC at a greater distance from the main development site.

Within the Benacre to Easton Bavents SPA, there are little tern breeding colonies at Kessingland Broad beaches, Benacre Broad beaches and Covehithe Broad, with Kessingland being the site most frequently used in recent years (email from RHDHV dated 2 November 2021). The closest coastal point to the SZC main development site is at the southern end of the SPA (Table 35), with the colony locations further to the north. The closest coastal point is 5km from the ≥2°C thermal uplift (98th percentile) plume and, as this is equal to the mean maximum foraging range of little tern, this means that there is no source-receptor pathway for colonies further to the north. Consequently, while overlaps have been calculated for the closest coastal point within the Benacre to Easton Bavents SPA, there will be no overlaps between foraging areas and thermal or chemical plumes for colonies further north, and so colony locations are not provided in this assessment.

Within the Minsmere-Walberswick SPA, the closest coastal point to the SZC main development site is around 2.1km south of the Minsmere colony (Table 35). Historically, little terns have also nested at Dunwich Beach and at Walberswick. The applicant selected Minsmere and Dingle for analysis because they “are the 2 sites that are most often used (which in the context of the recent history of little tern within the SPA is not particularly frequent) and which have historically supported the majority of birds attempting to nest within the SPA” (NE’s Senior Specialist in Marine Ornithology email 2021, personal communication, 2 November).

We consider the use of the Minsmere, Dingle and closest coastal point locations will be sufficiently representative to assess potential impacts on breeding little terns in the Minsmere-Walberswick SPA. Dunwich Beach is located between the Minsmere and Dingle colonies and so overlaps centred on this location would be intermediate between the two. Walberswick is north of Dingle and so percentage overlaps with thermal or chemical plumes will be lower than for the closer locations.

The Outer Thames Estuary SPA was first designated in 2010 on the basis of the over-wintering red-throated diver population it supports. It was extended in 2017 to enable greater provision of important marine foraging areas for both breeding little tern and common tern from a range of colonies on the east coast of England, which are now also qualifying features. For breeding little tern, these include the Alde-Ore Estuary SPA, Benacre to Easton Bavents SPA, Minsmere-Walberswick SPA, which also have breeding little tern features in their own right and are assessed as individual SPAs within this section. Marine foraging areas of little tern breeding colonies within the Great Yarmouth North Denes SPA, Foulness SPA and the Thanet Coast and Sandwich Bay SPA are also protected under the Outer Thames Estuary SPA. However, there are no source-receptor pathways linking breeding little terns at these locations to Sizewell due to their distance from the main development site (45km, 73km and >90km, respectively), relative to the 5km mean maximum foraging range of the feature.

Table 35: National Grid references for the little tern colonies and closest coastal points to the SZC main development site, within the Alde-Ore Estuary SPA (and Ramsar), Benacre to Easton Bavents SPA and Minsmere-Walberswick SPA

Site	Colony location	Grid reference (NGR)
Alde-Ore Estuary SPA (and Ramsar)	Slaughden Beach	TM46335500
Alde-Ore Estuary SPA (and Ramsar)	Closest coastal point	TM46375559
Benacre to Easton Bavents SPA	Closest coastal point	TM51507863
Minsmere-Walberswick SPA (and Ramsar)	Minsmere	TM477666
Minsmere-Walberswick SPA (and Ramsar)	Dingle	TM489733
Minsmere-Walberswick SPA (and Ramsar)	Closest coastal point	TM47676448

8.6.2. Species condition summary

As part of the assessment, we will consider the status of the qualifying features of the site, the site condition and the prevailing environmental conditions. We will also consider any threats or degradations of the species and its supporting habitats for the designated sites.

Alde-Ore Estuary SPA

For the breeding little tern feature of the Alde-Ore Estuary SPA, the information that the applicant provided to support the HRAR (NNB GenCo, 2021b, shadow HRA), and NE's supplementary advice on conservation objectives (Marine site detail (naturalengland.org.uk)) tell us that:

- the site classification records a mean of 48 pairs of little tern breeding, based on 5, yearly counts (1993 to 94, 1996 to 98) (jncc.gov.uk). However, in 2013, just 4 breeding pairs attempted to breed at the site. Despite their lack of breeding success, little tern roost on the shingle ridges at Shingle Street, Orfordness and Havergate Island. On arrival in spring, little tern explore the SPA and wider Suffolk coast looking for suitable shingle nesting sites before settling and breeding. The last known nesting colony was at Sudbourne Beach, south of Slaughden on Orfordness in 2013. In the same year, 40 birds were recorded on Shingle Street but due to disturbance they moved to the Deben Knolls of Deben Estuary SPA, where a breeding colony was established
- surveys in 2011 (commissioned by the applicant) recorded little tern foraging and commuting along the coastline. A peak count of 18 birds was observed resting on Sudbourne Beach in mid-May, after which up to 22 birds were present in the area until mid-June. During this period, little terns were frequently observed foraging over a spit approximately 1km offshore of Sudbourne Beach. Little terns were also seen loafing around the colony, with mating activity also recorded, although the colony was abandoned by 23 June 2011
- surveys in 2013 (commissioned by the applicant) also recorded little tern along the coastline. The peak count was 8 birds at Sudbourne Beach in early June 2013, at which point a colony attempted to establish. However, this was deserted by the time of the nest survey in late June
- these surveys derive from the most recent period for which there is documented breeding at the little tern colonies within the Alde-Ore Estuary SPA, which is no longer recognised as a 'regularly occupied' breeding colony

Benacre to Easton Bavents SPA

For the breeding little tern feature of the Benacre to Easton Bavents SPA, the information that the applicant provided to support the HRAR (NNB GenCo, 2021b;

shadow HRA), and NE's supplementary advice on conservation objectives (European Site Conservation Objectives for Benacre to Easton Bavents SPA - UK9009291 (naturalengland.org.uk)) tell us that:

- the Benacre to Easton Bavents SPA's qualifying population of 39 pairs of little terns constituted 1.6% of the national breeding population (5-year mean 1991 to 1995). The 5-year average for 2014 to 2018 was 40 breeding pairs. Historically, there were known nesting colonies in the SPA at Easton Broad and Covehithe Broad, while more recently breeding has occurred on the sand and shingle beaches at Kessingland, Benacre and Covehithe Broads, located approximately 22km, approximately 20km and approximately 17km north of the main development site, respectively
- in 2010, 2011 and 2013, the applicant undertook shore-based surveys to record little tern flight activity and foraging across a total of 15 vantage points between Dunwich and Orfordness. However, the most northerly of these sites (Dunwich) was approximately 11km south of Covehithe Broads. Given that the mean maximum foraging distance from breeding colonies in the SPA is 5km, the Dunwich vantage point was beyond the maximum foraging range for little terns in the Benacre to Easton Bavents SPA

Minsmere-Walberswick SPA

For the breeding little tern feature of the Minsmere-Walberswick SPA, the information that the applicant provided to support the HRAR (NNB GenCo, 2021b; shadow HRA), and NE's supplementary advice on conservation objectives (Marine site detail (naturalengland.org.uk)) tell us that:

- the Minsmere-Walberswick SPA's qualifying population of 32 pairs of little terns constituted approximately 1.2% of the national breeding population at the time of classification (1991). Since then, the number of little terns using the SPA has decreased by 95% to 1.6 breeding pairs (5-year mean, 2014 to 2018). There was no successful breeding at the Minsmere colony between 2009 (when a single breeding pair was recorded) and 2019 (when 10 pairs bred on the scrape, with 7 young raised to fledging). Successful breeding has occurred since 2009 at both Dingle and Walberswick, approximately 7.5 to 9km north of the main development site
- historically, numbers of little tern breeding within the Minsmere-Walberswick SPA have fluctuated greatly between years, with some years having a high number of nesting pairs and then the next year having none. NE's supplementary advice on conservation objectives says that "Benacre to East Bavents SPA, to the north of Minsmere-Walberswick SPA, has seen a significant increase in little terns breeding at the site, this may account for the dramatic decline in numbers using this SPA. The Kessingland colony has also seen an increase in breeding pairs in recent years. It is likely that breeding site selection has changed in response to currently unknown factors, such as

prey species availability, disturbance or predation. There are also breeding colonies located just south of the SPA at North Warren, within Sandlings SPA"

- in 2010, 2011 and 2013, the applicant undertook shore-based surveys to record little tern flight activity and foraging across a total of 15 vantage points between Dunwich and Orfordness. In addition, the applicant also undertook colony surveys at Dingle and Minsmere in 2010 and 2011
- during the 2010 surveys, there was evidence of attempted nesting at both Dingle and Dunwich Beach. No serious attempts at breeding were observed at Minsmere, while the attempted breeding by 7 to 8 pairs at Dingle was unsuccessful
- foraging activity was concentrated close to shore near Dingle, with a peak of around 100 birds foraging or loafing on the beach at the end of June 2010. Beyond the colonies, peak foraging behaviour was observed at vantage point 1, at the south end of the SPA
- during the 2010 survey period, birds were recorded heading south from both the Dingle and Minsmere colonies, although at both colonies much of the foraging activity occurred in the shallow waters close offshore (generally within 700m of the shoreline). Flight line data indicated that birds were moving between the colonies but were also heading further south along the shoreline towards Sizewell. Surveys from the VPs near Sizewell showed much of the foraging activity of birds from the SPA was in shallow waters within 500m of the shore
- results from colony surveys in May and June 2011 showed that there were no nesting attempts at Minsmere (although up to 79 birds were prospecting in mid-May), but successful breeding was recorded at Dingle/Walberswick. At the Dingle colony, small numbers of birds (one to seven) were recorded between 17 May and 20 May, mostly commuting but occasionally displaying. First mating was recorded on 20 May. Up to 110 birds were present at the beginning of June, and by late June a total of approximately 40 pairs were present at the colony, of which 26 pairs attempted to breed
- the first chick of 2011 was seen on 29 June and by mid-July there were 8 fledged young and 6 chicks from the Walberswick section of the colony. Peak counts at Dingle of 180 birds, including 150 loafing on the beach (including 10 fledged young), were recorded in late July, before numbers started to decrease and the colony was empty by 12 August. Much of the recorded foraging activity for the provisioning of chicks was relatively close inshore (within 1km of the colony), although occasionally birds were recorded foraging further offshore
- of the 9 sightings of little tern during the 2013 vantage point foraging surveys, the only sightings within the mean maximum foraging range of birds breeding within Minsmere-Walberswick SPA were of one to two individuals, foraging from Minsmere and moving south towards Sizewell

- although the project-specific survey data are from 2011 to 2013, the applicant tells us that in most years since their collection only small numbers of pairs have nested at the SPA colonies and that had more recent surveys been undertaken, it is therefore unclear whether they would have provided data which were any more representative of the current main foraging areas of the SPA breeding little tern population

Outer Thames Estuary SPA

For the breeding little tern feature of the Outer Thames Estuary SPA, the information that the applicant provided to support the HRAR (NNB GenCo, 2021b; shadow HRA), and NE's supplementary advice on conservation objectives (Marine site detail (naturalengland.org.uk)) tell us that:

- at the time of inclusion as a qualifying species, the Outer Thames Estuary SPA was estimated to provide supporting habitat for 373 little tern breeding pairs (based on counts from 2011 to 2015), which constituted 20% of the breeding population for Great Britain. These breeding pairs derived from breeding colonies at (or functionally linked to) the Alde-Ore Estuary SPA, Benacre to Easton Bavents SPA and Minsmere-Walberswick SPA, which are screened into the current assessment due to their breeding little tern features and their proximity to the main development site. Breeding pairs were also derived from breeding colonies at Great Yarmouth North Denes SPA, Foulness SPA and Thanet Coast and Sandwich Bay SPAs, which are screened out of the current assessment due to their distance from the main development site (Table 36). A colony of little terns also breeds on the Scroby Sands intertidal sandbank (not designated as an SPA), which is 6km off the Great Yarmouth coastline at the northern extremity of the Outer Thames Estuary SPA itself. Overall, numbers of breeding little tern have decreased since designation, although the pattern is not consistent between colonies (Table 36). Numbers of breeding pairs have increased at Great Yarmouth and North Denes SPA and Benacre to Easton Bavents SPA, while decreases have occurred at the remaining 4 SPAs, with some of the SPAs currently holding no breeding pairs and no longer recognised as regular breeding sites for the species (Table 36).

Table 36: Breeding little tern population estimates at coastal SPAs for which the Outer Thames Estuary SPA provides supporting habitat, as determined at (or near) the time of citation and designation of the SPA. Rows in bold indicate SPAs 'screened into' the current assessment – population estimates differ for these SPAs from those presented in the specific sections for these SPAs (above) due to differences in the years over which mean population sizes have been calculated. Table reproduced from Table 6.5 in NNB GenCo (2021b; shadow HRA)

SPA	Approximate distance to main development site (km)	Population size at (or near) time of breeding colony SPA citation (breeding pairs)	Mean population size for 2011-2015 (breeding pairs)
Alde-Ore Estuary	8	48	0.8
Benacre to Easton Bavents	14.5	39	57.6
Minsmere-Walberswick	<1	32	0.8
Great Yarmouth North Denes	45	277	314
Foulness	73	73	0
Thanet Coast and Sandwich Bay	>90	30	0
Total		451	373

8.6.3. Conservation objectives

Links to the full conservation objectives for the SPAs identified above are provided in Environment Agency (2022b; Annex 2), and the appropriate assessment will be concluded against the relevant conservation objectives provided. The conservation objectives for the SPAs will be used when concluding the assessment for the respective Ramsar sites.

8.6.4. Supporting habitats

Thermal and chemical plumes from SZC do not extend into the Alde-Ore Estuary and so the source-receptor pathway for little terns nesting in the Alde-Ore Estuary SPA therefore occurs when they are foraging within the Outer Thames Estuary SPA. Similarly, the source-receptor pathway for little terns nesting in the Benacre to Easton Bavents SPA and the Minsmere-Walberswick SPA (and Ramsar) occur when they are foraging within the Outer Thames Estuary SPA. Supporting habitats listed for little tern in Outer Thames Estuary SPA (Marine site detail (naturalengland.org.uk)) are:

- intertidal sand and muddy sand
- water column

8.6.5. Discussion

Risks carried through to appropriate assessment for the breeding little tern feature of the Alde-Ore SPA are:

- change in thermal regime
- toxic contamination (chemical)
- nutrient enrichment

Change in thermal regime

Absolute water temperatures

There is no potential for breeding little tern to be directly harmed by elevated water temperatures when SZC is operating alone, or when SZC and SZB are operating in combination (section 8.3.1).

Thermal uplift

There is no potential for an adverse effect on breeding little tern through thermal uplift from SZC alone, or SZC and SZB in combination, explained here for each SPA and Ramsar in turn.

Alde-Ore Estuary SPA

Considering the breeding little tern feature of the Alde-Ore Estuary SPA, overlaps between mean foraging area centred on the Slaughden colony and the ≥3°C thermal uplift (98th percentile) plume reduce from 0.8% (SZB, only) to 0.0% (SZC alone) (Table 21, Figure 28). There is a slight increase to 3.0% overlap when SZC and SZB are operating in combination (Table 21, Figure 28).

For the closest coastal point within the Alde-Ore Estuary SPA, the pattern is similar. Overlaps between mean foraging area and the ≥3°C thermal uplift (98th percentile) plume reduce from 2.8% (SZB, only) to 0.0% (SZC alone) (Table 21, Figure 29)). There is a slight increase to 5.3% overlap when SZC and SZB are operating in combination (Table 21, Figure 29).

As there are no overlaps between mean foraging areas of Alde-Ore Estuary SPA breeding little terns and the ≥3°C thermal uplift (98th percentile) plume from SZC alone, there will be no adverse effect on the breeding seabird feature.

There are no set thresholds that indicate what size of overlap may be problematical for breeding seabirds. However, when the overlap between the 'mean' foraging area and the 3°C thermal uplift (98th percentile) plume exceeded 1%, further investigation of the effect of SZC and SZB was triggered and overlaps with instantaneous thermal plumes were examined.

The overlap between foraging area and the area of water experiencing >3°C thermal uplift, at any single (hourly) time step of the model, best represents conditions a seabird might encounter if embarking on a foraging trip during that time step.

Although when SZC and SZB are operating in combination, overlaps between the mean foraging areas of little tern centred on the Slaughden colony and the ≥3°C thermal uplift (98th percentile) plume exceed 1%, there would be no overlap at all with instantaneous ≥3°C thermal uplift plumes for 88% of the hourly periods during the months the breeding seabird feature is present (Figure 30), with the median overlap also being 0% (Q1 = 0.00%, Q3 = 0.00%) (Table 21).

Similarly, when SZC and SZB are operating in combination, there would be no overlap at all between the mean foraging area of little tern centred on the closest coastal point with instantaneous ≥3°C thermal uplift plumes for 78.9% of the hourly periods during the months the breeding seabird feature is present (Figure 30), with the median overlap also being 0% (Q1 = 0.00%, Q3 = 0.00%) (Table 21).

A period of elevated overlaps is noticeable in the instantaneous thermal overlap data, for SZB alone, and SZC and SZB in combination, for Slaughden colony and the closest coastal point, beginning on 11 May 2009 and finishing in the early hours of 14 May (Figure 31). During this 3-day period, percentage overlap between mean foraging areas and the 3°C instantaneous thermal uplift plume rarely drops below

1%. This may be the result of weather conditions on these dates, but these results do indicate that greater-than-average (but still relatively low) overlap can occur for periods of days at a time. Short-term disruption to chick provisioning can occur naturally during periods of prolonged rain or when the sea is choppy – and provisioning of little tern chicks does not in any case take place at night (Davies, 1981).

The applicant's vantage point surveys in 2011 and 2013 recorded concentrated foraging immediately offshore of the Slaughden Beach colony, and (in 2011) over a spit approximately 1km offshore (Figure 27). This means that, when SZC and SZB are operating in combination, in addition to a large percentage of the mean foraging area being outside the instantaneous 3°C thermal plume for Alde-Ore little terns, the affected area would lie to the north of the zones of concentrated foraging activity recorded in 2011 and 2013 (which correspond to the most recent period for which there is documented breeding at the little tern colonies within the Alde-Ore Estuary SPA). Should a little tern colony establish further south in the Alde-Ore Estuary SPA, for example at Havergate Island, then the thermal uplift plume could lie entirely outside of the foraging area for these birds.

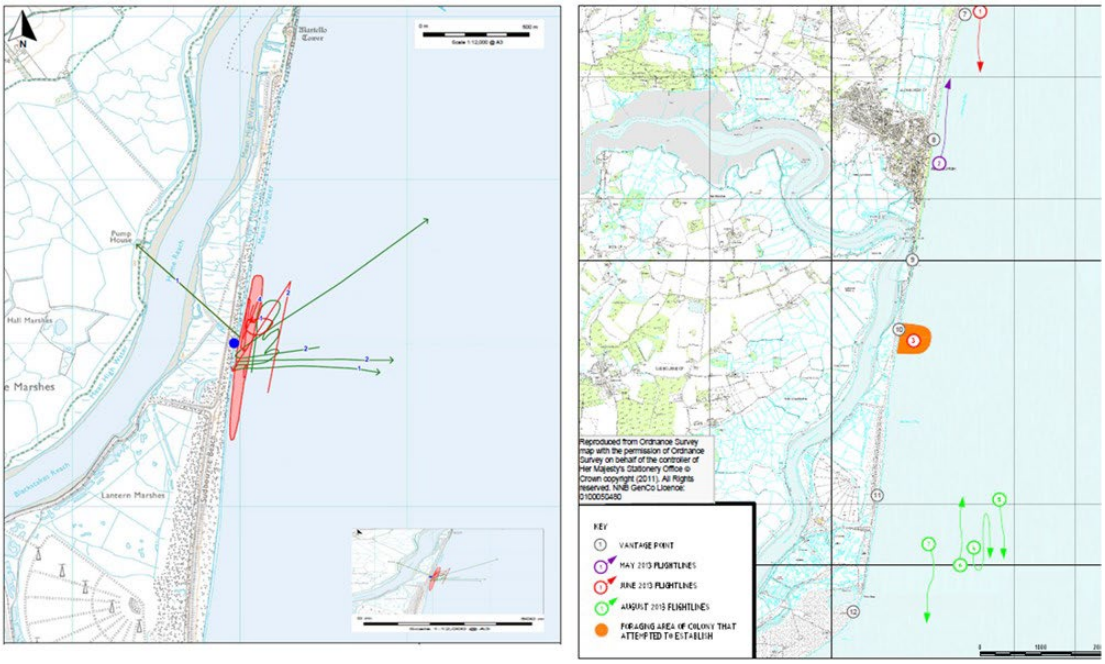

Figure 27: Concentrated foraging areas for little terns offshore from the Alde-Ore Estuary SPA recorded during surveys conducted in 2011 and 2013. Reproduced from Plates 6.1 and 6.2 in the applicant's information to support the HRAR (NNB GenCo, 2021b; shadow HRA)

Due to the low percentages of mean foraging areas that will be affected by ≥3°C thermal uplift at any one time, the location of the thermal plume to the north of the

Alde-Ore SPA and away from recorded areas of concentrated foraging activity, thermal uplift from SZC and SZB in combination will not adversely affect the breeding little tern feature of the Alde-Ore Estuary SPA and Ramsar (regardless of whether SZB is decommissioned in 2035 or its operational life is extended, potentially up to 2055).

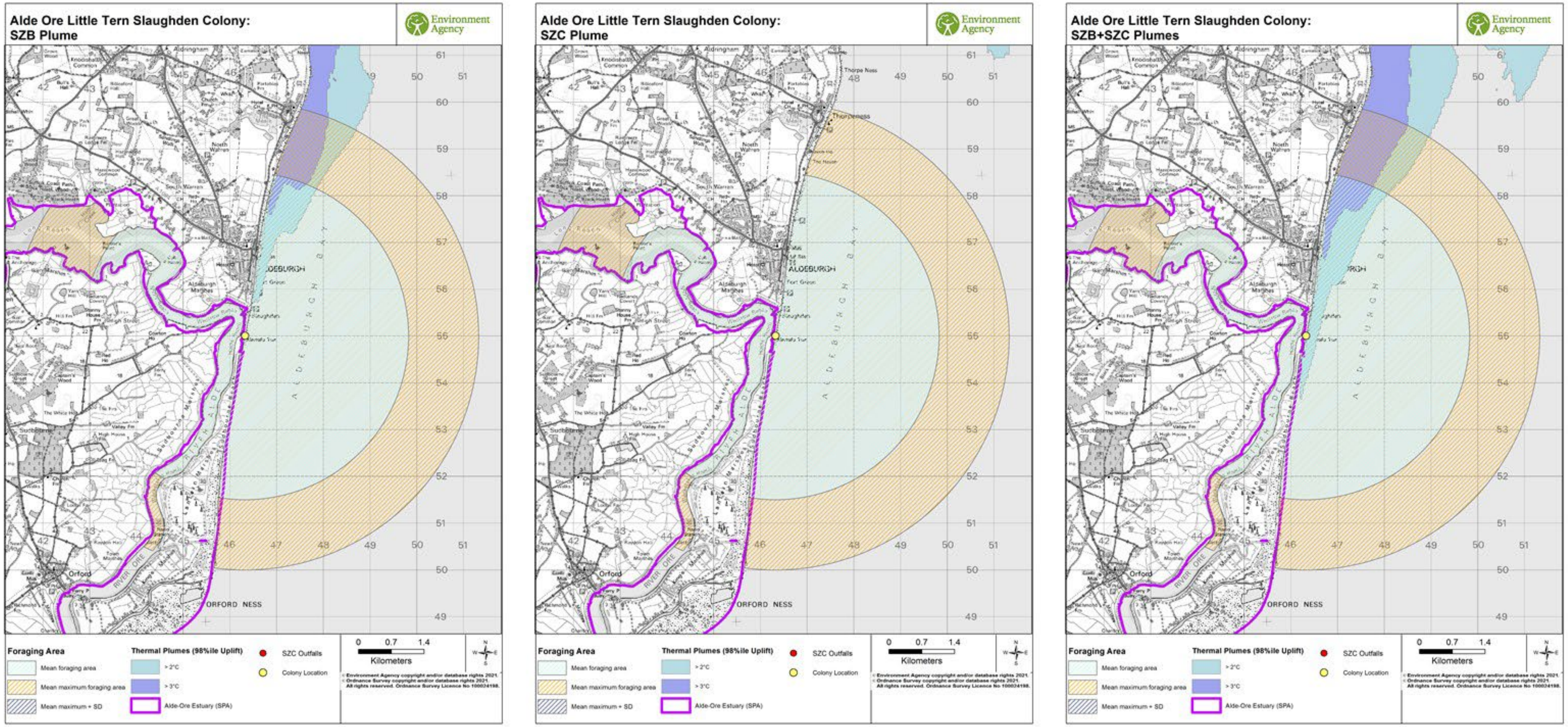

Figure 28: Mean and mean maximum foraging areas for breeding little tern centred on the Slaughden colony in the Alde-Ore Estuary SPA together with the ≥2°C and ≥3°C thermal uplift (98th percentile) plumes for SZB alone, SZC alone, and SZC and SZB in combination, as calculated by the applicant

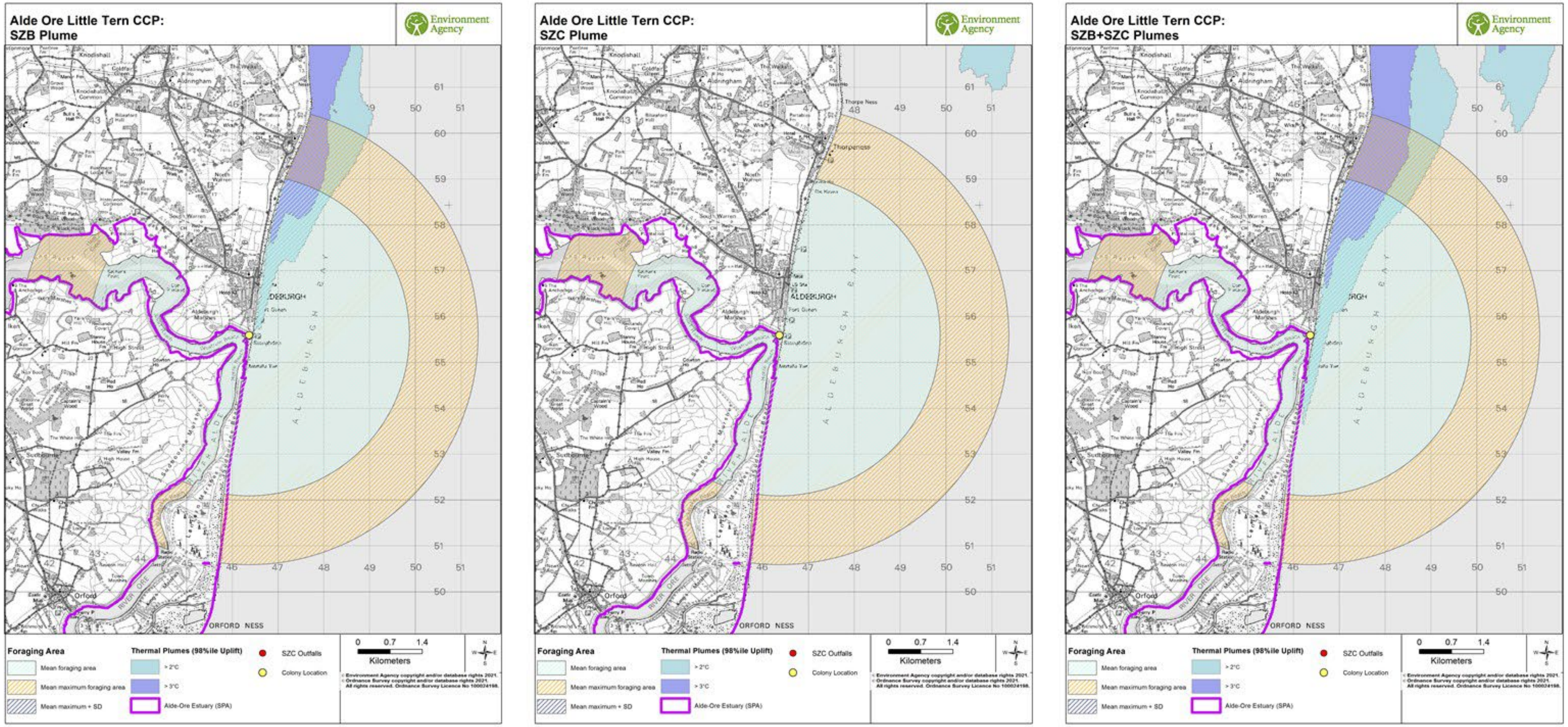

Figure 29: Mean and mean maximum foraging areas for breeding little tern centred on the closest coastal point in the Alde-Ore Estuary SPA together with the ≥2°C and ≥3°C thermal uplift (98th percentile) plumes for SZB alone, SZC alone, and SZC and SZB in combination, as calculated by the applicant

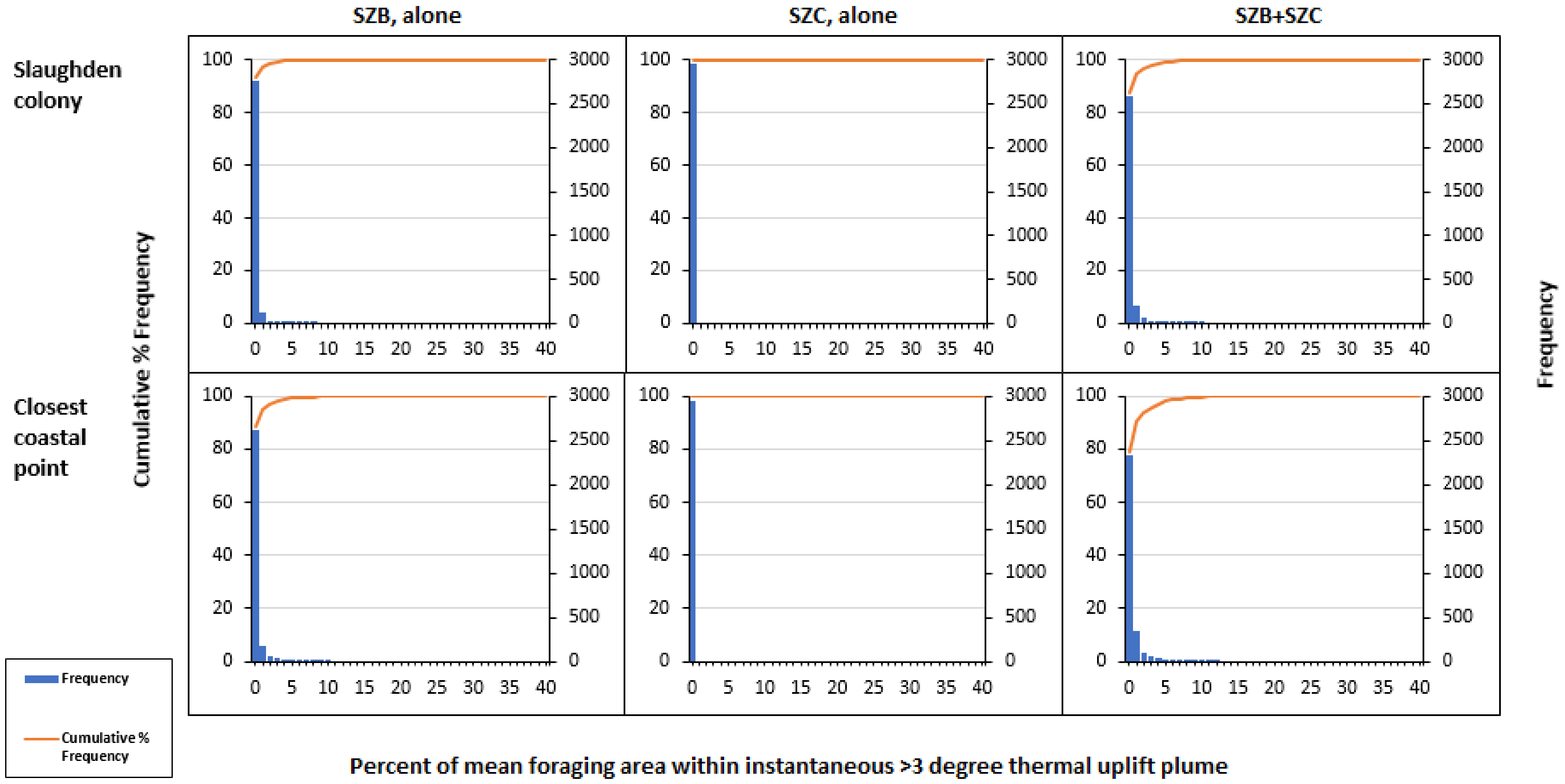

Figure 30: Frequency, and cumulative percentage frequency graphs showing the distribution of percentage overlaps between mean foraging area of Alde-Ore little terns centred on the Slaughden colony or the closest coastal point, and instantaneous ≥3°C thermal uplift plumes from SZB alone, SZC alone, and SZC and SZB in combination. Data provided by the applicant

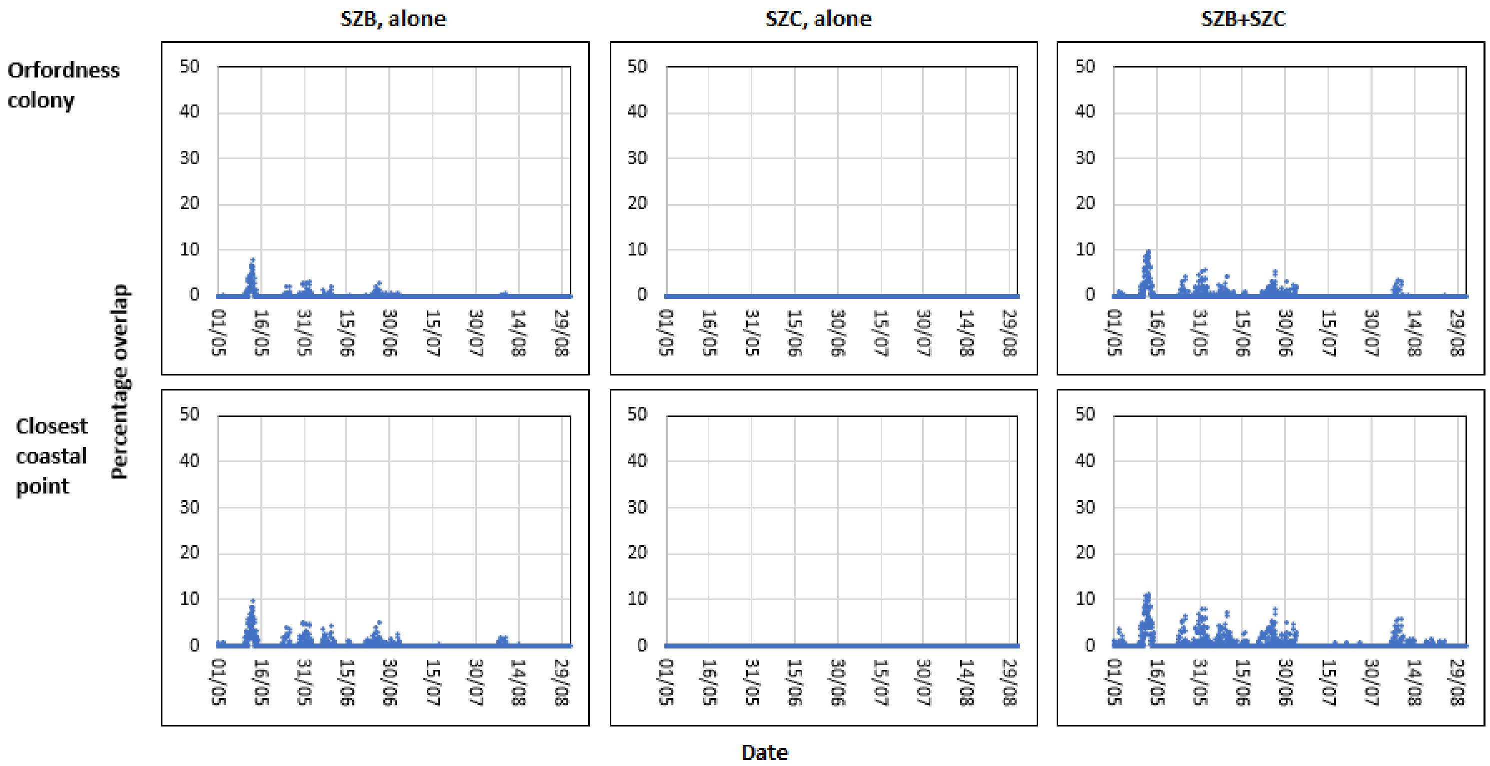

Figure 31: The distribution of percentage overlaps between mean foraging area of Alde-Ore little terns centred on the Slaughden colony or the closest coastal point, and instantaneous ≥3°C thermal uplift plumes from SZB alone, SZC alone, and SZC and SZB in combination, over the months when the breeding seabird feature is present. Data provided by the applicant

Benacre to Easton Bavents SPA

For little tern foraging areas centred on the closest coastal point within the Benacre to Easton Bavents SPA, there are no overlaps with the ≥3°C thermal uplift (98th percentile) plume, with the ≥2°C thermal uplift (98th percentile) plume also being entirely outside the mean and mean maximum foraging areas, for SZB alone, SZC alone, and SZC and SZB in combination (Table 22, Figure 32).

As there are no overlaps between mean foraging areas of Benacre to Easton Bavents SPA breeding little terns and the ≥3°C thermal uplift (98th percentile) plume from SZC alone, or for SZC and SZB in combination, there will be no adverse effects on the breeding seabird feature as a result of thermal uplift.

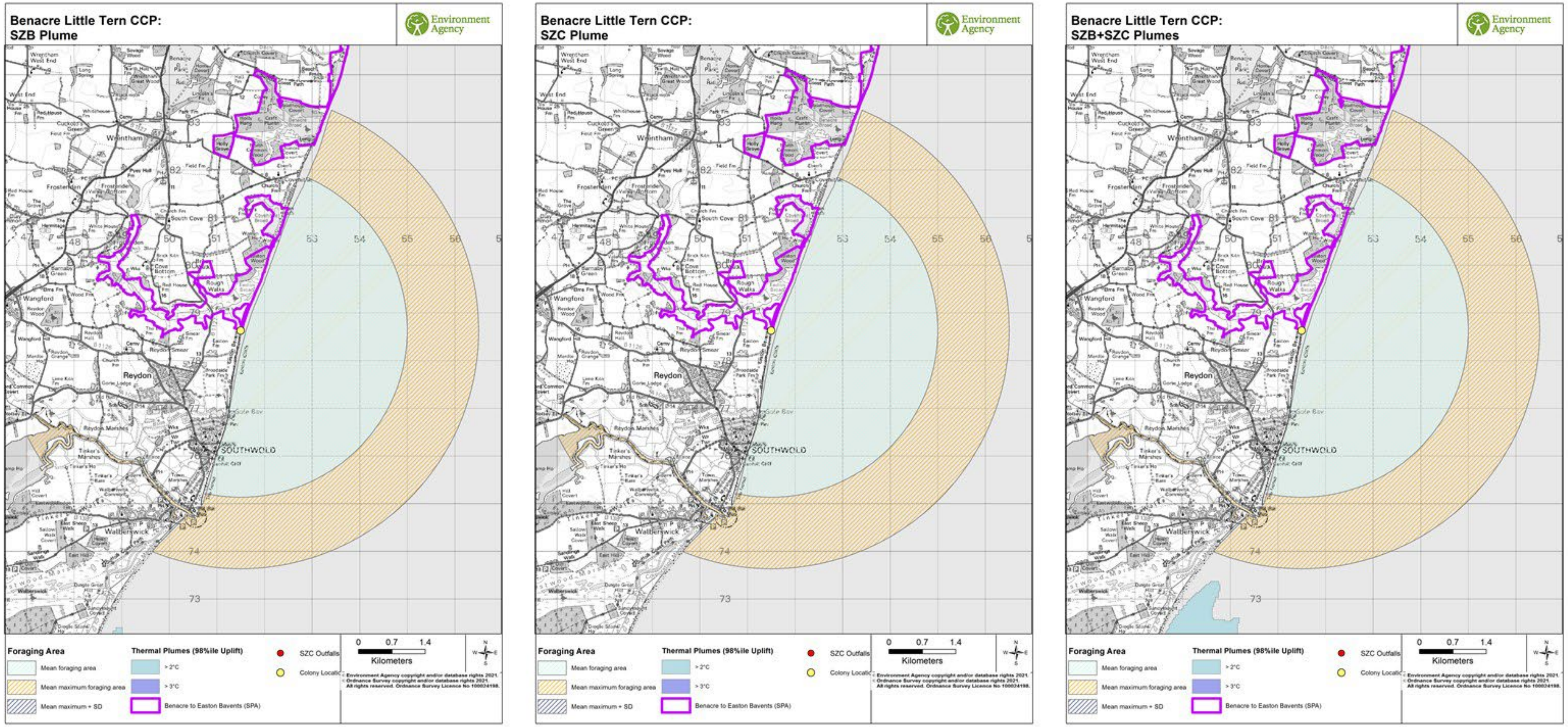

Figure 32: Mean and mean maximum + SD foraging areas for breeding little tern centred on the closest coastal point in the Benacre to Easton Bavents SPA together with the ≥2°C and ≥3°C thermal uplift (98th percentile) plumes for SZB alone, SZC alone, and SZC and SZB in combination, as calculated by the applicant

Minsmere-Walberswick SPA

The greatest overlaps between the mean foraging areas of little terns and the ≥3°C thermal uplift (98th percentile) plume occur in the Minsmere-Walberswick SPA for foraging areas centred on the Minsmere colony and the closest coastal point (Table 23), although overlaps are markedly lower when SZC is operating alone, due to the offshore location of the discharge point and the associated thermal uplift plume (Figure 34, Figure 35, Figure 36).

Overlaps between the mean foraging area centred on the Minsmere colony and the ≥3°C thermal uplift (98th percentile) plume reduce from 28.8% (SZB only) to 0.0% (SZC alone) (Table 23, Figure 34). There is an increase to 36.4% overlap when SZC and SZB are operating in combination (Table 23, Figure 34). With SZC and SZB operating in combination, little tern nesting at the Minsmere colony would experience higher percentage overlaps with instantaneous ≥3°C thermal plumes more often than under baseline conditions (SZB alone) (Q1 = 4.98%, median = 7.02%, Q3 = 10.81%) (Table 23, Figure 37).

For the closest coastal point within the Minsmere-Walberswick SPA (and Ramsar), overlaps between mean foraging area and the ≥3°C thermal uplift (98th percentile) plume reduce from 35.3% (SZB, only) to 3.6% (SZC alone) (Table 23, Figure 35). There is an increase to 45.9% overlap when SZC and SZB are operating in combination (Table 23, Figure 35). Despite an overlap of 3.6% with the ≥3°C thermal uplift (98th percentile) plume when SZC is operating alone, there would be no overlap at all with instantaneous ≥3°C thermal uplift plumes for 54% of the hourly periods during the months the breeding seabird feature is present (Figure 37), with a median overlap of 0.00% (Q1 = 0.00%, Q3 = 0.63%) (Table 23). With SZC and SZB operating in combination, little terns nesting at the closest coastal point would experience higher percentage overlaps with instantaneous ≥3°C thermal plumes more often than under baseline conditions (SZB alone) (Q1 = 4.98%, median = 7.02%, Q3 = 10.81%) (Table 23, Figure 37).

Being more distant from the main development site than the Minsmere colony, or the closest coastal point, overlaps between the mean foraging area and the ≥3°C thermal uplift (98th percentile) plume are lower for little tern from the Dingle colony. Here, there is no overlap between mean foraging area and the ≥3°C thermal uplift (98th percentile) plume for SZB alone, or for SZC alone, with just 1.9% overlap when SZC and SZB are operating in combination (Table 24, Figure 36). The median overlap with instantaneous ≥3°C thermal uplift plumes is 0.00% (Q1 = 0.00%, Q3 = 0.00%), with 88.9% of hourly periods showing no overlap between mean foraging area and instantaneous ≥3°C thermal uplift plumes (Table 24, Figure 37).

There is no discernible pattern as to when higher percentage overlaps occur, with relatively high overlaps occurring throughout the months when breeding little terns are present (Figure 38).

When SZC is operating alone, any fish avoidance behaviour will be minimal, and there will be no adverse effect on the breeding seabird feature of the Minsmere-Walberswick SPA as a whole. This is due to there being no overlap between the mean foraging area and the ≥3°C thermal uplift (98th percentile) plume for the Minsmere colony and the Dingle colony (and therefore also the Dunwich Beach and Walberswick colonies), and only low percentage overlap at the closest coastal point.

When SZC and SZB are operating in combination, little tern would experience higher overlap more often than baseline (SZB alone) for Minsmere and the closest coastal point. However, overlap at Dingle (and potential colonies further to the north within the SPA) would be very low, marginally lower than baseline. Increased overlaps, and therefore potential reduction in fish prey, would occur for colonies in the southern part of the SPA when SZC and SZB are operating together. SZB is expected to continue to operate until 2035, although there is potential for an extension of SZB's operational lifetime by 20 years to 2055 at the latest. Potential colonies to the north of Dingle would be unaffected.

During visual surveys, little terns were recorded foraging close to shore near Dingle, and within 500m of the shore near Sizewell (Figure 33). For the Minsmere colony and the closest coastal point (the locations nearest to Sizewell), the increase in the percentage of the foraging area experiencing ≥3°C thermal uplift primarily takes place offshore, due to the influence of the SZC outlet, and there is little difference between the area of ≥3°C thermal uplift (98th percentile) plume nearshore under SZB alone, or SZC and SZB in combination (Figure 34, Figure 35). Given the propensity of little tern for feeding near to shore, even in the surf zone (Eglington and Perrow, 2014), breeding little tern at the Minsmere colony or the closest coastal point would experience little practical difference in thermal uplift between SZC and SZB in combination and baseline (SZB alone).

At Dingle, when SZC and SZB are operating in combination, the ≥3°C thermal uplift (98th percentile) plume encroaches into the southern end of the mean foraging area of breeding little tern (Figure 36). The area of concentrated foraging off Dingle beach will be unaffected (Figure 33).

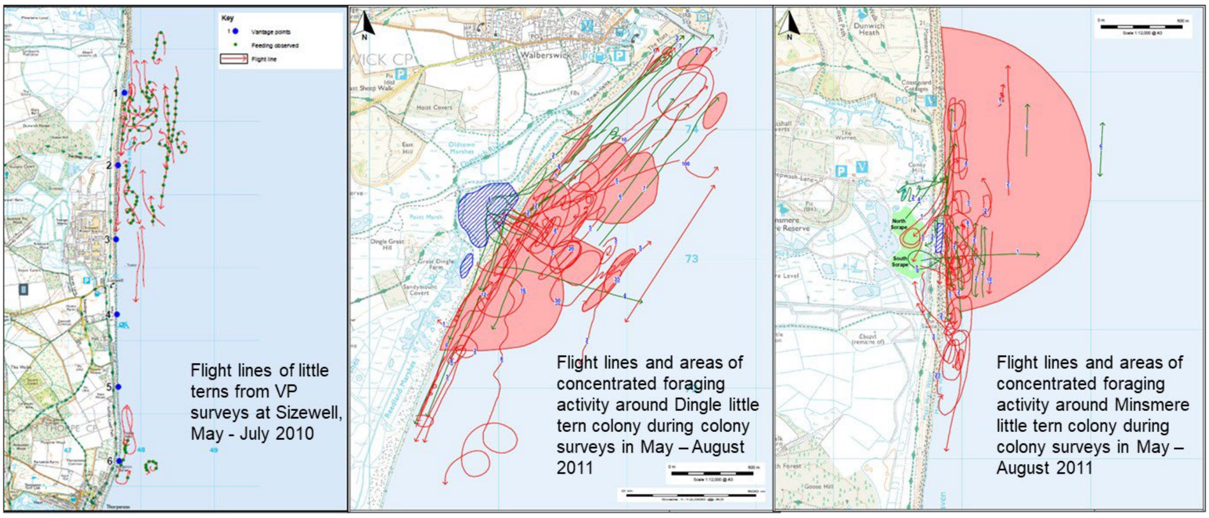

Figure 33: Concentrated foraging areas for little terns offshore from the Minsmere-Walberswick SPA recorded during surveys conducted in 2010 and 2011. Reproduced from Plates 6.6, 6.7 and 6.8 in the applicant's information to support the HRAR (NNB GenCo, 2021b; shadow HRA)

There will be no adverse effect on the breeding little tern feature of the Minsmere-Walberswick SPA while SZC and SZB are operating in combination. If SZB is decommissioned in 2035, then a small increase in frequency of overlap between mean foraging area and the 3°C thermal uplift plume, for 2 to 3 years, towards the south of the SPA will not adversely affect the breeding little tern feature over the site as a whole. The transitory nesting habits of little terns will help them adapt to the increase in thermal uplift, compared to baseline. If the operational life of SZB is extended, perhaps for 20 years to 2055, then any effects will still be concentrated towards the southern extent of the SPA over this time period. The transitory nesting habits of little tern will continue to help the feature to adapt by potentially adjusting their breeding location within the SPA to account for any effect resulting from thermal uplift.

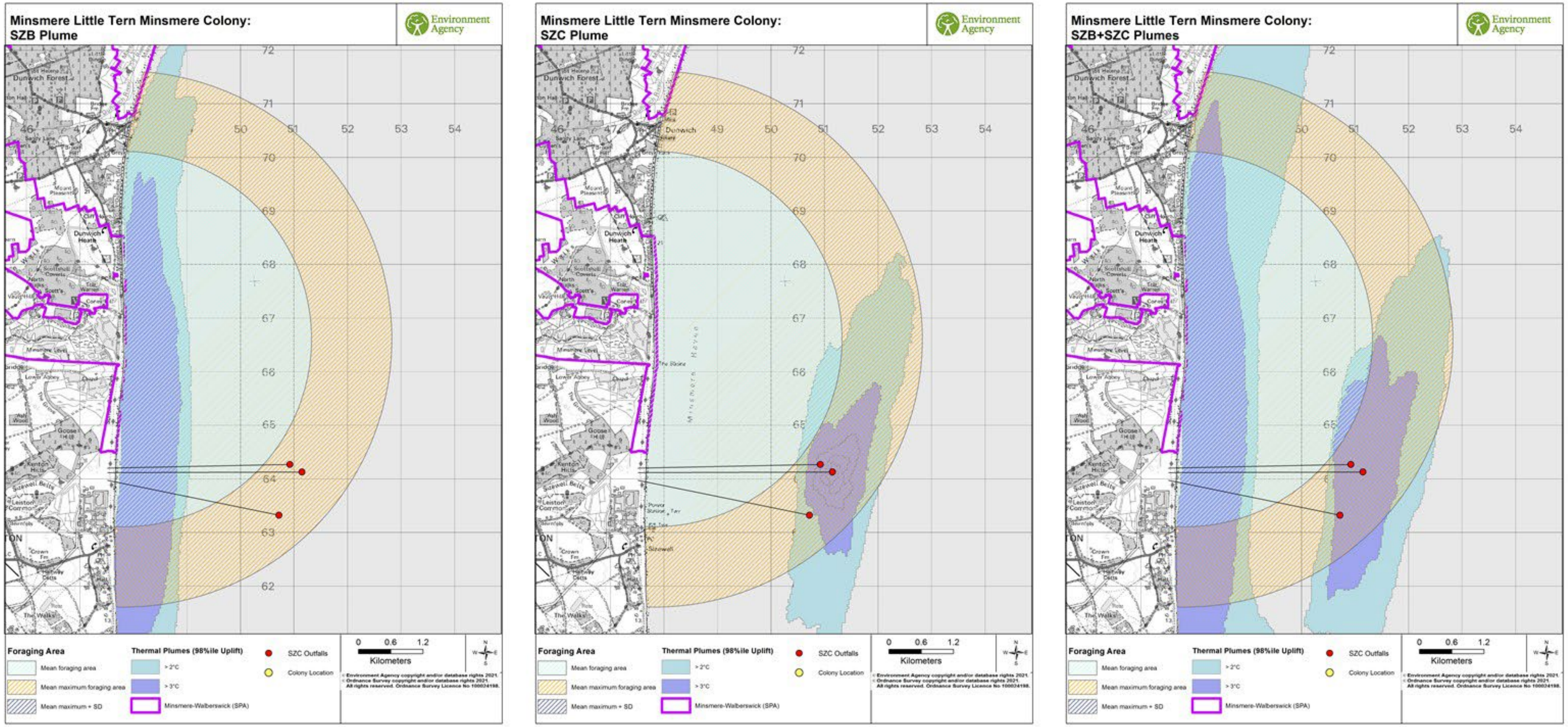

Figure 34: Mean and mean maximum foraging areas for breeding little tern centred on the Minsmere colony in the Minsmere-Walberswick SPA together with the ≥2°C and ≥3°C thermal uplift (98th percentile) plumes for SZB alone, SZC alone, and SZC and SZB in combination, as calculated by the applicant

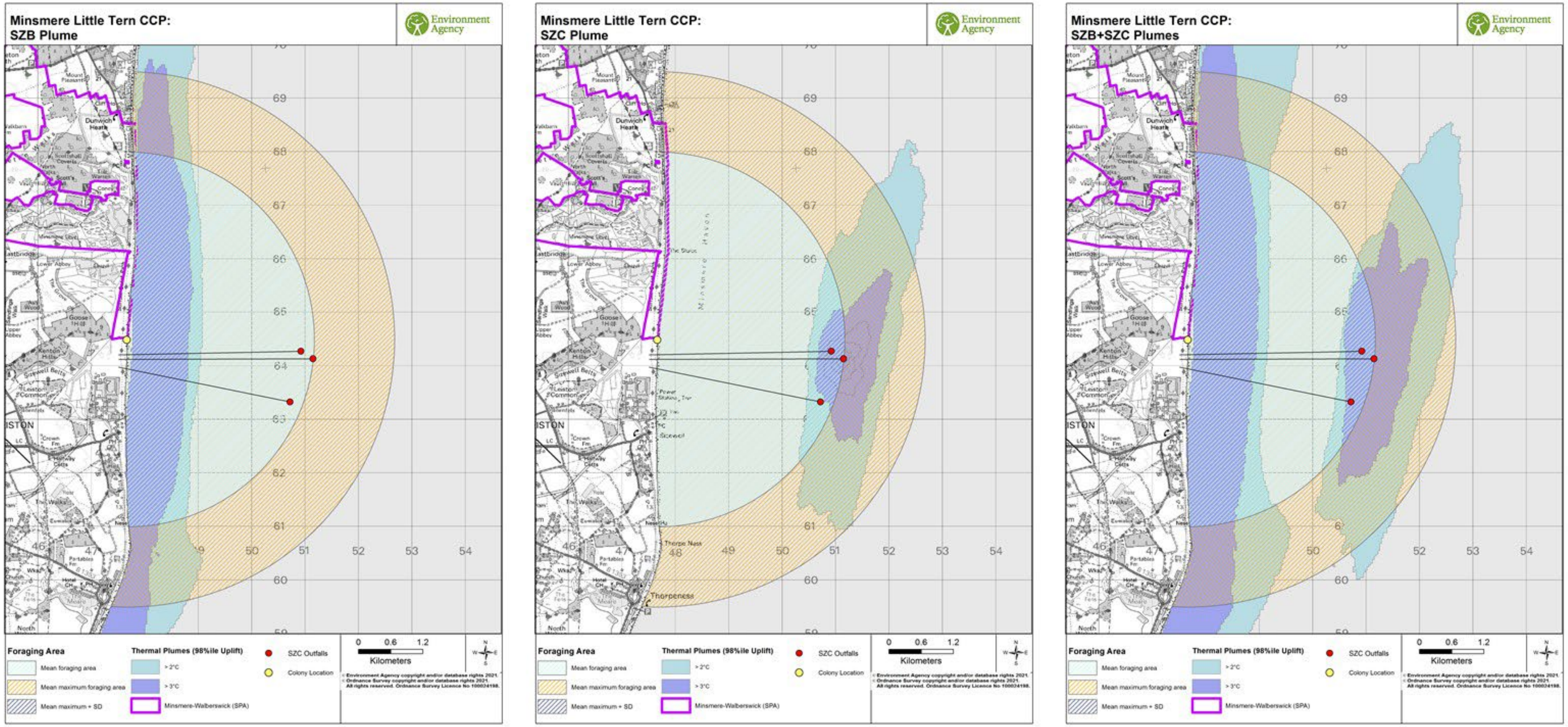

Figure 35: Mean and mean maximum foraging areas for breeding little tern centred on the closest coastal point in the Minsmere-Walberswick SPA together with the ≥2°C and ≥3°C thermal uplift (98th percentile) plumes for SZB alone, SZC alone, and SZC and SZB in combination, as calculated by the applicant

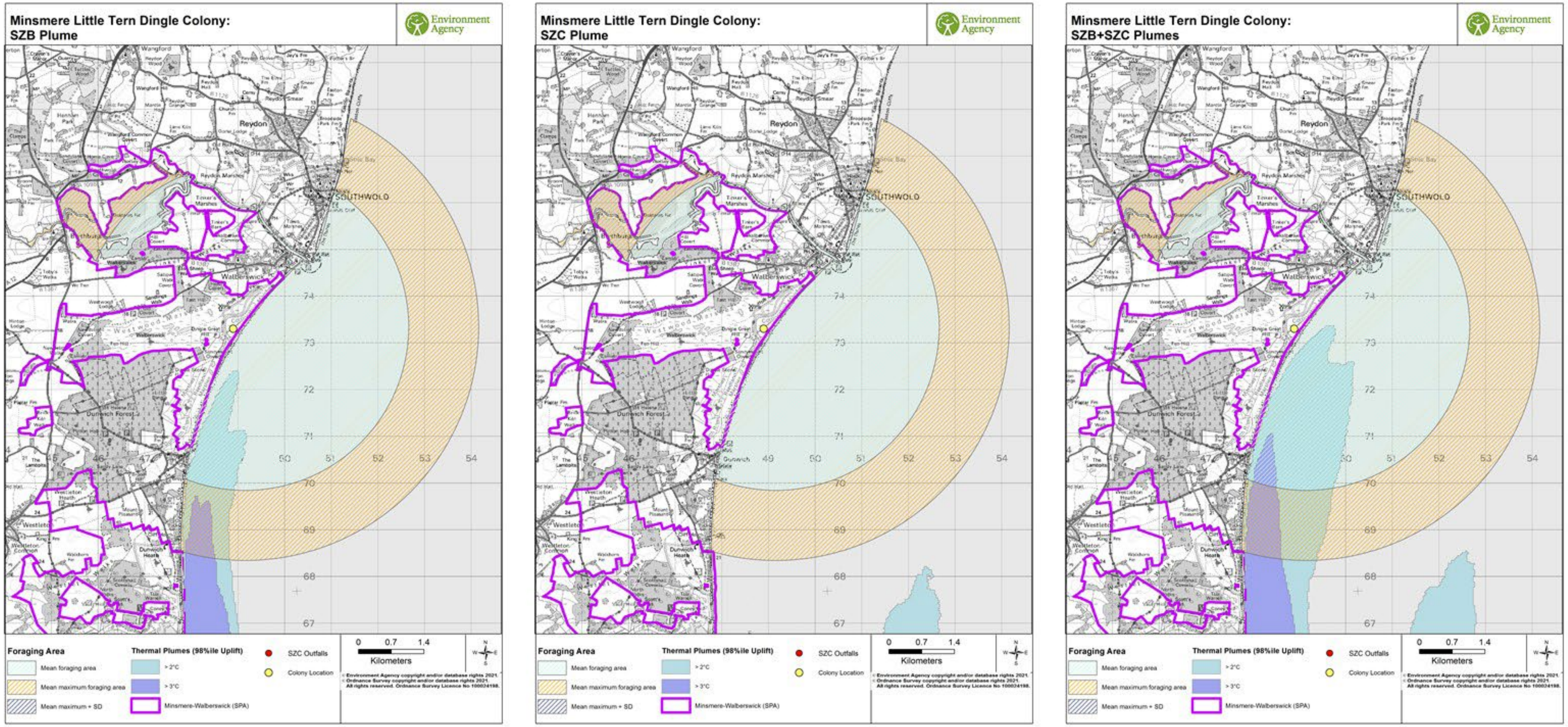

Figure 36: Mean and mean maximum foraging areas for breeding little tern centred on the Dingle colony in the Minsmere-Walberswick SPA together with the ≥2°C and ≥3°C thermal uplift (98th percentile) plumes for SZB alone, SZC alone, and SZC and SZB in combination, as calculated by the applicant

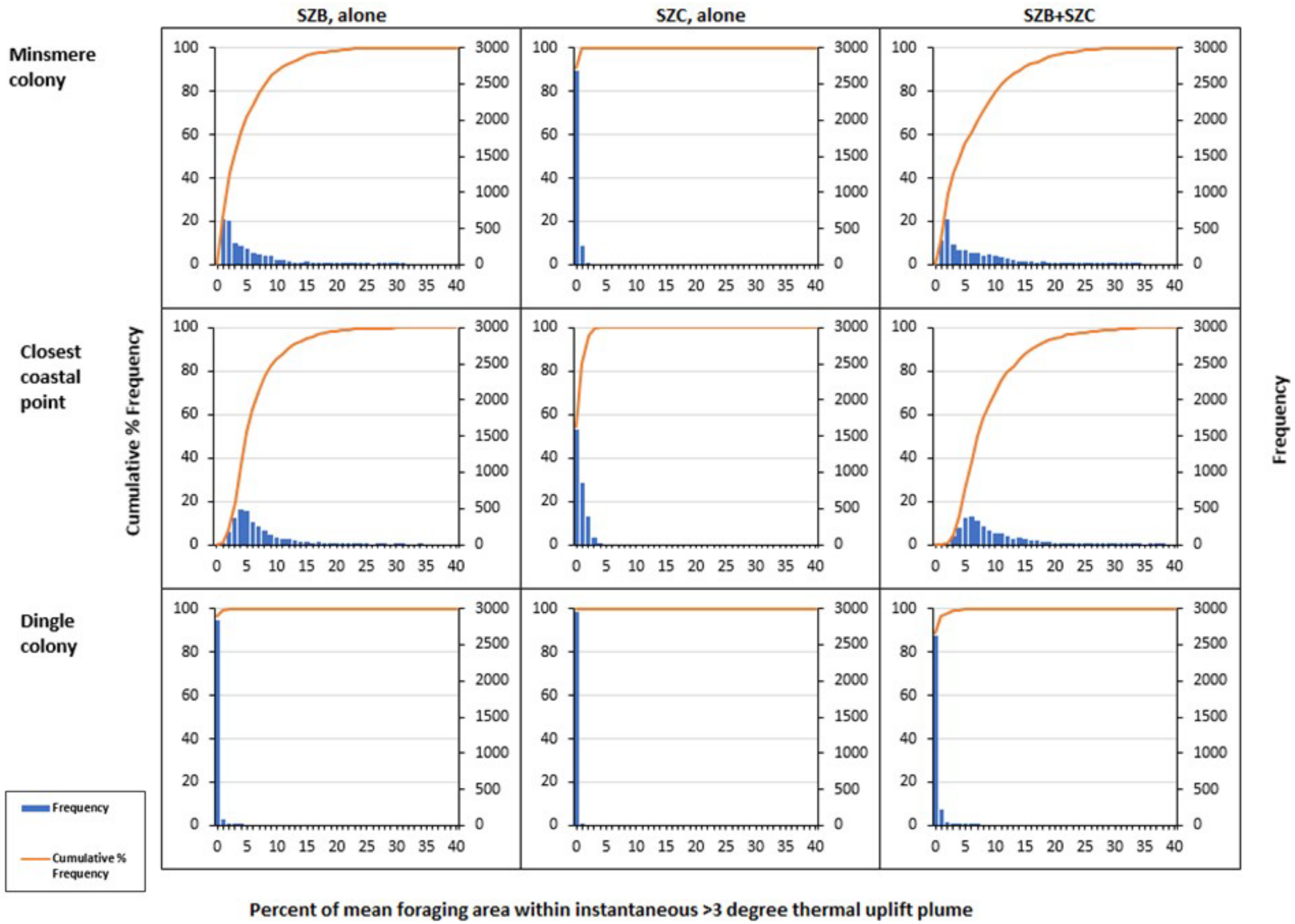

Figure 37: Frequency, and cumulative percentage frequency graphs showing the distribution of percentage overlaps between mean foraging area of Minsmere-Walberswick little terns centred on the Minsmere colony, the closest coastal point, or the Dingle colony and instantaneous ≥3°C thermal uplift plumes from SZB alone, SZC alone, and SZC and SZB in combination. Data provided by the applicant

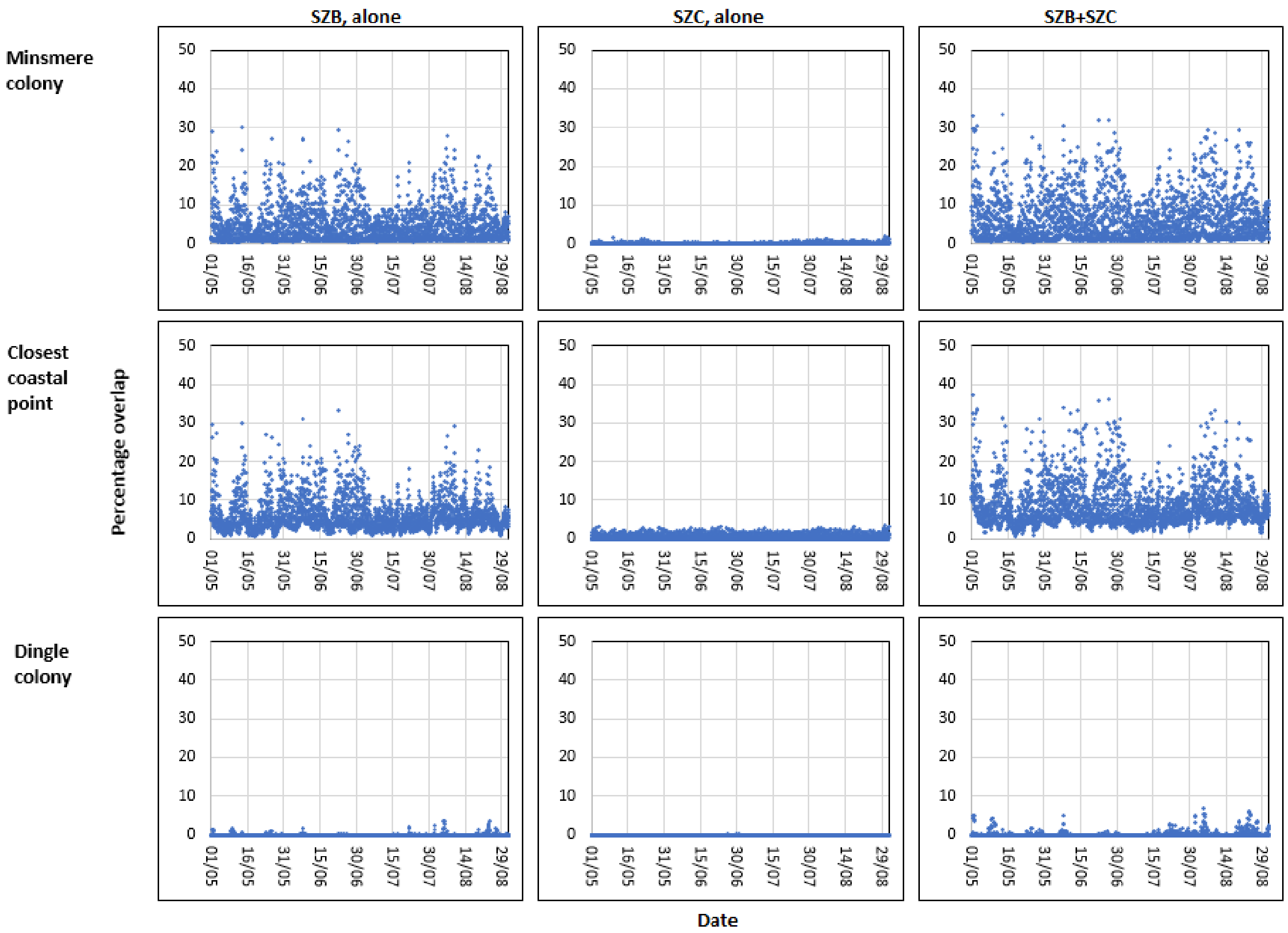

Figure 38: The distribution of percentage overlaps between mean foraging area of Minsmere-Walberswick little terns centred on the Minsmere colony, the closest coastal point, or the Dingle colony and instantaneous ≥3°C thermal uplift plumes from SZB alone, SZC alone, and SZC and SZB in combination, over the months when the breeding seabird feature is present. Data provided by the applicant

Outer Thames Estuary SPA

The Outer Thames Estuary SPA protects foraging areas for breeding little terns at colonies in the Alde-Ore Estuary SPA, Benacre to Easton Bavents SPA, Minsmere-Walberswick SPA, Great Yarmouth North Denes SPA, Foulness SPA and Thanet Coast and Sandwich Bay SPAs, as well as the Scroby Sands intertidal sandbank (which does not have an SPA designation).

Considering the temporal and geographical scale and location of thermal plumes in relation to the behaviour of the breeding little tern features, there will be no adverse effects on the breeding little tern features of the Alde-Ore Estuary SPA or the Minsmere-Walberswick SPA as a result of thermal uplift from SZC alone, or SZC and SZB in combination (section 8.6.5).

There are no source-receptor pathways linking breeding little terns in the Benacre to Easton Bavents SPA, Great Yarmouth North Denes SPA, Foulness SPA, Thanet Coast and Sandwich Bay SPAs, and the Scroby Sands intertidal sandbank to Sizewell due to their distance from the main development site.

Consequently, there will be no adverse effects on the breeding little tern features of the Outer Thames Estuary SPA as a result of thermal uplift from SZC alone, or SZC and SZB in combination.

Toxic contamination (chemical)

Direct effects

There is no potential for an adverse effect on breeding little tern through the direct effects of toxic contamination (chemical) from SZC alone, or SZC and SZB in combination, explained further here for each SPA in turn.

Alde-Ore Estuary SPA

There are no overlaps between mean foraging area and any of the chemical plumes discharged from SZC alone, or SZC and SZB in combination, for breeding little tern at the Slaughden colony or the closest coastal point (Table 21), and so the breeding little tern feature will not be adversely affected by toxic contamination (chemical).

Benacre to Easton Bavents SPA

There are no overlaps between mean foraging area and any of the chemical plumes discharged from SZC alone, or SZC and SZB in combination, for breeding little tern at the closest coastal point (Table 22), and so the breeding little tern feature will not be adversely affected by toxic contamination (chemical).

Minsmere-Walberswick SPA

The greatest overlaps between the mean foraging areas of little terns and the TRO ≥ EQS 10µg/l (95th percentile) plume occur in the Minsmere-Walberswick SPA for foraging areas centred on the Minsmere colony and the closest coastal point. Overlaps are markedly lower when SZC is operating alone, due to the offshore location of the discharge point and the associated TRO exceedance plume (Table 23, Figure 39, Figure 40). There are, however, no overlaps between mean foraging areas and either TRO, bromoform or hydrazine EQS/PNEC plumes for little terns from the Dingle colony for SZC alone, or SZC and SZB in combination (Table 24, Figure 41).

Overlaps between mean foraging area centred on the Minsmere colony and the TRO exceedance plume reduce from 12.8% (SZB, only) to 1.9% (SZC alone) (Table 23, Figure 39). There is a small increase to 14.7% overlap when SZC and SZB are operating in combination (Table 23, Figure 39). Despite an overlap of 1.9% with the TRO exceedance plume when SZC is operating alone, there would be no overlap at all with instantaneous TRO ≥ 10µg/l plumes for 26% of the hourly periods during the months the breeding seabird feature is present and ≤1% overlap for 94% of hourly periods (Q1 = 0.00%, median =0.01%, Q3 = 0.21%) (Table 23, Figure 42). With SZC and SZB operating in combination, there is little difference between percentage overlaps between mean foraging area and instantaneous 10µg/l TRO plumes, with interquartile ranges of around 1% to 5% in both cases (Table 23, Figure 42).

For the closest coastal point within the Minsmere-Walberswick SPA, overlaps between mean foraging area and the TRO exceedance plume reduce from 33.2% (SZB only) to 3.4% (SZC alone) (Table 23, Figure 40). There is an increase to 37.2% overlap when SZC and SZB are operating in combination (Table 23, Figure 40). Despite an overlap of 3.4% with the TRO exceedance plume when SZC is operating alone, around 95% of overlaps with the instantaneous TRO ≥ 10µg/l plumes would actually be ≤ 3% (Q1 = 0.53%, median = 0.81%, Q3 = 1.59%) (Table 23, Figure 42). With SZC and SZB operating in combination, little tern nesting at the closest coastal point would experience higher percentage overlaps (Q1 = 4.79%, median = 5.87%, Q3 = 7.22%), with instantaneous TRO ≥ 10µg/l plumes slightly more often than under baseline conditions (SZB alone) (Q1 = 3.96%, median = 4.77%, Q3 = 5.82%) (Table 23, Figure 42).

The percentage overlaps between mean foraging areas and the instantaneous ≥ 10µg/l TRO plume show no particular pattern over the course of the months when breeding little terns are present in the Minsmere-Walberswick SPA (Figure 43).

Exposure of little terns breeding at the Dunwich Beach colony to TRO would be intermediate between that of the Minsmere colony and the Dingle colony. Little tern breeding at the Walberswick colony would have no exposure to TRO within their mean foraging area, as is also the case for little tern breeding at the Dingle colony.

When SZC is operating alone, there are no overlaps between mean foraging area and the bromoform ≥ PNEC 5µg/l (95^{th} percentile) plume for little tern at the Minsmere colony or the Dingle colony (Table 23, Table 24). For little tern at the closest coastal point, there is a 1.2% overlap with the bromoform exceedance plume (Table 23). Instantaneous overlaps will be lower, and the offshore location (as for the TRO plume (Figure 40) means that due to little tern's preference for feeding nearshore, the potential for exposure would be low (should terns actually establish a colony at the closest coastal point).

When SZB and SZC are both operating in combination, overlaps with the bromoform exceedance plume for little tern at the Minsmere colony and the closest coastal point would be similar to baseline (SZB alone) (Table 23).

Direct toxic effects (chemical) from hydrazine discharged from SZC alone can be excluded for the Minsmere and Dingle colonies due to the low likelihood of contact between the seabirds and the plumes, and the precautionary nature of the PNECs (Table 23, Table 24). For mean foraging areas centred on the closest coastal point within the Minsmere-Walberswick SPA, overlap with the chronic hydrazine ≥ PNEC 0.4ng/l (as a mean) plume is 2.2% (Table 23). However, the overlap with the hydrazine ≥ acute PNEC 4ng/l is just 0.4%, and so there is very little possibility of a direct toxic effect on the Minsmere-Walberswick breeding little tern feature, even if a colony were to establish at the closest coastal point.

Due to the low percentage values of overlap between mean foraging area and chemical plumes, and the precautionary nature of the EQS and PNEC values with regard to direct toxic effects on birds, there will be no direct effect on Minsmere-Walberswick SPA breeding little tern from toxic contamination (chemical) as a result of the water discharge activities of SZC alone.

There will be no adverse effect on the breeding little tern feature of the Minsmere-Walberswick SPA while SZC and SZB are operating in combination. Due to the transitory nesting habits of little tern, and the precautionary nature of the EQS/PNEC values, a small increase in frequency of overlap between mean foraging area and chemical plumes towards the south of the SPA will not adversely affect the breeding little tern feature over the site as a whole. This will be the case whether SZB is decommissioned in 2035, or whether its operational life is extended to 2055.

Outer Thames Estuary SPA

The Outer Thames Estuary SPA protects foraging areas for breeding little terns at colonies in the Alde-Ore Estuary SPA, Benacre to Easton Bavents SPA, Minsmere-Walberswick SPA, Great Yarmouth North Denes SPA, Foulness SPA and Thanet Coast and Sandwich Bay SPAs, as well as the Scroby Sands intertidal sandbank (which does not have an SPA designation).

Considering the temporal and geographical scale of TRO, bromoform and hydrazine plumes in relation to the behaviour of the breeding little tern features, and the precautionary nature of the EQS/PNEC values, there will be no adverse effects on the breeding little tern features of the Alde-Ore Estuary SPA or Minsmere-Walberswick SPA as a direct result of toxic contamination (chemical) from SZC alone, or SZC and SZB in combination (section 8.6.5).

There are no source-receptor pathways for the toxic contamination (chemical) pressure between the Sizewell site and breeding little tern features of the Benacre to Easton Bavents SPA, Great Yarmouth North Denes SPA, Foulness SPA, Thanet Coast and Sandwich Bay SPAs, or the Scroby Sands intertidal sandbank due to their distance from the main development site.

Consequently, there will be no direct adverse effects on the breeding little tern features of the Outer Thames Estuary SPA as a result of toxic contamination (chemical) from SZC alone, or SZC and SZB in combination.

Indirect effects

There is no potential for an adverse effect on breeding little tern through the indirect effects of toxic contamination (chemical) from SZC alone, or SZC and SZB in combination, explained further here for each SPA and Ramsar in turn.

Alde-Ore Estuary SPA

There are no overlaps between mean foraging area and any of the chemical plumes discharged from SZC alone, or SZC and SZB in combination, for breeding little tern at the Slaughden colony or the closest coastal point (Table 21), and so there will be no indirect effects of toxic contamination (chemical).

Benacre to Easton Bavents SPA

There are no overlaps between mean foraging area and any of the chemical plumes discharged from SZC alone, or SZC and SZB in combination, for breeding little tern at the closest coastal point (Table 22), and so will be no indirect effects of toxic contamination (chemical).

Minsmere-Walberswick SPA

There are no indirect effects of toxic contamination (chemical) on the breeding little tern feature of the Minsmere-Walberswick SPA, from either SZC alone, or SZC and SZB in combination.

For SZC alone, although overlaps between mean foraging areas and TRO ≥ EQS 10μg/l (95th percentile) plumes exceed 1% when centred on the Minsmere colony or the closest coastal point, instantaneous overlaps are generally small, having a upper quartile value of 0.21% for Minsmere and 1.59% for the closest coastal point (Table 23, Figure 39, Figure 40, Figure 42). There is no overlap for little tern foraging ranges centred on the Dingle colony. Overlaps for foraging areas centred on the Dunwich Beach colony would be intermediate between those of the Minsmere colony and those of the Dingle colony. Being further north than the Dingle colony, there would also be no overlap between foraging areas centred on the Walberswick colony location and the TRO plume. The TRO exceedance plume for SZC alone is situated offshore, and so outside of the preferred foraging areas of little tern, which feed nearshore, including in the surf zone (Eglington and Perrow, 2014, Figure 33).

Given the absence of overlap with TRO plumes for the northernmost colonies, the generally low instantaneous overlaps experienced by the southerly colonies (and closest coastal point), the offshore location of the SZC discharge and the transitory nesting habits of little tern, then any avoidance behaviour by fish as a result of TRO discharged from SZC alone, would not have an adverse effect on the breeding little tern feature.

As the largest of the chemical plumes scoped into the assessment, overlaps between the TRO exceedance plume and mean foraging areas (as a proxy for areas of concentrated foraging activity) represents a worst-case scenario. The lack of indirect adverse effect from the discharge of TRO by SZC alone means that we can also conclude there will be no adverse effects on the breeding little tern feature resulting from the release of bromoform or hydrazine, and therefore no adverse effect from toxic contamination (chemical) from SZC alone.

For SZC and SZB in combination, although there are considerable overlaps between mean foraging areas and TRO ≥ EQS 10μg/l (95th percentile) plumes for mean foraging areas centred on the Minsmere colony (36.4%) and closest coastal point (45.9%), instantaneous overlaps are generally much smaller, having a upper quartile value of 5.3% for Minsmere and 7.2% for the closest coastal point (Table 23, Figure 39, Figure 40, Figure 42). At this scale, any avoidance behaviour by fish would not have an adverse effect on the breeding little tern feature.

There is no overlap for little tern foraging ranges centred on the Dingle colony.

Overlaps for foraging areas centred on the Dunwich Beach colony would be intermediate between those of the Minsmere colony and those of the Dingle colony. Being further north than the Dingle colony, there would also be no overlap between foraging areas centred on the Walberswick colony location and the TRO plume.

There is no interaction between the TRO exceedance plumes from SZC and SZB in combination. The SZC plume is situated offshore, and so outside of the preferred foraging areas of little tern, which feed nearshore, including in the surf zone (Eglington and Perrow, 2014, Figure 33). Consequently, although there is an increase in the proportion of the TRO exceedance plume within the mean foraging area of little terns centred on the Minsmere colony and the closest coastal point when SZC and SZB are operating in combination, the effect of this increase on the foraging behaviour of little terns will be lessened due to the offshore location of the SZC TRO exceedance plume.

Any avoidance behaviour by fish as a result of TRO discharged from SZC and SZB in combination would not have an adverse effect on the breeding little tern feature due to the absence of overlap with TRO plumes for the northernmost colonies, the similarity to baseline of the instantaneous overlaps experienced by the southerly colonies (and closest coastal point), the offshore location of the SZC discharge and the transitory nesting habits of little tern. This will be the case whether SZB is decommissioned in 2035, or whether its operational life is extended to 2055.

As the largest of the chemical plumes scoped into the assessment, overlaps between the TRO exceedance plume and mean foraging areas (as a proxy for areas of concentrated foraging activity) represents a worst-case scenario. The lack of indirect adverse effect from the discharge of TRO by SZC alone means that we can also conclude there will be no adverse effects on the breeding little tern feature resulting from the release of bromoform or hydrazine, and therefore no adverse effect from toxic contamination (chemical) from SZC and SZB in combination.

Outer Thames Estuary SPA

The Outer Thames Estuary SPA protects foraging areas for breeding little terns at colonies in the Alde-Ore Estuary SPA, Benacre to Easton Bavents SPA, Minsmere-Walberswick SPA, Great Yarmouth North Denes SPA, Foulness SPA and Thanet Coast and Sandwich Bay SPAs, as well as the Scroby Sands intertidal sandbank (which does not have an SPA designation).

Considering the temporal and geographical scale of TRO, bromoform and hydrazine plumes in relation to the behaviour of the breeding little tern features, there will be no adverse effects on the breeding little tern features of the Alde-Ore Estuary SPA and Minsmere-Walberswick SPA as an indirect result of toxic contamination (chemical) from SZC alone, or SZC and SZB in combination (section 8.6.5).

There are no source-receptor pathways for the toxic contamination (chemical) pressure between Sizewell and breeding little terns in the Benacre to Easton Bavents SPA, Great Yarmouth North Denes SPA, Foulness SPA, Thanet Coast and Sandwich Bay SPAs, or the Scroby Sands intertidal sandbank sites, due to their distance from the main development site.

Consequently, there will be no indirect adverse effects on the breeding little tern features of the Outer Thames Estuary SPA as a result of toxic contamination (chemical) from SZC alone or SZC and SZB in combination.

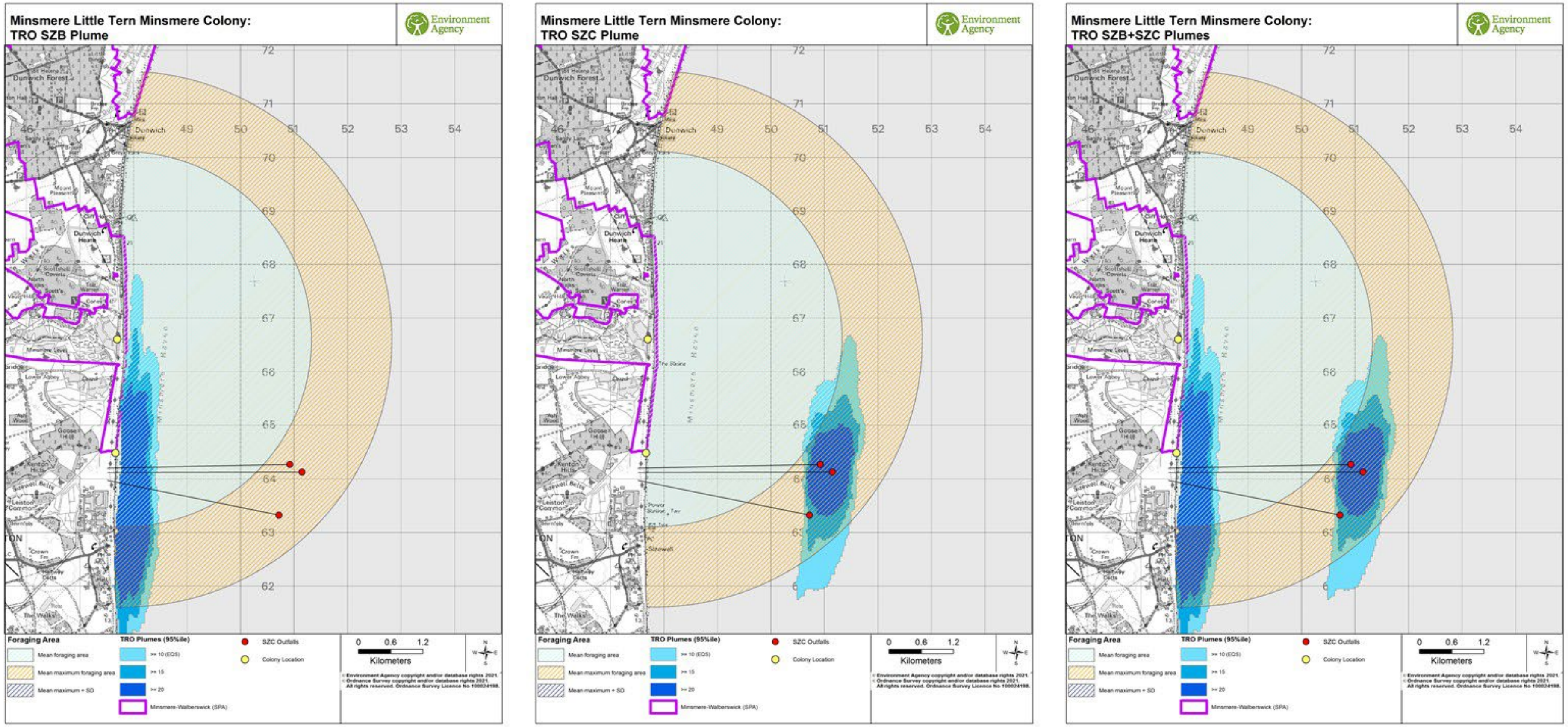

Figure 39: Mean and mean maximum foraging areas for breeding little tern centred on the Minsmere colony in the Minsmere-Walberswick SPA together with the EQS ≥ 10µg/l TRO (95th percentile) plumes for SZB alone, SZC alone, and SZC and SZB in combination, as calculated by the applicant

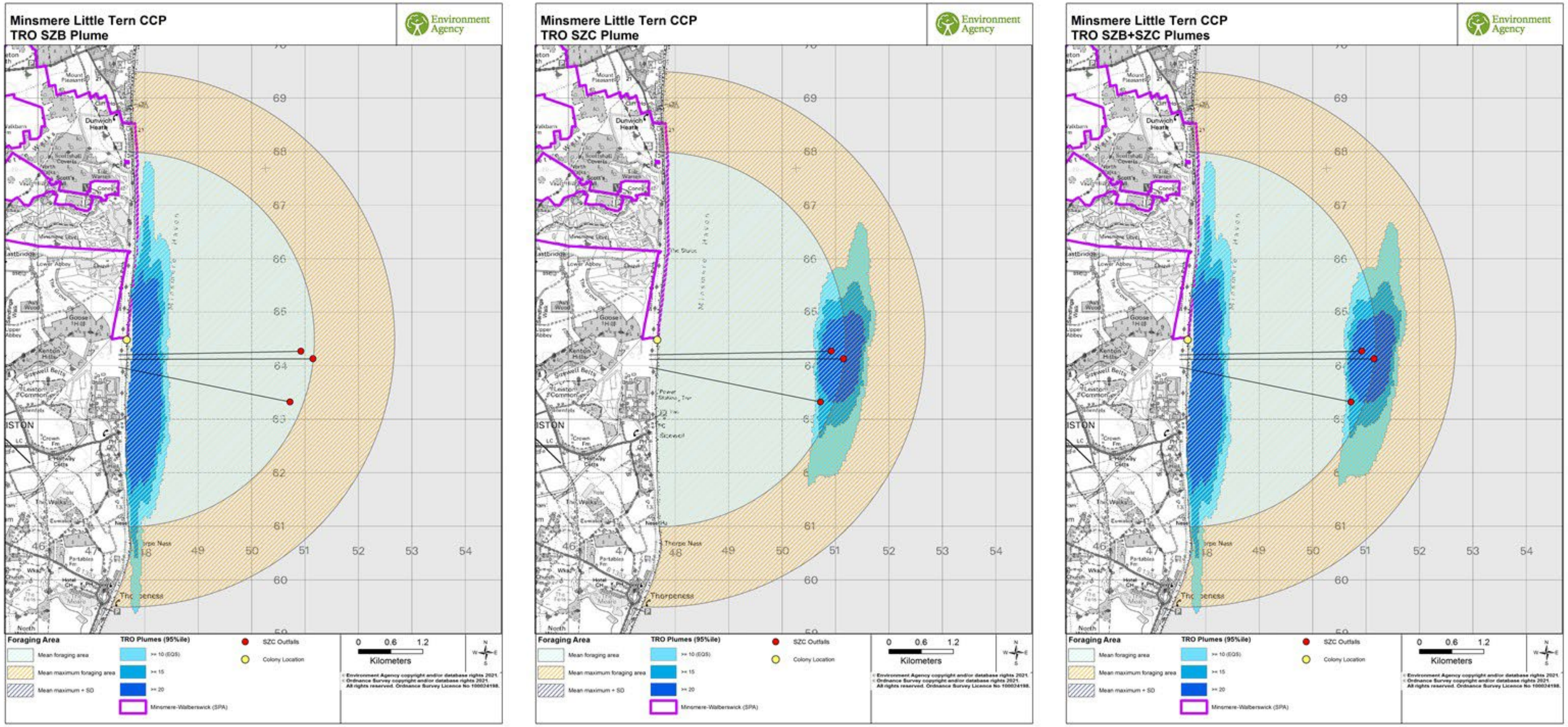

Figure 40: Mean and mean maximum foraging areas for breeding little tern centred on the closest coastal point within the Minsmere-Walberswick SPA together with the EQS ≥ 10µg/l TRO (95th percentile) plumes for SZB alone, SZC alone, and SZC and SZB in combination, as calculated by the applicant

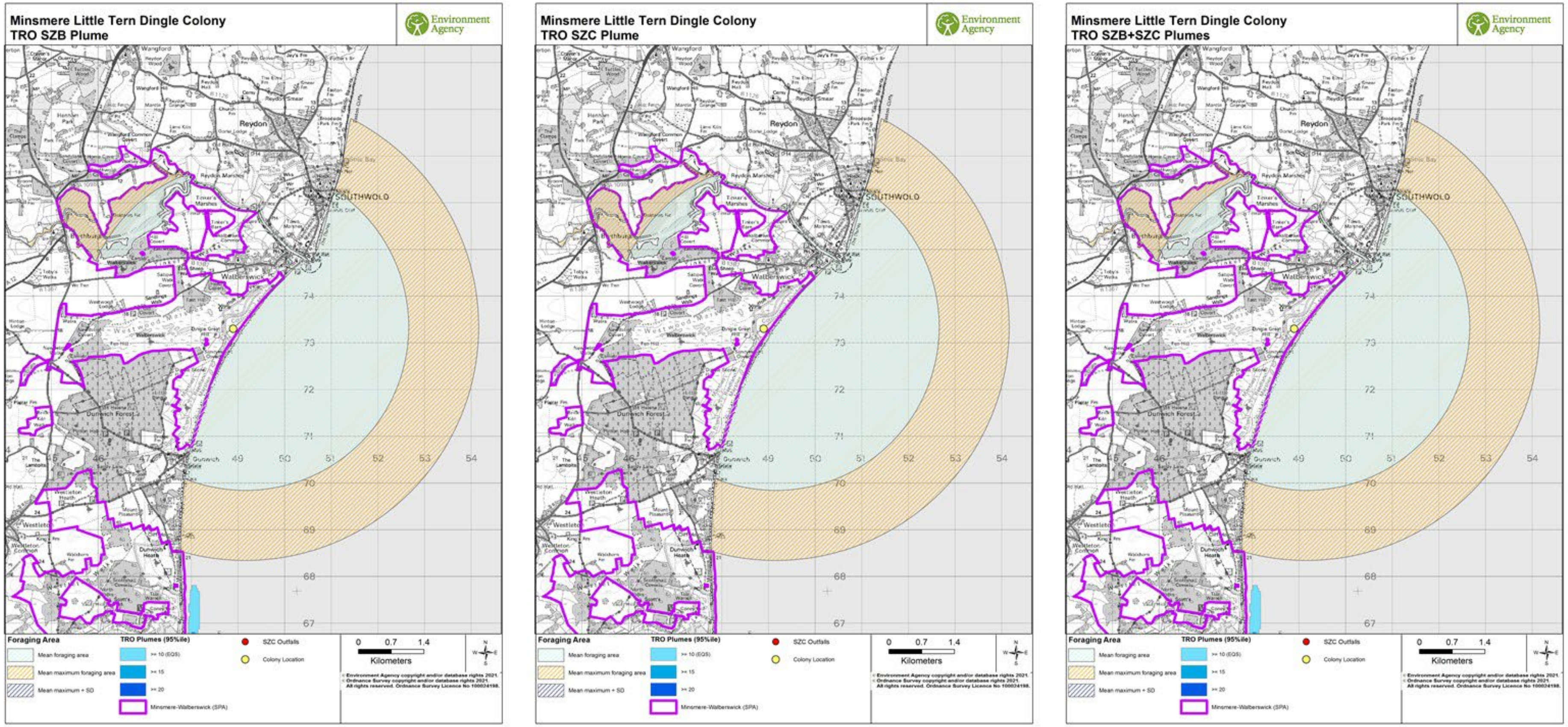

Figure 41: Mean and mean maximum foraging areas for breeding little tern centred on the Dingle colony within the Minsmere-Walberswick SPA together with the EQS ≥ 10µg/l TRO (95th percentile) plumes for SZB alone, SZC alone, and SZC and SZB in combination, as calculated by the applicant

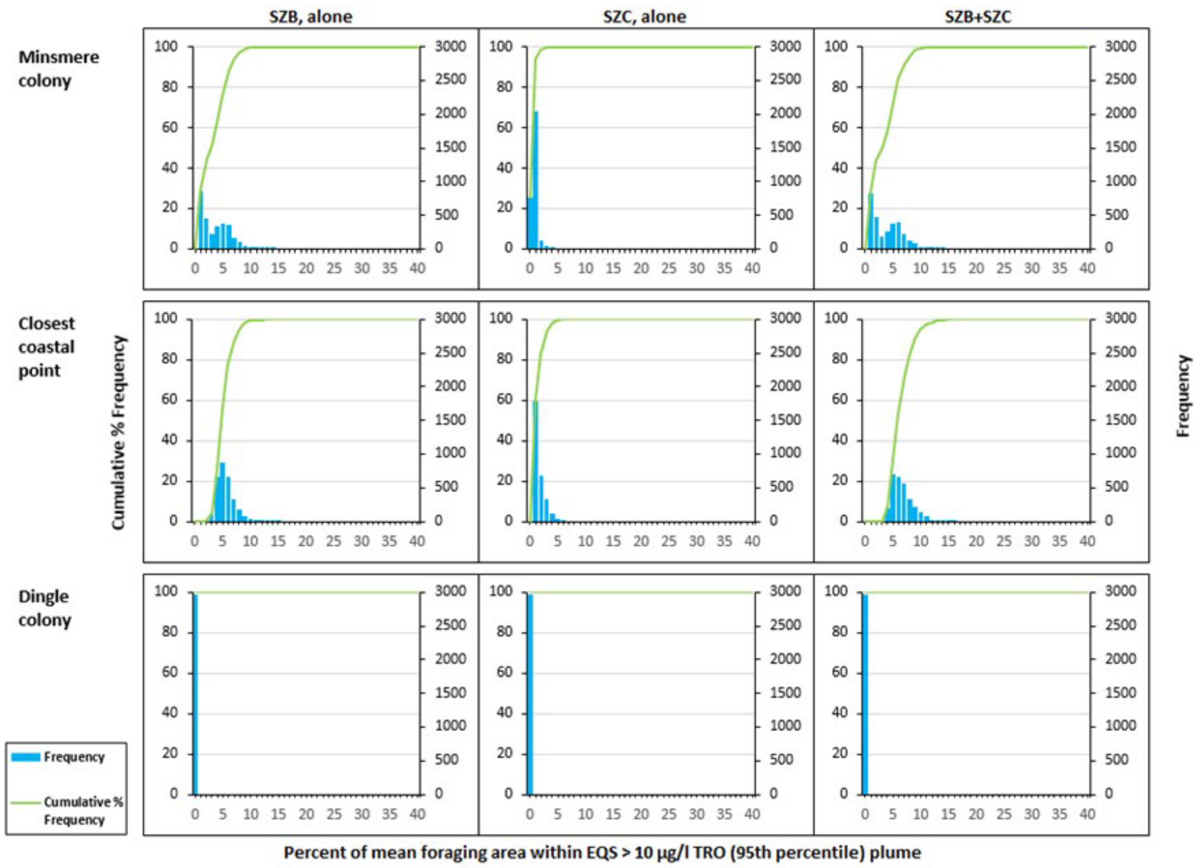

Figure 42: Frequency and cumulative percentage frequency graphs showing the distribution of percentage overlaps between mean foraging area of Minsmere-Walberswick little terns centred on the Minsmere colony, the closest coastal point, or the Dingle colony and instantaneous ≥ 10µg/l TRO plumes from SZB alone, SZC alone, and SZC and SZB in combination. Data provided by the applicant

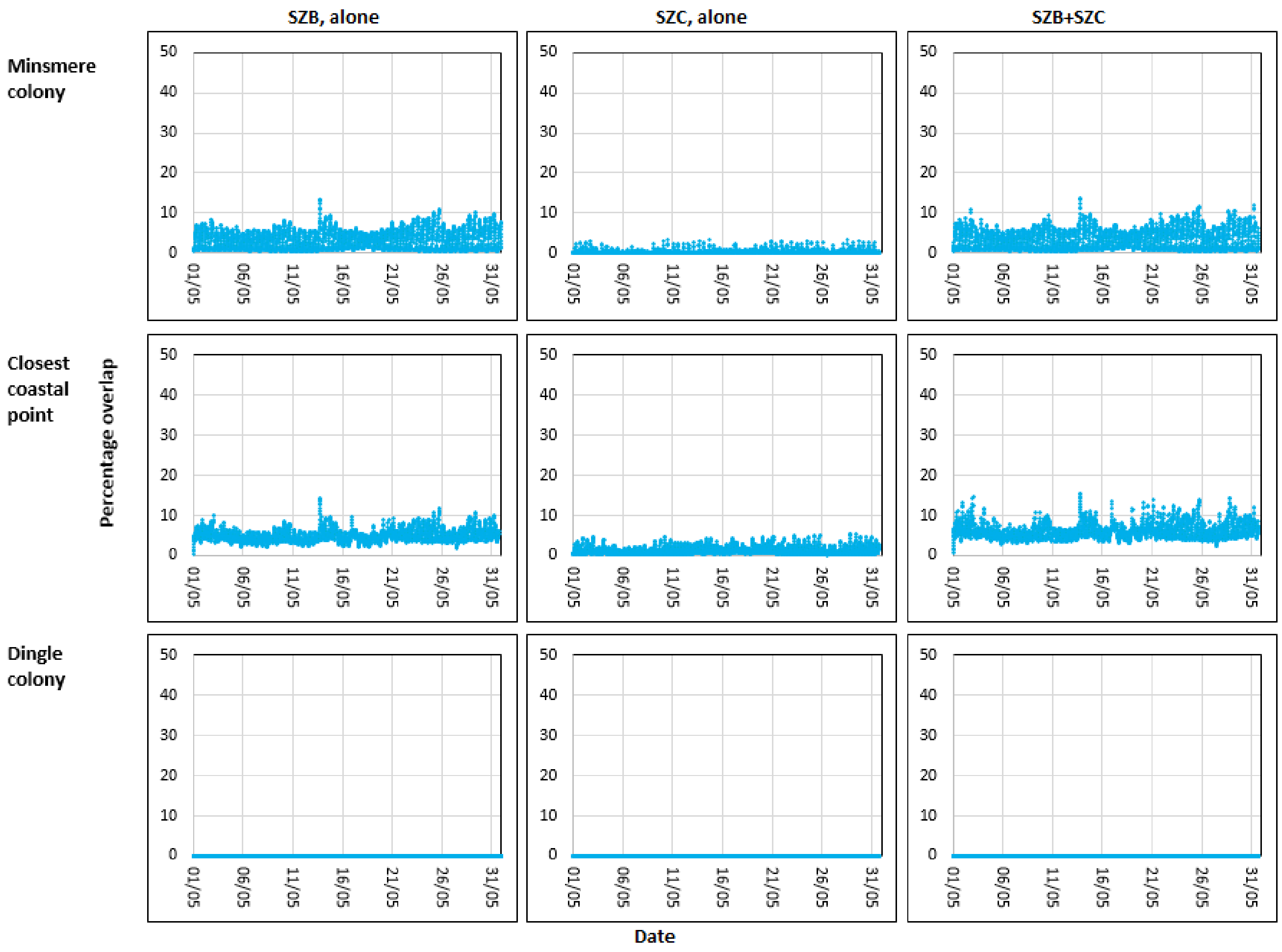

Figure 43: The distribution of percentage overlaps between mean foraging area of Minsmere-Walberswick little terns centred on the Minsmere colony, the closest coastal point, or the Dingle colony and instantaneous ≥ 10µg/l TRO plumes from SZB alone, SZC alone, and SZC and SZB in combination, over the months when the breeding seabird feature is present. Data provided by the applicant

Changes in nutrients/eutrophication

Direct effects

There are no source-receptor pathways by which organic or nutrient enrichment from SZC alone, or SZC and SZB in combination can directly affect breeding seabird features (section 8.3.3).

Indirect effects

There are no indirect effects of organic enrichment on the breeding little tern features from either SZC alone or SZC and SZB in combination (section 8.3.3).

Changes in nutrient enrichment, un-ionised ammonia and dissolved oxygen levels resulting from the operation of SZC alone or SZC and SZB in combination will not lead to any indirect effects on breeding seabird features (section 8.3.3).

Supporting habitats

There will be no adverse effects on the supporting habitats of breeding little tern feeding in the Outer Thames Estuary SPA as a result of the operation of SZC alone or SZC and SZB in combination.

Terns use the intertidal sand and muddy sand habitat for resting/loafing when the tide is out. Any effects on the intertidal sand and muddy sand supporting habitat will only occur when the tide is in and therefore the water discharge activities of SZC alone, or SZC and SZB in combination, will not affect the ability of the intertidal sand and muddy sand habitat to support breeding little terns.

Foraging takes place in the water column supporting habitat in the Outer Thames Estuary SPA, but given the small size of overlaps between thermal and chemical plumes from SZC alone, and the low level of nutrient input relative to tidal dynamics, any effects on the water column supporting habitat from SZC alone, will not adversely affect the breeding seabird feature (Table 37). When SZC and SZB are operating in combination, thermal and chemical plumes are comparable to, or somewhat worse than, baseline. However, any negative effects on little terns along the Suffolk and Norfolk coastline would be likely to be offset by their transitory breeding behaviour, whether SZB is decommissioned in 2035 or its operational life extended, potentially to 2055 (Table 37). The ability of the water column habitat to support breeding little tern will not be adversely affected by the water discharge activities of SZC and SZB in combination.

Table 37: The sensitivities of the water column supporting habitat for little tern foraging in the Outer Thames Estuary SPA, as described in NE Advice on Operations, together with the expected effects as a result of SZC alone, and SZC and SZB in combination

Pressure (from NE advice on operations)	Supporting habitat	Sensitivity	Effect of SZC alone	Effect of SZC+SZB
Increases in temperature	Water column	Sensitive	No effect. While thermal uplift may potentially affect the water column within the Outer Thames Estuary SPA, breeding little tern will be unaffected due to the area of uplift forming only a small percentage of their potential foraging area, and being offshore, away from concentrated foraging locations. Further resilience is provided by the functional linkage of Suffolk and Norfolk colonies and the transitory nesting habits of little terns. The ability of the water column habitat to support breeding little terns will be unaffected.	No effect. The percentage of the water column supporting habitat affected by thermal uplift is greater for SZC and SZB in combination than for SZB alone or SZC alone, but the area of uplift still forms only a small percentage of the potential foraging area. The increase in area of thermal uplift with SZC and SZB operating in combination takes place primarily offshore, away from concentrated foraging locations. Further resilience is provided by the functional linkage of Suffolk/Norfolk colonies and the transitory nesting habits of little terns. The ability of the water column habitat to support breeding little terns will be unaffected, whether SZB is decommissioned in 2035 or its life extended, potentially to 2055.
Other substances	Water column	Not assessed	No effect. Little terns foraging from some colonies within the nearby SPAs would encounter some areas of TRO, bromoform and hydrazine	No effect. Little terns foraging from some colonies within nearby SPAs would encounter slightly increased percentages of the water column affected by TRO, bromoform and hydrazine

Pressure (from NE advice on operations)	Supporting habitat	Sensitivity	Effect of SZC alone	Effect of SZC+SZB
(solid, liquid or gas)			exceedance. However, the areas affected are small percentages of the foraging area, and the threshold values used are precautionary with regard to direct and indirect effects. Several colonies will be unaffected. The ability of the water column habitat to support breeding little terns will be unaffected.	exceedance as compared to baseline (SZB alone). However, for TRO, the area of exceedance likely to be encountered on any particular foraging trip is relatively low and forms only a small percentage of the potential foraging area. TRO is the largest plume and therefore represents a worst case with regard to toxic contamination (chemical). Several colonies will be unaffected. The increase in area of exceedance when SZC and SZB are operating in combination takes place primarily offshore, away from concentrated foraging locations for breeding little terns. Further resilience is provided by the functional linkage of Suffolk and Norfolk colonies and the transitory nesting habits of little terns. The ability of the water column habitat to support breeding little terns will be unaffected, whether SZB is decommissioned in 2035 or its operational life is extended, potentially to 2055.
Nutrient enrichment	Water column	Sensitive	No effect. Nutrient enrichment, from SZC alone, will be insufficient to lead to opportunistic macroalgal or phytoplankton blooms and the ability of the water column habitat to support	No effect. As for SZC alone.

Pressure (from NE advice on operations)	Supporting habitat	Sensitivity	Effect of SZC alone	Effect of SZC+SZB
			the foraging behaviour of the breeding little tern features will be unaffected.	
Changes in suspended solids (water clarity)	Water column	Sensitive	No effect. There is no potential for nutrient enrichment to increase turbidity and the ability of the water column habitat to support the foraging behaviour of the breeding little tern features will be unaffected.	No effect. As for SZC alone.

8.6.6. Conclusion

Alde-Ore Estuary SPA

We have considered the relevant risks associated with the discharges, from SZC alone, and from SZC and SZB in combination, that are the subject of this application, on the little tern (breeding) feature of the Alde-Ore Estuary SPA in light of the designated site's conservation objectives and supplementary advice on conservation objectives (Table 38).

Despite the decline in numbers of breeding pairs since the site was designated (from 48 pairs to no longer being regularly occupied), the scale of impacts from the discharges from the cooling water system and the FRR system, compared to the foraging area of the feature, allows us to conclude that there will be **no adverse effect** on this qualifying feature from the water discharge activities of SZC alone, in terms of maintaining or restoring the:

- extent and distribution of the habitats of the qualifying features
- structure and function of the habitats of the qualifying features
- supporting processes on which the habitats of the qualifying features rely
- populations of each of the qualifying features
- distribution of qualifying features within the site

SZB is expected to continue to operate until 2035, although there is potential for an extension of SZB's operational lifetime by 20 years to 2055 at the latest. Consequently, SZC and SZB may be operating in combination for between 2 and 22 years. However, the scale and location of impacts from the discharges from the cooling water system and the FRR system, together with the transitory breeding behaviour of little tern, allows us to conclude that there will be **no adverse effect** on this qualifying feature from the water discharge activities of SZC and SZB in combination, in terms of maintaining or restoring the:

- extent and distribution of the habitats of the qualifying features
- structure and function of the habitats of the qualifying features
- supporting processes on which the habitats of the qualifying features rely
- populations of each of the qualifying features
- distribution of qualifying features within the site

Benacre to Easton Bavents SPA

We have considered the relevant risks associated with the discharges, from SZC alone, and from SZC and SZB in combination, that are the subject of this application, on the little tern (breeding) feature of the Benacre to Easton Bavents SPA in light of the designated site's conservation objectives and supplementary advice on conservation objectives (Table 38).

Due to its distance from the SZC discharge point and the 5km mean maximum foraging range of breeding little tern, there is no overlap with ≥2°C or ≥3°C thermal uplift (98th percentile) plumes or chemical plumes, and therefore minimal interaction with the discharges from the cooling water system and the FRR system. We therefore conclude that there will be **no adverse effect** on this qualifying feature from the water discharge activities of SZC alone, in terms of maintaining or restoring the:

- extent and distribution of the habitats of the qualifying features
- structure and function of the habitats of the qualifying features
- supporting processes on which the habitats of the qualifying features rely
- populations of each of the qualifying features
- distribution of qualifying features within the site

Similarly, there is minimal interaction with the discharges from the cooling water systems and the FRR systems of SZC and SZB in combination, which us to conclude that, irrespective of the decommissioning date of SZB, there will be **no adverse effect** on this qualifying feature from the water discharge activities of SZC and SZB in combination, in terms of maintaining or restoring the:

- extent and distribution of the habitats of the qualifying features
- structure and function of the habitats of the qualifying features
- supporting processes on which the habitats of the qualifying features rely
- populations of each of the qualifying features
- distribution of qualifying features within the site

Minsmere to Walberswick SPA

We have considered the relevant risks associated with the discharges, from SZC alone, and from SZC and SZB in combination, that are the subject of this application, on the little tern (breeding) feature of the Minsmere-Walberswick SPA in light of the designated site's conservation objectives and supplementary advice on conservation objectives (Table 38).

There has been a decline in numbers of breeding pairs since the site was designated, from 32 breeding pairs at the time of classification (1991) to 1.6 breeding pairs (5-year mean peak count 2014 to 2018). However, the scale and location of impacts from the discharges from the cooling water system and the FRR system, compared to the potential foraging area and areas of concentrated foraging activity, coupled with the transitory nesting behaviour and meta-population structure of the feature, allows us to conclude that there will be **no adverse effect** on this qualifying feature from the water discharge activities of SZC alone, in terms of maintaining or restoring the:

- extent and distribution of the habitats of the qualifying features

- structure and function of the habitats of the qualifying features
- supporting processes on which the habitats of the qualifying features rely
- populations of each of the qualifying features
- distribution of qualifying features within the site

SZB is expected to continue to operate until 2035, although there is potential for an extension of SZB's operational lifetime by 20 years to 2055 at the latest. Consequently, SZC and SZB may be operating in combination for between 2 and 22 years. However, the scale, location and duration of impacts from the discharges from the cooling water systems and the FRR systems of SZC and SZB in combination, compared to the potential foraging area and areas of concentrated foraging activity, coupled with the transitory nesting behaviour and meta-population structure of the feature, allows us to conclude that, irrespective of the date of SZB decommissioning, there will be **no adverse effect** on this qualifying feature from the water discharge activities of SZC and SZB in combination, in terms of maintaining or restoring the:

- extent and distribution of the habitats of the qualifying features
- structure and function of the habitats of the qualifying features
- supporting processes on which the habitats of the qualifying features rely
- populations of each of the qualifying features
- distribution of qualifying features within the site

Outer Thames Estuary SPA

We have considered the relevant risks associated with the discharges, from SZC alone, and from SZC and SZB in combination, that are the subject of this application, on the little tern (breeding) feature of the Outer Thames Estuary SPA in light of the designated site's conservation objectives and supplementary advice on conservation objectives (Table 38).

There has been an overall decrease in numbers of breeding pairs since the site was designated, from 451 breeding pairs at or near the time of the constituent breeding colony's classification to 373 breeding pairs (2011 to 2015). However, the scale and location of impacts from the discharges from the cooling water system and the FRR system, compared to the potential foraging area and areas of concentrated foraging activity of all constituent colonies, coupled with the transitory nesting behaviour and meta-population structure of the feature, allows us to conclude that there will be **no adverse effect** on this qualifying feature from the water discharge activities of SZC alone, in terms of maintaining or restoring the:

- extent and distribution of the habitats of the qualifying features
- structure and function of the habitats of the qualifying features
- supporting processes on which the habitats of the qualifying features rely
- populations of each of the qualifying features

- distribution of qualifying features within the site

SZB is expected to continue to operate until 2035, although there is potential for an extension of SZB’s operational lifetime by 20 years to 2055 at the latest. Consequently, SZC and SZB may be operating in combination for between 2 and 22 years. However, the scale, location and duration of impacts from the discharges from the cooling water systems and the FRR systems of SZC and SZB in combination, compared to the potential foraging area and areas of concentrated foraging activity of all constituent colonies, coupled with the transitory nesting behaviour and meta-population structure of the feature, allows us to conclude that, (irrespective of the date of SZB decommissioning) there will be **no adverse effect** on this qualifying feature from the water discharge activities of SZC and SZB in combination, in terms of maintaining or restoring the:

- extent and distribution of the habitats of the qualifying features
- structure and function of the habitats of the qualifying features
- supporting processes on which the habitats of the qualifying features rely
- populations of each of the qualifying features
- distribution of qualifying features within the site

Table 38: The outcome of our appropriate assessment of the impact of water discharge activities from the operation of SZC alone, on targets contained within Natural England's Supplementary Advice on Conservation Objectives for the breeding little tern feature of the Alde-Ore Estuary SPA, Benacre to Easton Bavents SPA, Minsmere-Walberswick SPA and Outer Thames Estuary SPA (the table only shows targets which may be affected by water discharge activities)

Attribute	Sub-attribute	Site	Target	Outcome of SZC alone assessment	Outcome of SZC+SZB assessment
Breeding population	Abundance	Alde-Ore Estuary SPA	Restore the size of the breeding population at a level to be agreed*, while avoiding deterioration from its current level as indicated by the latest mean peak count or equivalent. *In the absence of an abundance value from the SPA citation, for information, the JNCC standard data form states there were 48 pairs of breeding little tern.	None of the attributes below will be adversely affected and so there will be no effect on the maintenance or restoration of the breeding little tern features.	As for SZC alone.
Breeding population	Abundance	Benacre to Easton Bavents SPA	Maintain the size of the breeding little tern	None of the attributes below will be adversely	As for SZC alone.

Attribute	Sub-attribute	Site	Target	Outcome of SZC alone assessment	Outcome of SZC+SZB assessment
			population at a level which is above 39 pairs, while avoiding deterioration from its current level as indicated by the latest mean peak count or equivalent.	affected and so there will be no effect on the maintenance or restoration of the breeding little tern features.	
Breeding population	Abundance	Minsmere-Walberswick SPA	Restore the size of the breeding population to a level which is above 32 breeding pairs, while avoiding deterioration from its current level as indicated by the latest mean peak count or equivalent.	None of the attributes below will be adversely affected and so there will be no effect on the maintenance or restoration of the breeding little tern features.	As for SZC alone.
Breeding population	Abundance	Outer Thames Estuary SPA	Maintain the size of the breeding population at a level which is at or above 746 breeding individuals, while avoiding deterioration from its current level as indicated	None of the attributes below will be adversely affected and so there will be no effect on the maintenance or restoration of the breeding little tern features.	As for SZC alone.

Attribute	Sub-attribute	Site	Target	Outcome of SZC alone assessment	Outcome of SZC+SZB assessment
			by the latest mean peak count or equivalent.		
Connectivity with supporting habitats	Connectivity with supporting habitats	Alde-Ore Estuary SPA, Benacre to Easton Bavents SPA, Minsmere-Walberswick SPA, Outer Thames Estuary SPA	Maintain safe passage of birds moving between nesting and feeding areas.	There are no physical obstructions to safe passage associated with the WDA permit. Absolute water temperature and chemical plumes would have no direct effect on breeding little tern and would not affect the safe passage of birds.	As for SZC alone.
Supporting habitat	Extent and distribution of supporting habitat for the breeding season	Alde-Ore Estuary SPA, Benacre to Easton Bavents SPA, Minsmere-Walberswick SPA, Outer Thames Estuary SPA	Maintain the extent, distribution and availability of suitable habitat (either within or outside the site boundary) which supports the feature for all necessary stages of its breeding cycle (courtship, nesting, feeding).	There will be no effect on the ability of suitable habitats to support breeding little terns.	As for SZC alone.

Attribute	Sub-attribute	Site	Target	Outcome of SZC alone assessment	Outcome of SZC+SZB assessment
Supporting habitat	Food availability	Alde-Ore Estuary SPA, Benacre to Easton Bavents SPA, Minsmere-Walberswick SPA, Outer Thames Estuary SPA	Maintain the abundance and availability of key prey species (for example, crustacea, annelids, sand eel, herring, clupeidae) at prey sizes preferred by little tern.	Due to the zero to low percentage overlap between foraging areas, areas of thermal uplift and areas of chemical exceedance, the distribution, abundance and availability of key main prey species at sizes preferred by little tern will be maintained.	The scale, location and duration of thermal uplift and chemical exceedance mean that the distribution, abundance and availability of key main prey species at sizes preferred by little tern will be maintained. Additional resilience is provided by the transitory nesting behaviour of little tern, which can locate their breeding attempts in response to localised changes in prey availability.
Water quality	Contaminants	Alde-Ore Estuary SPA, Benacre to Easton Bavents SPA, Minsmere-Walberswick SPA, Outer Thames Estuary SPA	Reduce aqueous contaminants to levels equating to high status according to Annex VIII and good status according to Annex X of the Water Framework Directive,	There will be mixing zones in which the EQS/PNEC values for TRO, bromoform and hydrazine will be exceeded. However, these will not be large	As for SZC alone.

Attribute	Sub-attribute	Site	Target	Outcome of SZC alone assessment	Outcome of SZC+SZB assessment
			avoiding deterioration from existing levels.	enough to result in deterioration in water quality at a scale which will affect the breeding little tern feature. The decay of biota discharged by the FRR system will not lead to the release of un-ionised ammonia to the extent that there will be a deterioration in water quality that will affect the breeding little tern feature.	
Water quality	Dissolved oxygen (DO)	Alde-Ore Estuary SPA, Benacre to Easton Bavents SPA, Minsmere-Walberswick SPA, Outer Thames Estuary SPA	Maintain the DO concentration at levels equating to high ecological status, avoiding deterioration from existing levels.	The decay of dead and moribund biota discharged by the FRR system will not lead to a deterioration from existing levels of DO concentration.	
Water quality	Nutrients	Alde-Ore Estuary SPA, Benacre to	Maintain water quality at mean winter dissolved	Discharges from the cooling water and FRR	As for SZC alone.

Attribute	Sub-attribute	Site	Target	Outcome of SZC alone assessment	Outcome of SZC+SZB assessment
		Easton Bavents SPA, Minsmere-Walberswick SPA, Outer Thames Estuary SPA	inorganic nitrogen levels where biological indicators of eutrophication (opportunistic macroalgal and phytoplankton blooms) do not affect the integrity of the site and features avoiding deterioration from existing levels.	systems will not lead to increases in dissolved inorganic nitrogen levels to the extent that indicators of eutrophication affect the integrity of the site.	
	Turbidity	Alde-Ore Estuary SPA, Benacre to Easton Bavents SPA, Minsmere-Walberswick SPA, Outer Thames Estuary SPA	Maintain natural levels of turbidity (for example, concentrations of suspended sediment, plankton and other material) across the habitat.	Organic enrichment will not lead to any increase in turbidity.	As for SZC alone.

8.7. Common tern (breeding)

By reference to its mean maximum + standard deviation foraging range (26.9km), the following site with breeding common tern as a qualifying feature has been identified by the applicant and considered appropriate for assessment:

- Outer Thames Estuary SPA

An ecological narrative for the feature is given in Environment Agency (2022c; Annex 3).

The following appropriate assessment will assess the potential for an adverse effect alone on the integrity of this site listed from direct and indirect effects on breeding common tern, resulting from the cooling water system and FRR system discharges.

8.7.1. Designated sites

The applicant considered that common tern was present as a breeding species from May to August in the Outer Thames Estuary SPA (NNB GenCo, 2021b; shadow HRA), based on the work of Furness (2015). NE's Senior Specialist in Marine Ornithology confirmed that these months were appropriate for use in our HRAR (email dated 9 November 2021).

The information that the applicant provided to support the HRAR (NNB GenCo, 2021b; shadow HRA), and NE's supplementary advice on conservation objectives tell us that:

- the Outer Thames Estuary SPA provides supporting habitat for breeding common terns, which are qualifying features of Breydon Water SPA and Foulness SPA. The Outer Thames Estuary SPA also supports common tern breeding from a number of other colonies, including within the Minsmere-Walberswick SPA (at Minsmere) and the Alde-Ore Estuary SPA (at Orfordness and Havergate Island), although the species is not a qualifying feature of either of these SPAs. There is also a breeding colony of common tern on the Scroby Sands intertidal sandbank, 6km off the Great Yarmouth coastline at the northern extremity of the Outer Thames Estuary SPA

The Breydon Water SPA and Foulness SPA are beyond the 26.9km mean maximum + standard deviation foraging range of common tern, being around 40km north and around 73km south-west of the main development site, respectively. They have therefore been screened out of the current assessment due to the lack of source-receptor pathways (Table 40).

This assessment will consider the potential for water discharge activities from SZC to adversely affect the Outer Thames breeding common terns via impacts on colonies at Minsmere Beach (in the Minsmere-Walberswick SPA) and Orfordness (in the Alde-Ore Estuary) (Table 39).

In order to provide a high-level perspective of how percentage overlap may vary with colony location, the assessment will also refer to foraging ranges centred on the closest coastal point to the SZC main development site, within the Minsmere-Walberswick SPA and the Alde-Ore Estuary SPA. The closest coastal point in the Alde-Ore Estuary SPA is around 4.5km to the north of the Orfordness colony. In the Minsmere-Walberswick SPA, the closest coastal point is around 2km south of the Minsmere colony.

Breeding has also been recorded on Havergate Island in the Alde-Ore Estuary SPA, but this is further from the main development site and so use of the Orfordness and closest coastal point locations will be precautionary.

Table 39: National Grid references for the Orfordness and Minsmere common tern colonies, together with the closest coastal point to the SZC main development site, within the Alde-Ore Estuary SPA and the Minsmere-Walberswick SPA

Site	Colony location	Colony grid reference (NGR)
Alde-Ore Estuary SPA	Orfordness	TM454512
Alde-Ore Estuary SPA	Closest coastal point	TM46375559
Minsmere-Walberswick SPA	Minsmere	TM477666
Minsmere-Walberswick SPA	Closest coastal point	TM47676448

8.7.2. Species condition summary

As part of the assessment, we should consider the status of the qualifying features of the site, the site condition and the prevailing environmental conditions. We will also consider any threats or degradations of the species and its supporting habitats for the designated sites.

The information that the applicant provided to support the HRAR (NNB GenCo, 2021b; shadow HRA), and NE's supplementary advice on conservation objectives (Marine site detail (naturalengland.org.uk)) tell us that:

- at the time of its inclusion as a qualifying species, the Outer Thames Estuary SPA was estimated to support 270 pairs of breeding common tern from SPA breeding colonies, constituting almost 3% of the breeding population in Great Britain. This was based on counts from 2011 to 2015, with additional breeding pairs from non-designated colonies. Numbers of common terns within the Alde-Ore Estuary SPA have declined to very low levels in recent years, with no birds breeding on Havergate Island and single pairs only recorded at Orfordness in both 2017 and 2018), while within the Minsmere-Walberswick SPA they have tended to range between 100 to 150 pairs (Table 40). For the Outer Thames Estuary SPA as a whole, insufficient time has elapsed since the baseline data were collected (2011 to 2015) to draw an appropriate comparison with current abundance data (Marine site detail (naturalengland.org.uk))

Table 40: Breeding common tern populations at coastal SPAs for which Outer Thames Estuary SPA provides important supporting habitat (bold indicates SPAs 'screened into' the current assessment), reproduced from Table 6.6 in the applicant's information to support the HRAR (NNB GenCo, 2021b; shadow HRA). The Breydon Water SPA includes colonies considered to be functionally linked to the SPA (for example, Scroby Sands) as well as colonies within the SPA

SPA	Approximate distance to the main development site (km)	Current breeding population (breeding pairs)	SPA qualifying feature
Breydon Water	40	252 (5-year mean, 2011-15)	Yes
Foulness	73	17.5 (5-year mean, 2011-15)	Yes
Minsmere-Walberswick	1	103 (2012-15)	No
Alde-Ore Estuary	17	19 (2014-18)	No

The applicant recorded common tern flight activity during coastal vantage point surveys in 2011, 2012 and 2013. However, common terns may forage considerable distances offshore, well beyond the distances at which birds can be recorded during shore-based surveys. While useful, these surveys have limited value in determining the full marine extent of important foraging areas of this species.

During the vantage point surveys, large numbers of foraging birds, including juveniles, were recorded at all vantage points between July and September. Much of this foraging activity occurred close inshore (in 2011), with 47% of records less than 100m from the coastline and 79% within 500m. It must be noted that these are percentages of foraging activity that was seen - distant offshore foraging may not have been recorded. Common terns were also regularly recorded commuting up and down the coast, often 2 to 3km from the shoreline. Common terns were regularly observed close to the shoreline adjacent to Minsmere-Walberswick SPA foraging around the Sizewell B outlet, with birds returning from the waters around the outlet to nests at Minsmere, often carrying food items for their young. Once breeding terns had departed from Minsmere, the number of terns, including juveniles, recorded at the outlet and resting on the adjacent beach increased. As such, it seems likely that the outlet provides an important foraging resource for common terns from the Minsmere colony.

8.7.3. Conservation objectives

Links to the full conservation objectives for the SPAs identified here are provided in Environment Agency (2022b; Annex 2), and the appropriate assessment will be concluded against the relevant conservation objectives provided.

8.7.4. Supporting habitats

Supporting habitats listed for breeding common tern in Outer Thames Estuary SPA (Marine site detail (naturalengland.org.uk)) are:

- intertidal sand and muddy sand
- water column

8.7.5. Discussion

Risks carried through to appropriate assessment for the breeding common tern feature of the Outer Thames Estuary SPA are:

- change in thermal regime
- toxic contamination (chemical)
- nutrient enrichment

Change in thermal regime

Absolute water temperatures

There is no potential for breeding common tern to be directly harmed by elevated water temperatures when SZC is operating alone, or when SZC and SZB are operating in combination (section 8.3.1).

Thermal uplift

There is no potential for an adverse effect on breeding common tern through thermal uplift from SZC alone, or SZC and SZB in combination, explained further here for breeding colonies within the Alde-Ore Estuary SPA and the Minsmere-Walberswick SPA.

Alde-Ore Estuary SPA

Although the ≥3°C thermal uplift (98th percentile) plumes from SZB alone, and SZC alone, lie within the potential foraging area of breeding common terns nesting at the Orfordness colony, there are no overlaps between the mean foraging area (a proxy for concentrated foraging activity) and the ≥3°C thermal uplift (98th percentile) plume (Table 25, Figure 45). When SZC and SZB are operating in combination there is a very slight (0.1%) overlap with the ≥3°C thermal uplift (98th percentile) plume at the northern end of the mean foraging area (Table 25, Figure 45).

The closest coastal point to the main development site, within the Alde-Ore Estuary SPA, is to the north of the Orfordness colony. Should common terns breed here, 3.4% of their mean foraging area would overlap with the ≥3°C thermal uplift (98th percentile) plume when SZB is operating alone - the overlap occurring along the coast to the north of the closest coastal point (Table 25, Figure 46). For SZB alone, the median overlap with instantaneous ≥3°C thermal uplift plumes is just 0.03% (Q1 = 0.00%, Q3 = 0.33%), with nearly 90.0% of hourly periods experiencing ≤1% overlap between mean foraging area and instantaneous ≥3°C thermal uplift plumes (Table 25, Figure 47).

The offshore location of the SZC outlet means that there would be no overlap between the mean foraging area of breeding common tern, centred on the closest coastal point, and the ≥3°C thermal uplift (98th percentile) plume for SZC alone (Table 25, Figure 46). The interaction between thermal uplift plumes from SZC and SZB in combination means that there is an increase in overlap (compared to baseline) between the mean foraging area and the ≥3°C thermal uplift (98th percentile) plume, to 5.8%. The area of exceedance is again along the coast to the north of the closest coastal point (Table 25, Figure 46). However, on most foraging trips, only a low proportion of the mean foraging area of common tern nesting at the closest coastal point would experience ≥3°C thermal uplift plume. The median overlap between instantaneous ≥3°C thermal uplift and mean foraging area is just 0.19% (Q1 = 0.00%, Q3 = 0.81%), with nearly 90.0% of hourly periods showing ≤2%

overlap between the mean foraging area and instantaneous ≥3°C thermal uplift plumes (Table 25, Figure 47).

There is no discernible pattern as to when higher percentage overlaps occur, with relatively high overlaps occurring throughout the months when breeding little terns are present (Figure 48).

When SZC is operating alone, there are no overlaps between the mean foraging area and the ≥3°C thermal uplift (98th percentile) plume for breeding common tern at either the Orfordness colony or the closest coastal point. There would therefore also be no overlap were common terns to breed further to the south within the Alde-Ore Estuary SPA, for example on Havergate Island. Any fish avoidance behaviour will be minimal and so thermal uplift from SZC alone will not adversely affect the Outer Thames Estuary SPA common terns breeding within the boundary of the Alde-Ore Estuary SPA.

When SZC and SZB are both operating in combination, common tern nesting in the Alde-Ore Estuary SPA would experience marginally higher overlap more often than baseline (SZB alone) for Orfordness and the closest coastal point. Overlap to the south of Orfordness, for example at Havergate Island, would be lower or absent entirely. Marginally increased overlaps, and therefore potential reduction in fish prey, would occur for colonies in the northern part of the Alde-Ore Estuary SPA when SZC and SZB are operating in combination. Potential colonies to the south of Orfordness would be affected to a lesser degree.

During visual surveys, much of the recorded foraging activity of common tern occurred close inshore, with concentrated foraging being recorded from Sizewell south to Aldeburgh, and off Orfordness (section 8.7.2, Figure 44). Due to the foraging range of common terns, distant offshore foraging may not have been recorded (section 8.7.2). Areas where concentrated foraging was recorded (Figure 44:) generally lie within the locations of the coastal ≥3°C thermal uplift (98th percentile) plume when SZB is operating alone and when SZC and SZB are operating in combination (Figure 45, Figure 46).

Natural England's Supplementary Advice on Conservation Objectives notes that, in the Outer Thames Estuary SPA, common terns forage within the water column of open sea, estuaries, rivers and bodies of freshwater. Prey availability, and therefore foraging opportunities, within the Alde-Ore Estuary itself would be unaffected by thermal uplift resulting from the water discharge activities of SZC alone or SZC and SZB in combination, as the plumes do not reach the estuary mouth. Eglington and Perrow (2014) note that common terns use more varied habitats, have a wider range of feeding techniques, and take a wider variety of prey than other tern species. Common terns can also show 'extreme plasticity in foraging and provisioning strategy' – they have the capacity to exploit diverse prey resources by employing a variety of foraging methods (Eglington and Perrow, 2014).

There will be no adverse effect on Outer Thames Estuary SPA breeding common tern nesting within the Alde-Ore Estuary SPA when SZC and SZB are operating in combination. Due to the generalist diet and variety of feeding methods of common terns, a small increase in frequency and scale of overlap between mean foraging area and the ≥3°C thermal uplift plume, towards the northern end of the SPA will not adversely affect breeding common tern over the Alde-Ore Estuary SPA as a whole, irrespective of whether SZB is decommissioned in 2035 or whether its operational life is extended, potentially to 2055.

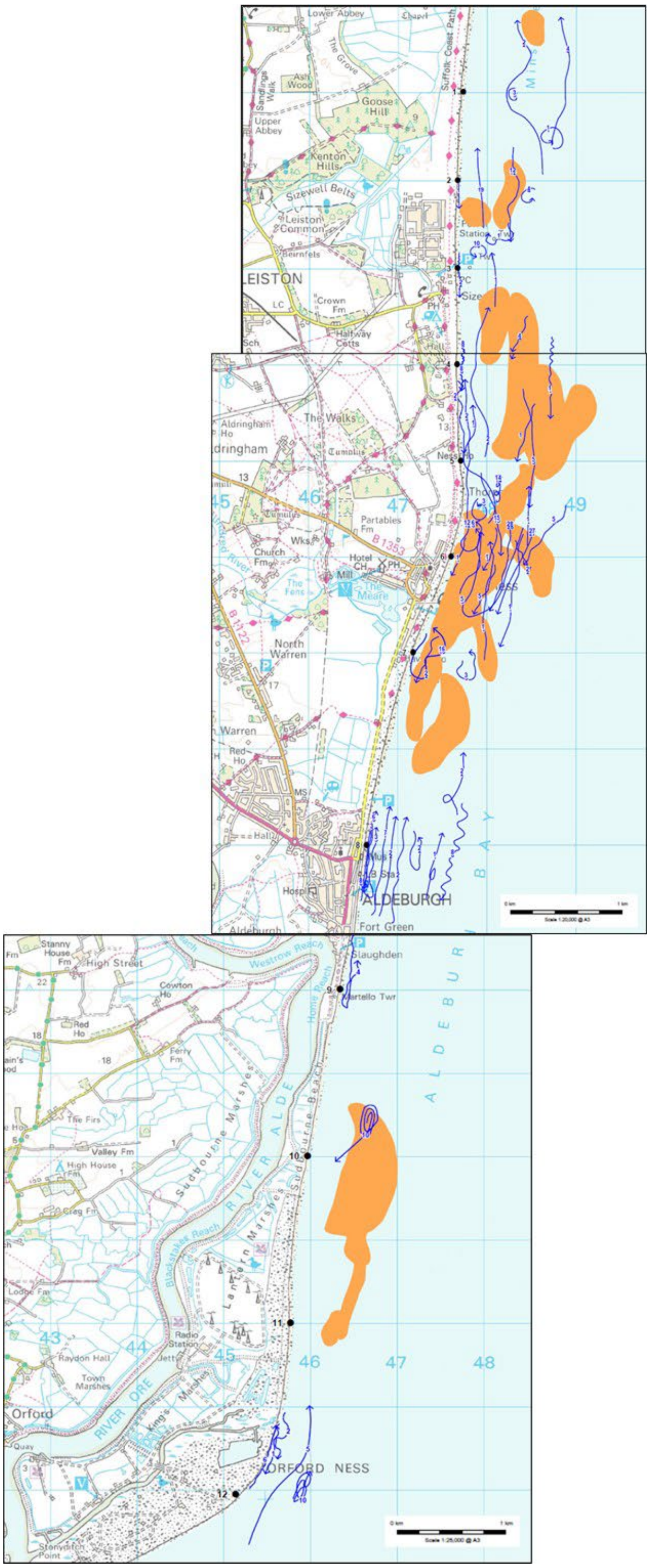

Figure 44: Flight lines and concentrated foraging areas for common terns during vantage point surveys (VPs 1 – 5, Sizewell to Orfordness) in 2011 and 2012. Reproduced from Plate 6.11 in NNB GenCo (2021b; shadow HRA)

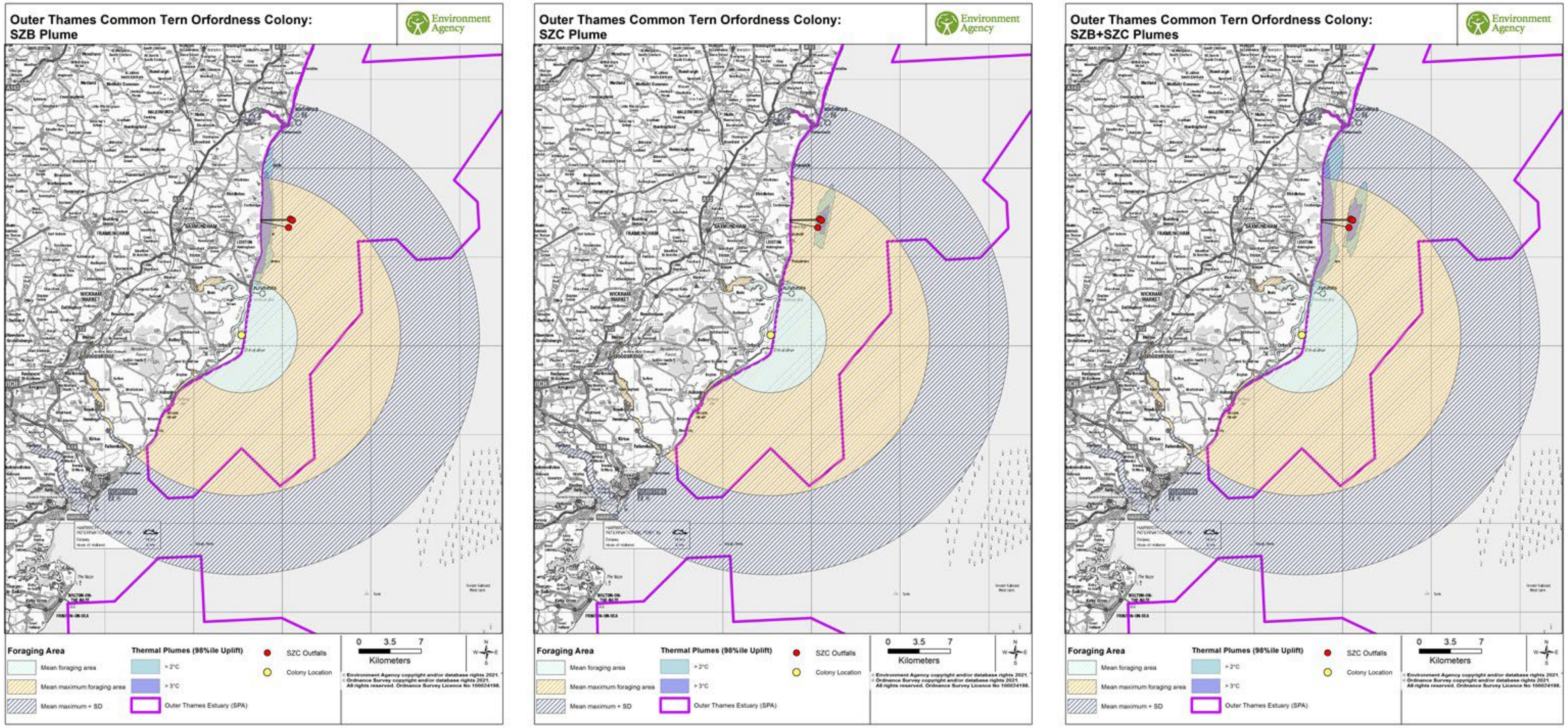

Figure 45: Mean, mean maximum, and mean maximum + SD foraging areas for breeding common tern centred on the Orfordness colony in the Alde-Ore Estuary SPA together with the ≥2°C and ≥3°C thermal uplift (98th percentile) plumes for SZB alone, SZC alone, and SZC and SZB in combination, as calculated by the applicant

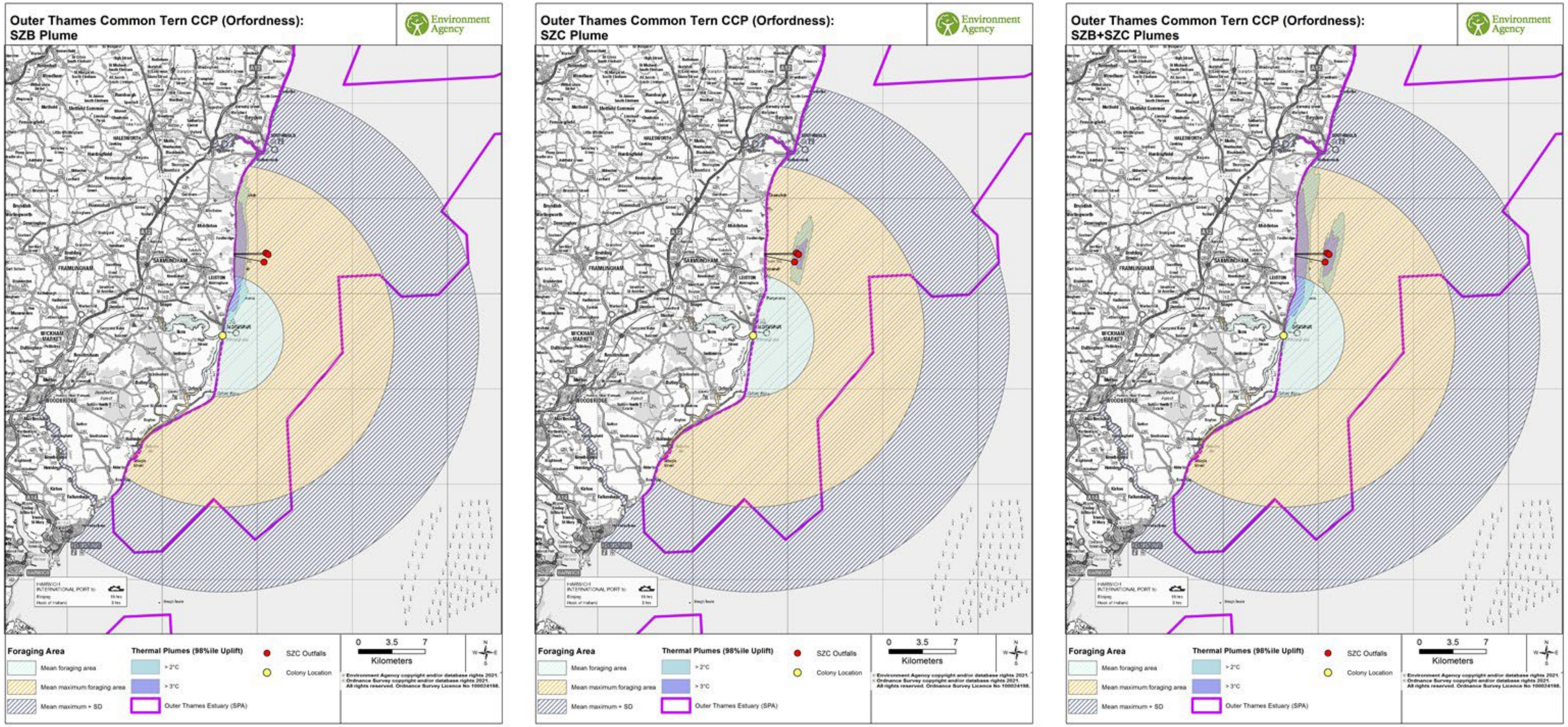

Figure 46: Mean, mean maximum, and mean maximum + SD foraging areas for breeding common tern centred on the closest coastal point to the main development site in the Alde-Ore Estuary SPA together with the ≥2°C and ≥3°C thermal uplift (98th percentile) plumes for SZB alone, SZC alone, and SZC and SZB in combination, as calculated by the applicant

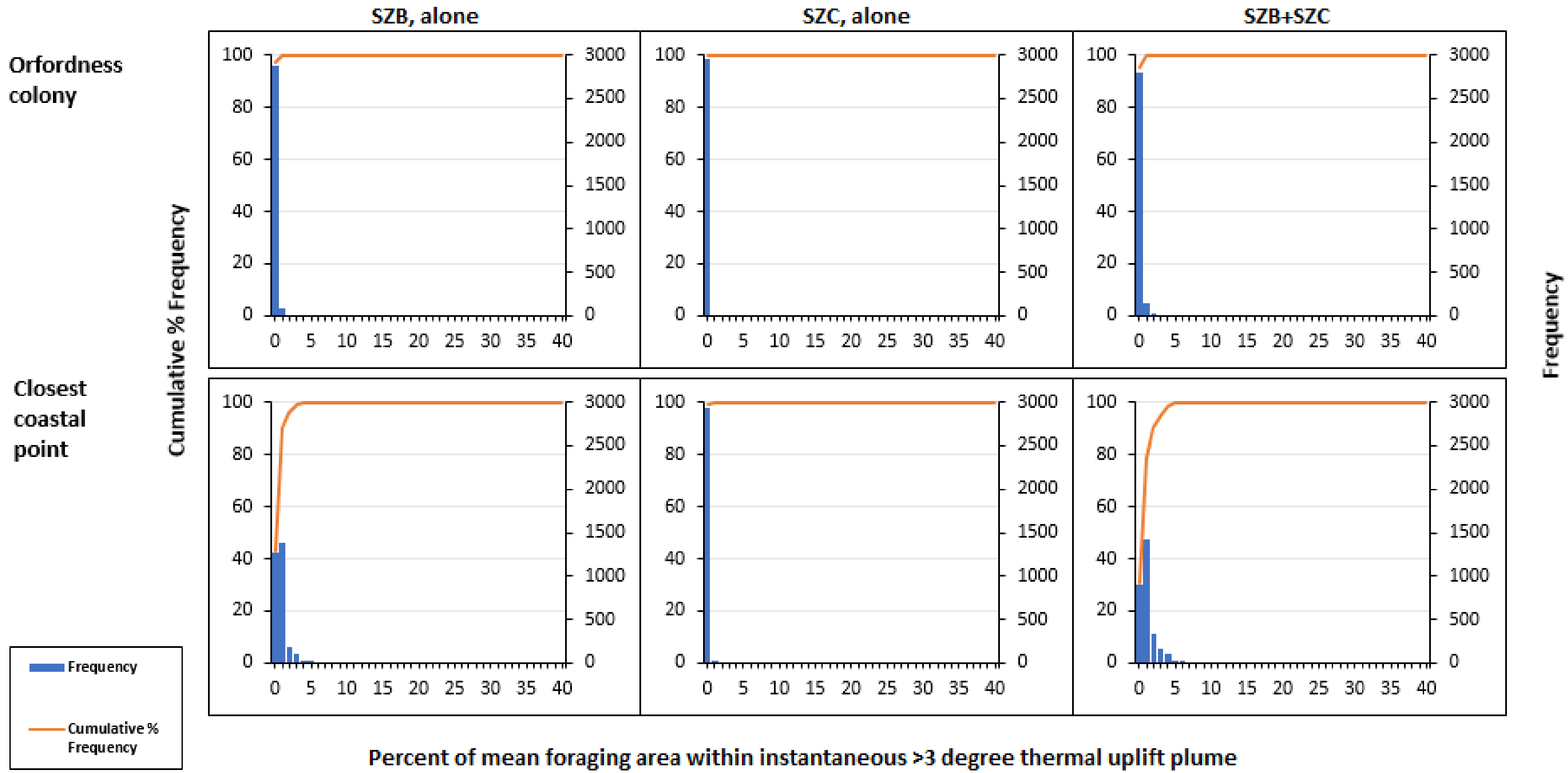

Figure 47: Frequency and cumulative percentage frequency graphs showing the distribution of percentage overlaps between mean foraging areas of Outer Thames Estuary SPA breeding common terns and instantaneous ≥ 3°C thermal uplift plumes from SZB alone, SZC alone, and SZC and SZB in combination, for foraging areas centred on the Orfordness colony and the closest coastal point (within the boundary of the Alde-Ore Estuary SPA). Data provided by the applicant

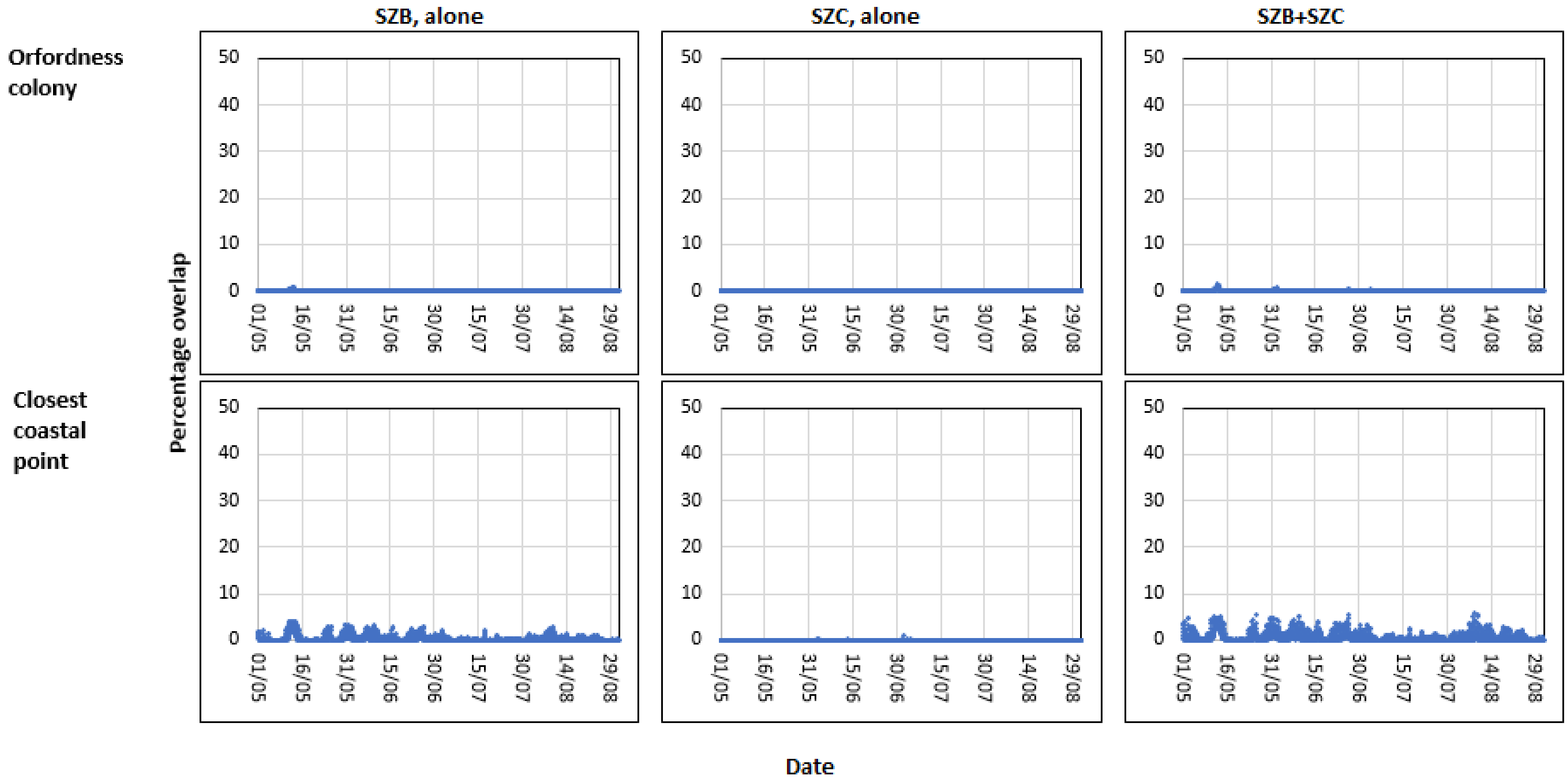

Figure 48: The distribution of percentage overlaps between mean foraging area of Outer Thames Estuary breeding common terns and instantaneous ≥3°C thermal uplift plumes from SZB alone, SZC alone, and SZC and SZB in combination, for foraging areas centred on the Orfordness colony and the closest coastal point (within the boundary of the Alde-Ore Estuary SPA). Data provided by the applicant

Minsmere-Walberswick SPA

The ≥3°C thermal uplift (98th percentile) plumes from SZB alone, SZC alone, and SZC and SZB in combination, lie largely within the mean foraging area of breeding common terns nesting at the Minsmere colony (Table 26, Figure 50).

Under baseline conditions (SZB alone), 12.8% of the mean foraging area of common terns nesting at the Minsmere colony is within the ≥3°C thermal uplift (98th percentile) plume, although the median overlap between mean foraging area and instantaneous ≥3°C thermal uplift plumes is 1.61% (Q1 = 1.08%, Q3 = 2.52%) (Table 26, Figure 50). Around 90% of hourly periods experience ≤4% overlap between mean foraging area and instantaneous ≥3°C thermal uplift plumes (Figure 52). The area experiencing thermal uplift borders the coastline, extending up to ≈2km offshore (Figure 50).

When SZC is operating alone, the ≥3°C thermal uplift (98th percentile) plume overlaps with a smaller percentage of the mean foraging area (4.0%) of Minsmere colony common terns. The area of exceedance is situated further offshore, due to the relative location of the SZB and SZC outlets (Table 26, Figure 50). The median overlap between mean foraging area and instantaneous ≥3°C thermal uplift plumes is just 0.02% (Q1 = 0.00%, Q3 = 0.06%), with 85% of hourly periods experiencing ≤1% overlap between the mean foraging area and instantaneous ≥3°C thermal uplift plumes (Figure 52).

When SZC and SZB are operating in combination, the overlap between the mean foraging area of Minsmere colony common terns and the ≥3°C thermal uplift (98th percentile) is 23.2%, nearly double that of the baseline. This is due to both outlets lying within the mean foraging area, and the interaction between the 2 plumes (Table 26). When SZC and SZB are operating in combination, higher overlaps between the mean foraging area and instantaneous ≥3°C thermal uplift plumes are more frequent than for SZB alone (Q1 = 1.78%, median = 2.65%, Q3 = 4.21%, Figure 52).

As with the Minsmere colony, should a common tern colony establish at the closest coastal point to the main development site within the Minsmere-Walberswick SPA, the ≥3°C thermal uplift (98th percentile) plumes from SZB alone, SZC alone, and SZC and SZB in combination would lie largely within the mean foraging area, with 14.5%, 3.9% and 25.5%, respectively of the mean foraging areas being within the area of exceedance (Table 26, Figure 51). When considering instantaneous ≥3°C thermal uplift plumes, which better represent conditions common terns would experience on any given foraging trip, overlaps are lower than with the 98th percentile. Median values are 1.71% (Q1 = 1.07%, Q3 = 2.74%) for SZB alone, 0.02% (Q1 = 0.00%, Q3 = 0.64%) for SZC alone and 2.98% (Q1 = 1.95%, Q3 = 4.44%) for SZC and SZB in combination (Table 26, Figure 52).

There is no discernible pattern as to when higher percentage overlaps occur, with relatively high overlaps occurring throughout the months when breeding common terns are present (Figure 53).

When SZC is operating alone, overlaps between the mean foraging area and instantaneous ≥3°C thermal uplift plumes are very low (<1%) for breeding common tern at either the Minsmere colony or the closest coastal point. Overlaps would also be low, or absent entirely, should common tern breed further to the north within the Minsmere-Walberswick SPA. Any fish avoidance behaviour will be minimal and so thermal uplift from SZC alone will not adversely affect Outer Thames Estuary SPA common terns breeding within the boundary of the Minsmere-Walberswick SPA.

When SZC and SZB are both operating, common terns nesting in the Minsmere-Walberswick SPA would experience higher overlaps more often than baseline (SZB alone). Therefore, there would be a potential reduction in fish prey for breeding common tern nesting in the Minsmere-Walberswick SPA when SZC and SZB are operating together.

During visual surveys, much of the recorded foraging activity of common tern occurred close inshore, with concentrated foraging being recorded from Sizewell south to Aldeburgh, with many of these areas lying within the mean foraging area for common terns nesting in the Minsmere-Walberswick SPA (section 8.7.2, Figure 44, Figure 50, Figure 51). Concentrated foraging areas were also recorded immediately offshore from Minsmere (Figure 49). Due to the foraging range of common terns, distant offshore foraging may not have been recorded (section 8.7.2). Areas where concentrated foraging was recorded (Figure 44, Figure 49) generally lie within the coastal ≥3°C thermal uplift (98^{th} percentile) plume when SZB is operating alone, and when SZC and SZB are operating in combination (Figure 50, Figure 51).

Eglington and Perrow (2014) note that common terns use more varied habitats, have a wider range of feeding techniques, and take a wider variety of prey than other tern species. Common terns can also show ‘extreme plasticity in foraging and provisioning strategy’ – they have the capacity to exploit diverse prey resources by employing a variety of foraging methods (Eglington and Perrow, 2014).

There will be no adverse effect on Outer Thames Estuary SPA breeding common tern nesting within the Minsmere-Walberswick SPA when SZC and SZB are operating in combination. This is due to the generalist diet and variety of feeding methods of common terns, and the still relatively low percentage overlaps between mean foraging area and instantaneous ≥3°C thermal uplift plumes, irrespective of whether SZB is decommissioned in 2035 or whether its operational life is extended, potentially to 2055.

Outer Thames Estuary SPA

The Outer Thames Estuary SPA protects foraging areas for breeding common terns at colonies in the Breydon Water SPA, Foulness SPA, Minsmere-Walberswick SPA, and Alde-Ore Estuary SPA, as well as the Scroby Sands intertidal sandbank (which does not have an SPA designation).

Considering the temporal and geographical scale and location of thermal plumes in relation to the behaviour of the breeding common tern features, there will be no adverse effects on the breeding common tern features of the Alde-Ore Estuary SPA and Minsmere-Walberswick SPA as a result of thermal uplift from SZC alone or SZC and SZB in combination (section 8.7.5).

There are no source-receptor pathways for change in thermal regime between Sizewell and breeding common terns in the Breydon Water SPA, Foulness SPA and the Scroby Sands intertidal sandbank, due to their distance from the main development site.

Consequently, there will be no adverse effects on the breeding common tern features of the Outer Thames Estuary SPA as a result of thermal uplift from SZC alone or SZC and SZB in combination.

Figure 49: Flight lines and concentrated foraging areas for common terns during vantage point surveys March-August 2013. Reproduced from Plate 6.12 in NNB GenCo (2021b; shadow HRA)

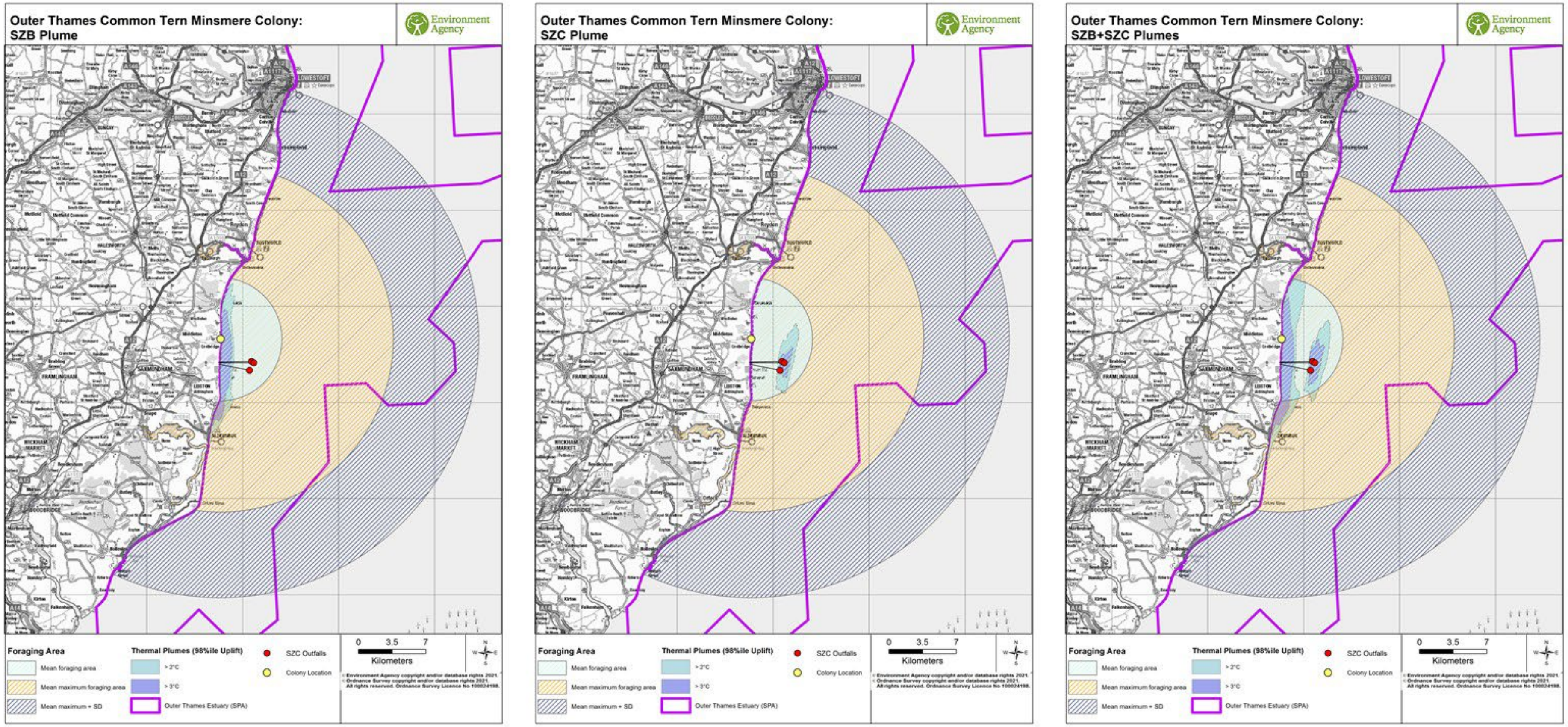

Figure 50: Mean, mean maximum, and mean maximum + SD foraging areas for breeding common tern centred on the Minsmere colony in the Minsmere-Walberswick SPA together with the ≥2°C and ≥3°C thermal uplift (98th percentile) plumes for SZB alone, SZC alone, and SZC and SZB in combination, as calculated by the applicant

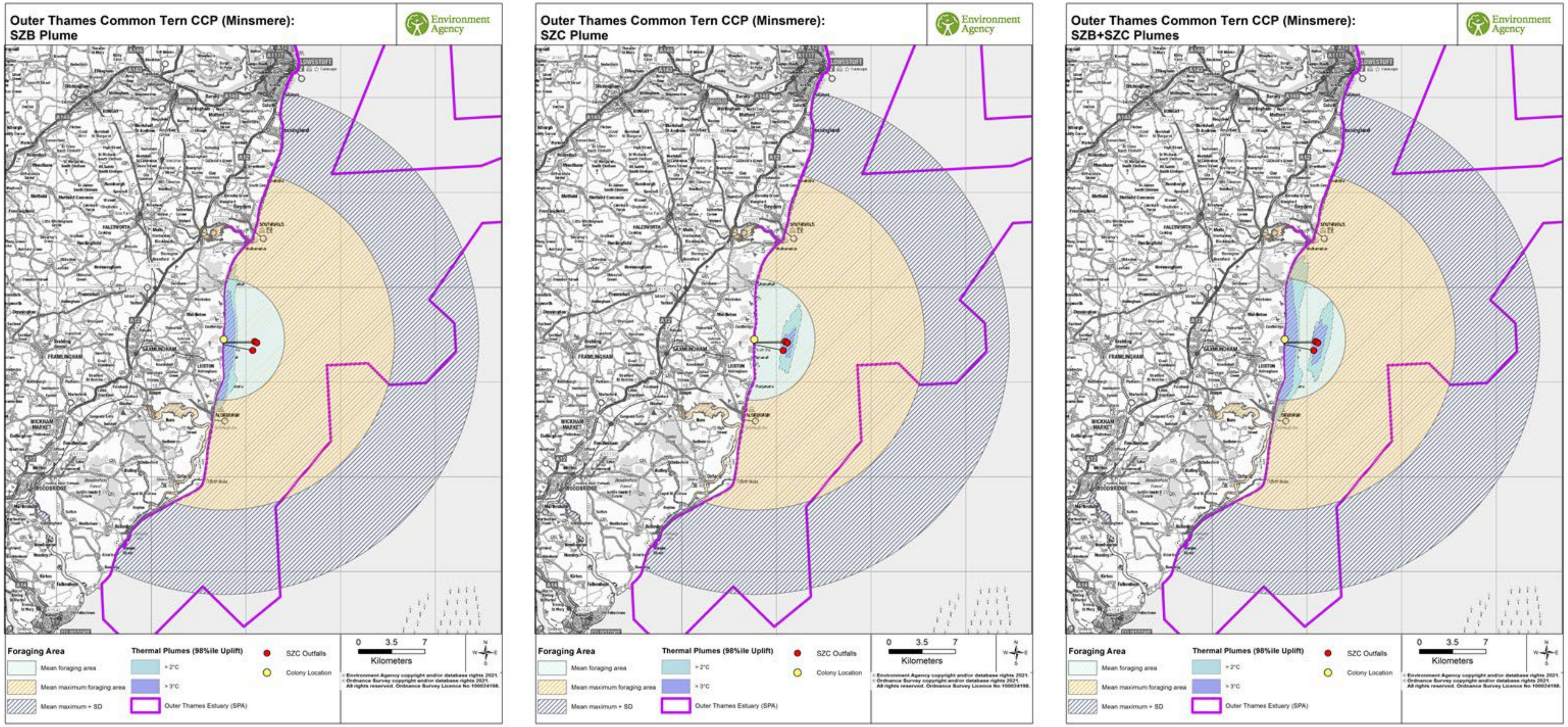

Figure 51: Mean, mean maximum, and mean maximum + SD foraging areas for breeding common tern centred on the closest coastal point to the main development site in the Minsmere-Walberswick SPA together with the ≥2°C and ≥3°C thermal uplift (98th percentile) plumes for SZB alone, SZC alone, and SZC and SZB in combination, as calculated by the applicant

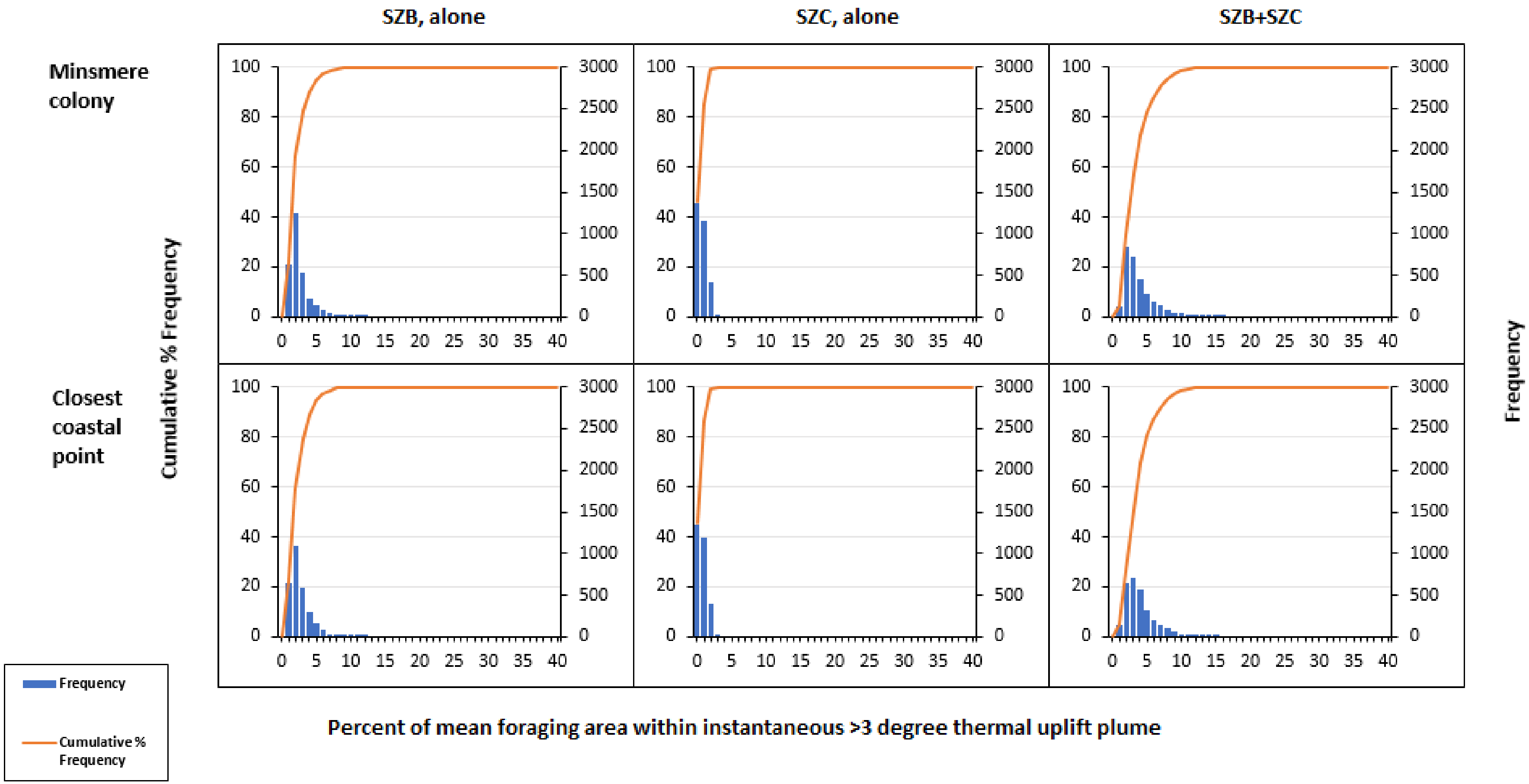

Figure 52: Frequency and cumulative percentage frequency graphs showing the distribution of percentage overlaps between mean foraging areas of Outer Thames Estuary SPA breeding common terns and instantaneous ≥ 3°C thermal uplift plumes from SZB alone, SZC alone, and SZC and SZB in combination, for foraging areas centred on the Minsmere colony and the closest coastal point (within the boundary of the Minsmere-Walberswick SPA). Data provided by the applicant

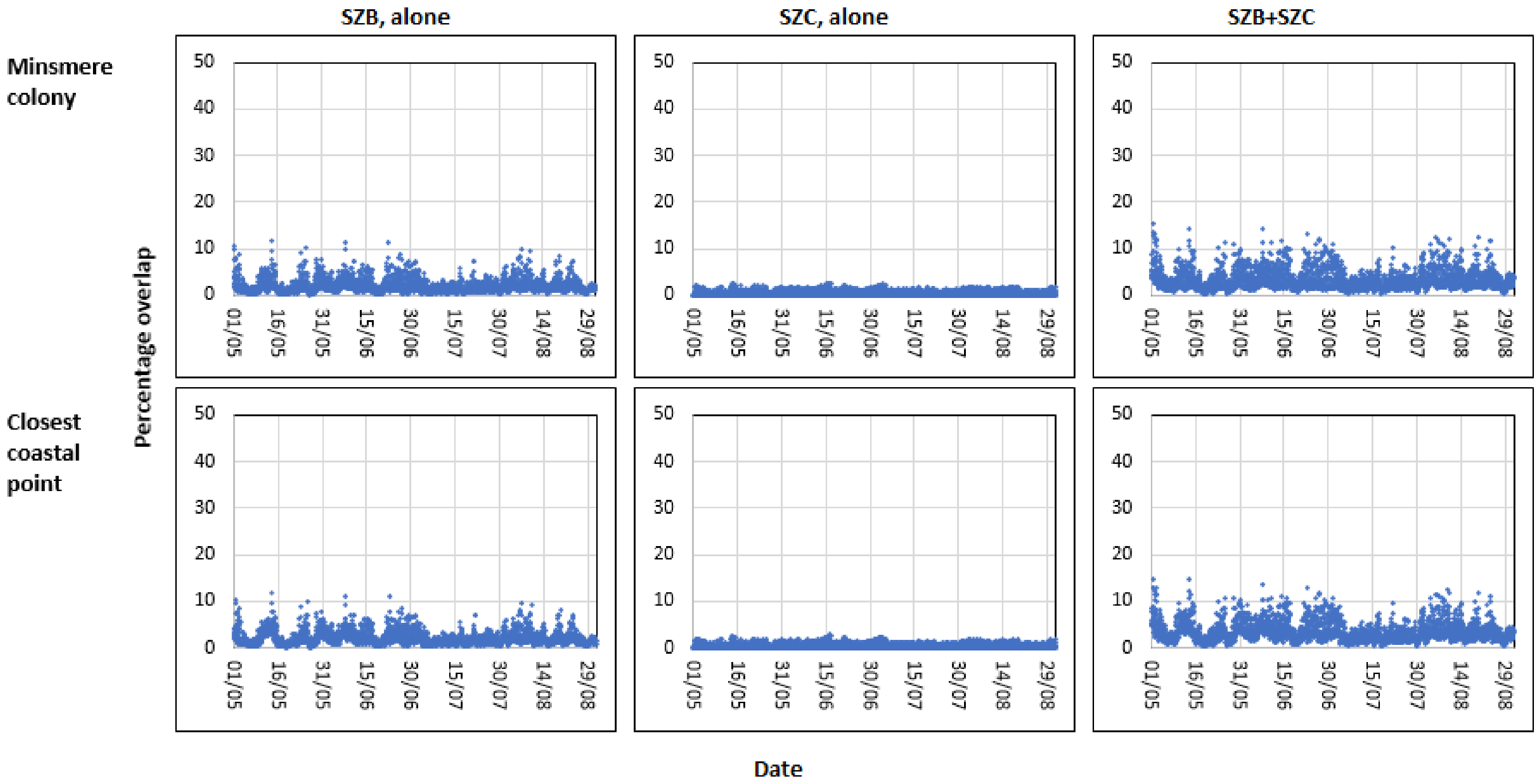

Figure 53: The distribution of percentage overlaps between mean foraging area of Outer Thames Estuary breeding common terns and instantaneous ≥3°C thermal uplift plumes from SZB alone, SZC alone, and SZC and SZB in combination, for foraging areas centred on the Minsmere colony and the closest coastal point (within the boundary of the Minsmere-Walberswick SPA). Data provided by the applicant

Toxic contamination (chemical)

Direct effects

There is no potential for an adverse effect on Outer Thames SPA breeding common tern through the direct effects of toxic contamination (chemical) from SZC alone, or SZC and SZB in combination, as explained further here.

Alde-Ore Estuary SPA

For common tern breeding at the Orfordness colony, there are no overlaps between mean foraging area and any of the chemical plumes discharged from SZB alone, SZC alone, or SZC and SZB in combination (Table 25). This would also be the case should a colony establish further south (for example, Havergate Island).

Should common tern breed at the closest coastal point to the main development site within the Alde-Ore Estuary SPA, there would be no overlap between their mean foraging area and any of the chemical plumes discharged from SZC alone.

Due to the absence of overlap between mean foraging area and chemical plumes, and the precautionary nature of the EQS and PNEC values with regard to direct toxic effects on birds, there will be no direct effect on common terns breeding in the Alde-Ore Estuary SPA from toxic contamination (chemical) as a result of the water discharge activities of SZC alone.

As there is no effect from SZC alone, and there is no interaction between the chemical plumes from SZC and SZB in combination, there will also be no adverse effect resulting from the water discharge activities of SZC from SZC and SZB in combination.

Minsmere-Walberswick SPA

When SZC is operating alone, there is little difference from baseline (SZB alone) in terms of the percentage overlap between mean foraging area and the TRO exceedance plume for common tern centred on the Minsmere colony, or the closest coastal point within the Minsmere-Walberswick SPA, with overlaps being around 6% (Table 26). However, the location of the TRO plume alters, from coastal (SZB alone) to offshore (SZC alone) (Figure 54, Figure 55). For both the Minsmere colony and the closest coastal point, the percentage overlap doubles to around 12% when SZC and SZB are both operating, as compared to the baseline (SZB alone), as the roughly equally-sized plumes from both outlets lie within the mean foraging area (Table 26, Figure 54, Figure 55).

Overlaps between mean foraging area and instantaneous ≥ 10μg/l TRO plumes are generally low. From a baseline (SZB alone) median of around 1.5% (Q1 ≈ 1.2%, Q3 ≈ 1.8%), percentage overlap reduces to 0.9% (Q1 ≈ 0.6%, Q3 ≈ 1.5%) for SZC alone, and increases to around 2.5% (Q1 ≈ 2.1%, Q3 ≈ 3.2%) for SZC and SZB in combination, for both the Minsmere colony and the closest coastal point (Table 26, Figure 56).

The percentage overlaps between mean foraging areas and the instantaneous ≥ 10µg/l TRO plume show no particular pattern over the course of the months when breeding common terns are present (Figure 57).

Should breeding colonies of common terns establish to the north of the Minsmere colony (for example, at Dingle), exposure to TRO would generally reduce with increasing distance from the outlets.

The potential for direct exposure to areas of bromoform exceedance are lower still than for TRO, with the overlap between mean foraging ranges (centred on the Minsmere colony and the closest coastal point) and the bromoform exceedance plume dropping from around 5% (SZB alone) to <1% (SZC alone), but increasing slightly to around 5.5% for SZC and SZB in combination (Table 26). As with TRO, overlap with instantaneous ≥ 5µg/l bromoform plumes, representing the conditions a common tern might encounter on any given foraging trip, would generally be lower than the overlap with the 95th percentile plume.

Direct toxic effects (chemical) from hydrazine discharged from SZC alone, and SZC and SZB in combination can be excluded for the Minsmere colony and the closest coastal point due to the low likelihood of contact between the seabirds and the acute plumes (≈0.2%, Table 26), and the precautionary nature of the hydrazine PNECs.

Overall, for SZC alone, due to the low percentage values of overlap between mean foraging area and chemical plumes, and the precautionary nature of the EQS and PNEC values with regard to direct toxic effects on birds, there will be no direct effect on breeding common terns in the Minsmere-Walberswick SPA from toxic contamination (chemical) as a result of the water discharge activities of SZC alone.

Similarly, there will be no direct effect on breeding common terns in the Minsmere-Walberswick SPA from toxic contamination (chemical) as a result of the water discharge activities of SZC and SZB in combination, due to the low percentage values of overlap between mean foraging area and chemical plumes, and the precautionary nature of the EQS and PNEC values with regard to direct toxic effects on birds.

Outer Thames Estuary SPA

The Outer Thames Estuary SPA protects foraging areas for breeding common terns at colonies in the Breydon Water SPA, Foulness SPA, Minsmere-Walberswick SPA, and Alde-Ore Estuary SPA, as well as the Scroby Sands intertidal sandbank (which does not have an SPA designation).

Considering the temporal and geographical scale of TRO, bromoform and hydrazine exceedance plumes in relation to the behaviour of the breeding common tern features, and the precautionary nature of the EQS/PNEC values, there will be no adverse effects on common tern breeding within the Alde-Ore Estuary SPA and Minsmere-Walberswick SPA as a direct result of toxic contamination (chemical) from SZC alone, or SZC and SZB in combination (section 8.7.5).

There are no source-receptor pathways for the toxic contamination (chemical) pressure between Sizewell and the breeding common tern features of the Breydon Water SPA, Foulness SPA and the Scroby Sands intertidal sandbank, due to their distance from the main development site.

Consequently, there will be no adverse effects on the breeding common tern features of the Outer Thames Estuary SPA as a direct result of toxic contamination (chemical) from SZC alone or SZC and SZB in combination.

Indirect effects

There is no potential for an adverse effect on Outer Thames SPA breeding common tern through the indirect effects of toxic contamination (chemical) from SZC alone or SZC and SZB in combination, as explained further here.

Alde-Ore Estuary SPA

There are no indirect effects of toxic contamination (chemical) on breeding common tern nesting within the Alde-Ore SPA, from either SZC alone or SZC and SZB in combination.

For SZC alone, there are no overlaps between mean foraging area and any of the chemical exceedance plumes for foraging areas centred on the Orfordness colony or the closest coastal point, and therefore any avoidance behaviour by prey fish within the wider area would have minimal effect on breeding common tern (Table 25).

As there is no indirect effect from SZC alone, and there is no interaction between the chemical plumes from SZC and SZB in combination, there will also be no indirect adverse effect resulting from the water discharge activities of SZC from SZC and SZB in combination.

Minsmere-Walberswick SPA

There are no indirect effects of toxic contamination (chemical) on breeding common tern nesting within the Minsmere-Walberswick SPA, from either SZC alone or SZC and SZB in combination.

When SZC is operating alone, the overlap between mean foraging area and the offshore TRO exceedance plume for common tern centred on the Minsmere colony, or the closest coastal point, is around 6%. Overlap with the instantaneous ≥ 10µg/l TRO plume is generally much lower, with a median of <1% (Table 26). Any avoidance behaviour by prey fish within the wider area would have minimal effect on breeding common tern nesting in the Minsmere-Walberswick SPA, particularly given their ‘extreme plasticity in foraging and provisioning strategy’ (Eglington and Perrow, 2014). As the largest of the chemical plumes scoped into the assessment, overlaps between the TRO exceedance plume and mean foraging areas (as a proxy for areas of concentrated foraging activity) represent a worst-case scenario. The lack of indirect adverse effect from the discharge of TRO by SZC alone, means that we can also conclude there will be no adverse effects on the breeding little tern feature resulting from the release of bromoform or hydrazine, and therefore no adverse effect from toxic contamination (chemical) from SZC alone.

For SZC and SZB in combination, although there are sizeable overlaps (≈12%) between mean foraging areas and EQS ≥ 10µg/l TRO (95th percentile) plumes for mean foraging areas centred on the Minsmere colony and the closest coastal point, instantaneous overlaps are generally much smaller, having a upper quartile value of 3.21% for Minsmere and 3.10% for the closest coastal point (Table 26, Figure 54, Figure 55). While this represents a doubling of baseline conditions, at this scale any avoidance behaviour by fish would not have an adverse effect on breeding common terns in the Minsmere-Walberswick SPA, particularly given their more generalist diet, as compared to other tern species, and the variety of foraging methods they can employ. This will be the case irrespective of whether SZB is decommissioned in 2035 or whether its operational life is extended, as far as 2055.

As the largest of the chemical plumes scoped into the assessment, overlaps between the TRO exceedance plume and mean foraging areas (as a proxy for areas of concentrated foraging activity) represent a worst-case scenario. The lack of indirect adverse effect from the discharge of TRO by SZC and SZB in combination, means that we can also conclude there will be no adverse effects on breeding common terns in the Minsmere-Walberswick SPA resulting from the release of bromoform or hydrazine, and therefore no indirect adverse effect from toxic contamination (chemical) from SZC and SZB in combination.

Outer Thames Estuary SPA

The Outer Thames Estuary SPA protects foraging areas for breeding common terns at colonies in the Breydon Water SPA, Foulness SPA, Minsmere-Walberswick SPA, and Alde-Ore Estuary SPA, as well as the Scroby Sands intertidal sandbank (which does not have an SPA designation).

Considering the temporal and geographical scale of TRO, bromoform and hydrazine exceedance plumes in relation to the behaviour of the breeding common tern features, and the precautionary nature of the EQS/PNEC values, there will be no adverse effects on common tern breeding within the Alde-Ore Estuary SPA and Minsmere-Walberswick SPA as an indirect result of toxic contamination (chemical) from SZC alone or SZC and SZB in combination (section 8.7.5).

There are no source-receptor pathways between Sizewell and the breeding common tern features of the Breydon Water SPA, Foulness SPA and the Scroby Sands intertidal sandbank, due to their distance from the main development site.

Consequently, there will be no adverse effects on the breeding common tern features of the Outer Thames Estuary SPA as an indirect result of toxic contamination (chemical) from SZC alone or SZC and SZB in combination.

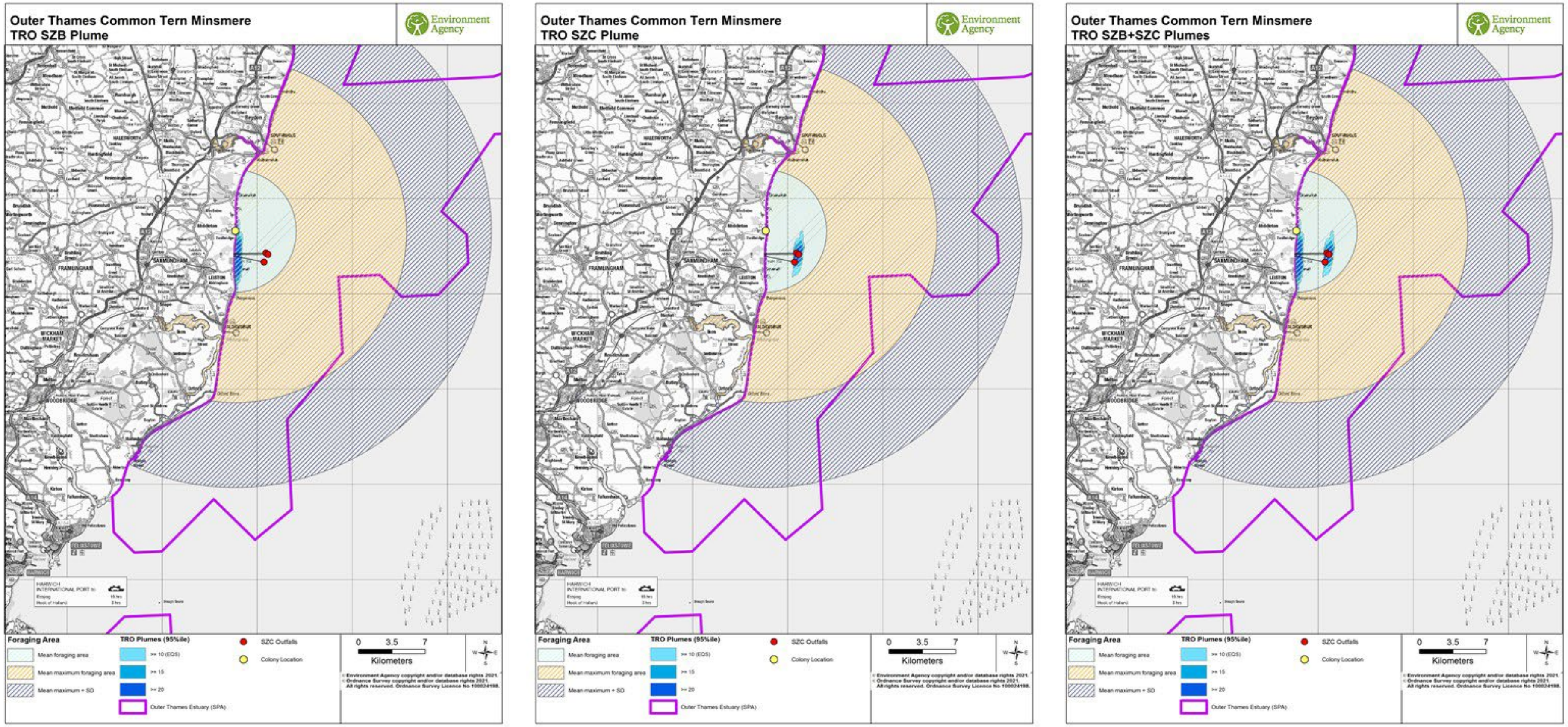

Figure 54: Mean and mean maximum foraging areas for breeding common tern centred on the Minsmere colony in the Minsmere-Walberswick SPA together with the EQS ≥ 10µg/l TRO (95th percentile) plumes for SZB alone, SZC alone, and SZC and SZB in combination, as calculated by the applicant

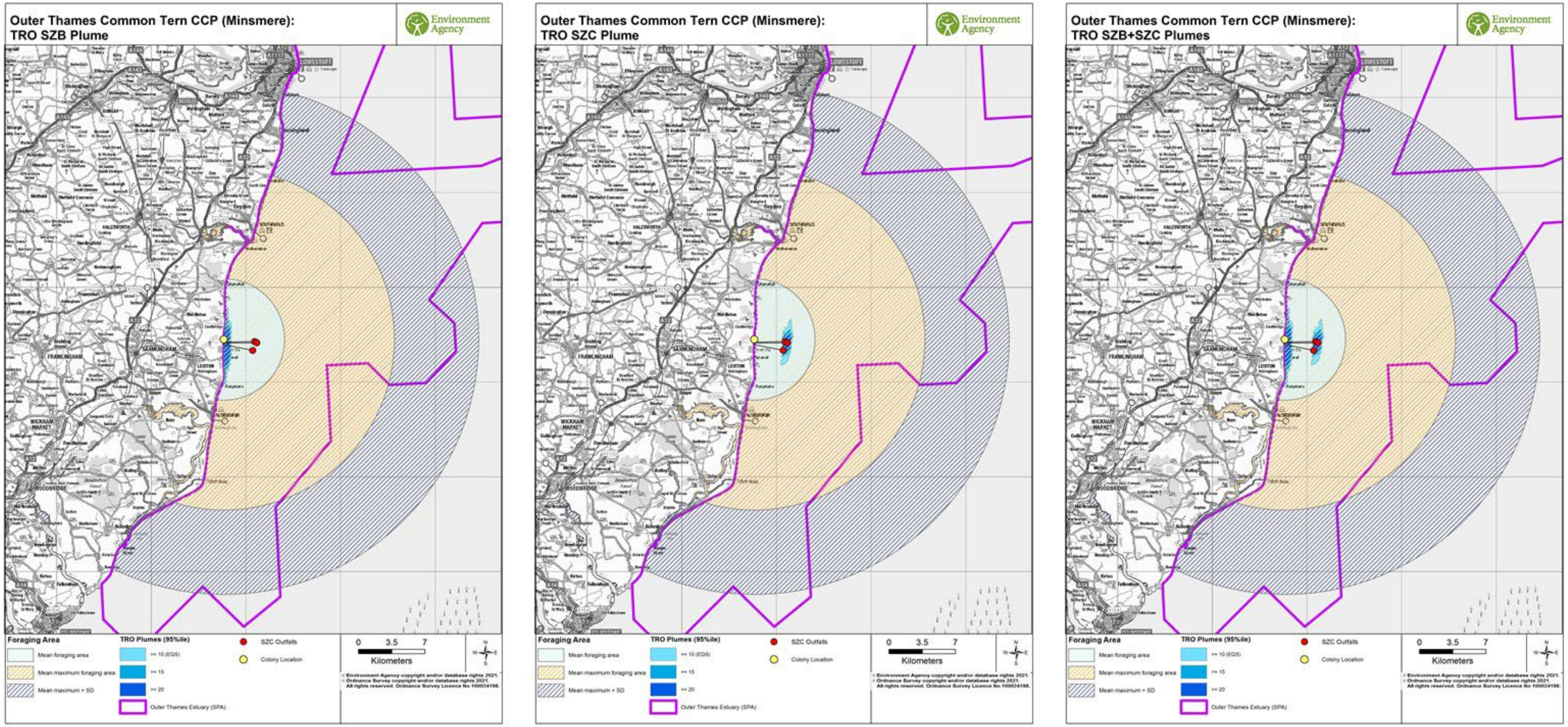

Figure 55: Mean and mean maximum foraging areas for breeding common tern centred on the closest coastal point within the Minsmere-Walberswick SPA together with the EQS ≥ 10µg/l TRO (95th percentile) plumes for SZB alone, SZC alone, and SZC and SZB in combination, as calculated by the applicant

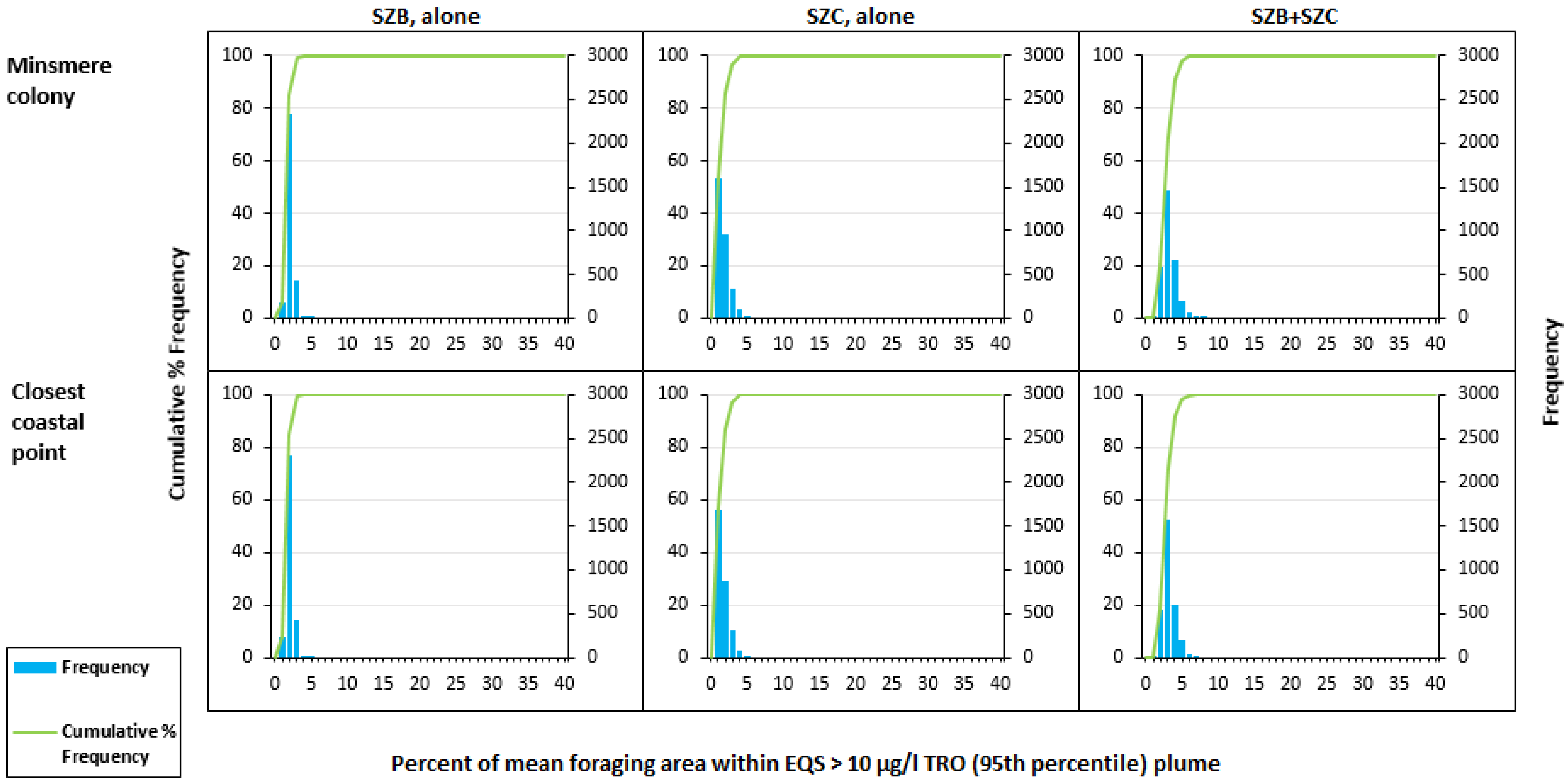

Figure 56: Frequency and cumulative percentage frequency graphs showing the distribution of percentage overlaps between mean foraging area of Minsmere-Walberswick common terns centred on the Minsmere colony, or the closest coastal point, and instantaneous ≥ 10µg/l TRO thermal uplift plumes from SZB alone, SZC alone, and SZC and SZB in combination. Data provided by the applicant

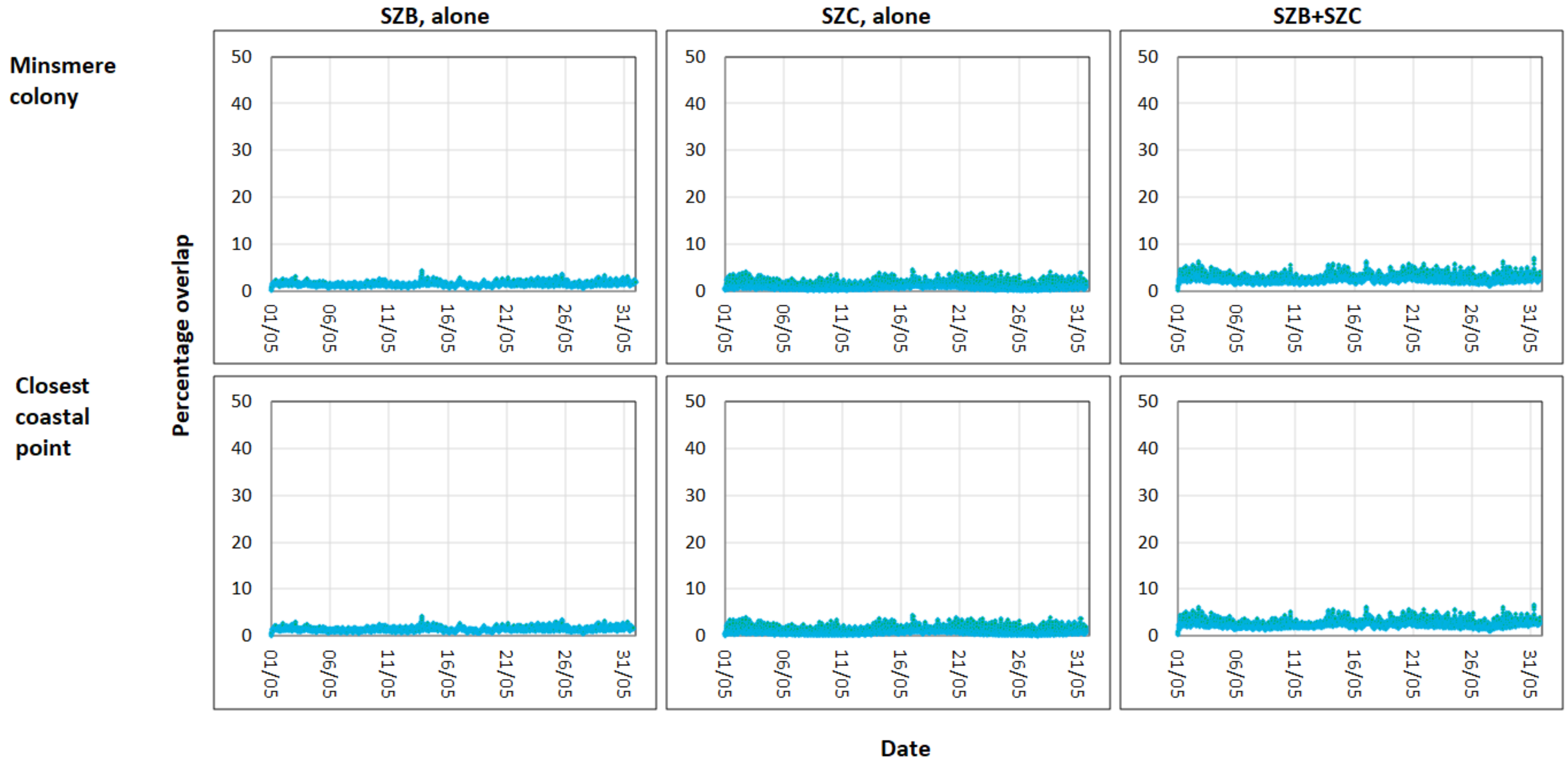

Figure 57: The distribution of percentage overlaps between mean foraging area of Minsmere-Walberswick common terns centred on the Minsmere colony, or the closest coastal point, and instantaneous ≥ 10µg/l TRO plumes from SZB alone, SZC alone, and SZC and SZB in combination, over the months when the breeding seabird feature is present. Data provided by the applicant

8.7.6. Changes in nutrients/eutrophication

Direct effects

There are no source-receptor pathways by which organic or nutrient enrichment from SZC alone or SZC and SZB in combination can directly affect breeding seabird features (section 8.3.3).

Indirect effects

There are no indirect effects of organic enrichment on the breeding little tern features, from either SZC alone or SZC and SZB in combination (section 8.3.3).

Changes in nutrient enrichment, un-ionised ammonia and dissolved oxygen levels resulting from the operation of SZC alone or SZC and SZB in combination will not lead to any indirect effects on breeding seabird features (section 8.3.3).

8.7.7. Supporting habitats

There will be no adverse effects on the supporting habitats of the Outer Thames Estuary SPA breeding common tern feature as a result of the operation of SZC alone or SZC and SZB in combination.

Terns use the intertidal sand and muddy sand habitat for resting/loafing when the tide is out. Any effects on the intertidal sand and muddy sand supporting habitat will only occur when the tide is in and therefore the water discharge activities of SZC alone or SZC and SZB in combination will not affect the ability of the intertidal sand and muddy sand habitat to support breeding common terns.

Foraging takes place in the water column supporting habitat, but water discharge activities from SZC will only affect breeding common tern nesting at 2 of the colonies whose foraging areas are protected by the Outer Thames Estuary SPA. For these colonies, within the Alde-Ore Estuary SPA and the Minsmere-Walberswick SPA, due to the small size of overlaps between thermal and chemical plumes from SZC alone, and the low level of nutrient input relative to tidal dynamics, any effects on the water column supporting habitat from SZC alone, will not adversely affect the breeding seabird feature (Table 41).

When SZC and SZB are operating in combination, overlap between mean foraging areas and thermal or chemical plumes are generally greater than baseline for common tern nesting in the Minsmere-Walberswick SPA, and broadly comparable to baseline for common tern nesting in the Alde-Ore SPA. However, any negative effects on common terns would be likely to be offset by the plasticity in their foraging behaviour (Table 41). The ability of the water column habitat to support breeding common tern will not be adversely affected by the water discharge activities of SZC and SZB in combination, irrespective of whether SZB is decommissioned in 2035 or whether its operational life is extended, potentially to 2055.

Table 41: The sensitivities of the water column supporting habitat for breeding common tern foraging in the Outer Thames Estuary SPA, as described in NE Advice on Operations, together with the expected effects as a result of SZC alone, and SZC and SZB in combination

Pressure (from NE advice on operations)	Supporting habitat	Sensitivity	Effect of SZC alone	Effect of SZC+SZB
Increases in temperature	Water column	Sensitive	No effect. Thermal uplift may potentially affect the water column for common tern breeding in the Alde-Ore Estuary SPA and Minsmere-Walberswick SPA. However, for these terns the area of uplift forms only a small percentage of their potential foraging area. Breeding common tern in other colonies, foraging in the Outer Thames Estuary SPA, are not affected due to their distance from the main development site. Further resilience is provided by the more generalist diet and wider variety of foraging strategies of common tern, as compared to little tern and Sandwich tern. The ability of the water column habitat to support the breeding common tern feature will be unaffected.	No effect. For common tern breeding within the Minsmere-Walberswick SPA, the percentage of the water column supporting habitat potentially affected by thermal uplift is greater for SZC and SZB in combination than for SZB alone, or SZC alone. However, the area of uplift a common tern may encounter on any given foraging trip still forms only a small percentage of the potential foraging area. Common terns breeding in the Alde-Ore Estuary SPA are even less affected, due to their greater distance from the main development site. More distant colonies feeding within the Outer Thames Estuary SPA are entirely unaffected. Further resilience is provided by the more generalist diet and wider variety of foraging strategies of common tern, as compared to little tern and Sandwich tern. The ability of the water column habitat to support the breeding common tern feature will be unaffected, regardless of whether SZB is decommissioned in 2035 or its operational life is extended, up to 2055.

Pressure (from NE advice on operations)	Supporting habitat	Sensitivity	Effect of SZC alone	Effect of SZC+SZB
Other substances (solid, liquid or gas)	Water column	Not assessed	No effect. Common terns foraging from the Alde-Ore Estuary SPA and Minsmere-Walberswick SPA will potentially encounter some areas of TRO, bromoform and hydrazine exceedance. However, the areas affected are small percentages of the overall foraging area, and the EQS and PNEC values used are precautionary with regard to direct and indirect effects on seabirds. More distant colonies will be unaffected. The ability of the water column habitat to support the breeding common tern feature of the Outer Thames Estuary SPA will be unaffected.	No effect. Due to chemical plumes from SZC and SZB in combination both occurring within the foraging area of breeding common tern nesting within the Minsmere-Walberswick SPA, areas of exceedance generally double for SZC and SZB as compared to SZC, but remain a small percentage of the overall foraging area. There is no overlap between chemical exceedance plumes and the mean foraging areas of common terns at either the Orfordness colony or the closest coastal point within the Alde-Ore Estuary SPA and baseline conditions are therefore unchanged when SZC and SZB are operating in combination. The EQS and PNEC values used are precautionary with regard to direct and indirect effects on seabirds. More distant colonies foraging in the Outer Thames Estuary SPA will be unaffected. The ability of the water column habitat to support the breeding common tern feature of the Outer Thames Estuary SPA will be unaffected.
Nutrient enrichment	Water column	Sensitive	No effect. Nutrient enrichment, from SZC alone, will be insufficient to lead to opportunistic macroalgal or phytoplankton blooms and the ability of the water column habitat to support the foraging behaviour of	No effect. As for SZC alone.

Pressure (from NE advice on operations)	Supporting habitat	Sensitivity	Effect of SZC alone	Effect of SZC+SZB
			the breeding common tern feature will be unaffected.	
Changes in suspended solids (water clarity)	Water column	Sensitive	No effect. There is no potential for nutrient enrichment to increase turbidity and the ability of the water column habitat to support the foraging behaviour of the breeding common tern feature will be unaffected.	No effect. As for SZC alone.

8.7.8. Conclusion

We have considered the relevant risks associated with the discharges from SZC alone, and from SZC and SZB in combination, that are the subject of this application, on the common tern (breeding) feature of the Outer Thames Estuary SPA in light of the designated site's conservation objectives and supplementary advice on conservation objectives (Table 42).

Due to its relatively recent designation, population trends for the common tern (breeding) feature of the Outer Thames Estuary SPA are not available (Marine site detail (naturalengland.org.uk)). However, the scale and location of impacts from the discharges from the cooling water system and the FRR, compared to the potential foraging areas of all common tern colonies supported by the Outer Thames Estuary SPA, coupled with the relatively generalist diet and variety of foraging methods available to common terns, allows us to conclude that there will be **no adverse effect** on this qualifying feature from the water discharge activities of SZC alone, in terms of maintaining or restoring the:

- extent and distribution of the habitats of the qualifying features
- structure and function of the habitats of the qualifying features
- supporting processes on which the habitats of the qualifying features rely
- populations of each of the qualifying features
- distribution of qualifying features within the site

SZB is expected to continue to operate until 2035, although there is potential for an extension of SZB's operational lifetime by 20 years to 2055 at the latest. Consequently, SZC and SZB may be operating in combination for between 2 and 22 years. However, the scale and location of impacts from the cooling water and FRR systems discharges from both stations in combination, compared to the potential foraging areas and areas of concentrated foraging activity of all common tern colonies supported by the Outer Thames Estuary SPA, coupled with the common tern's relatively generalist diet and variety of foraging methods, allows us to conclude that (irrespective of the date of SZB decommissioning) there will be **no adverse effect** on this qualifying feature from the water discharge activities of SZC and SZB in combination, in terms of maintaining or restoring the:

- extent and distribution of the habitats of the qualifying features
- structure and function of the habitats of the qualifying features
- supporting processes on which the habitats of the qualifying features rely
- populations of each of the qualifying features
- distribution of qualifying features within the site

Table 42: The outcome of our appropriate assessment of the impact of water discharge activities from the operation of SZC alone, and SZC and SZB in combination, on targets contained within Natural England's Supplementary Advice on Conservation Objectives for the breeding common tern feature of the Outer Thames Estuary SPA (the table only shows targets which may be affected by water discharge activities)

Attribute	Sub-attribute	Target	Outcome of SZC alone assessment	Outcome of SZC+SZB assessment
Breeding population	Abundance	Maintain the size of the breeding population at a level which is at or above 532 breeding individuals, while avoiding deterioration from its current level as indicated by the latest mean peak count or equivalent.	None of the attributes below will be adversely affected and so there will be no effect on the maintenance of the breeding common tern feature.	As for SZC alone.
Connectivity with supporting habitats	Connectivity with supporting habitats	Maintain safe passage of birds moving between nesting and feeding areas.	There are no physical obstructions to safe passage associated with the WDA permit. Absolute water temperature and chemical plumes would have no direct effect, but there is also very little overlap between thermal and chemical plumes and the foraging area of breeding common terns nesting within SPAs close to the main development site, with the thermal and	As for SZC alone.

Attribute	Sub-attribute	Target	Outcome of SZC alone assessment	Outcome of SZC+SZB assessment
			chemical plumes being beyond the foraging range of breeding common tern from more distant colonies.	
Supporting habitat	Extent and distribution of supporting habitat for the breeding season	Maintain the extent, distribution and availability of suitable habitat (either within or outside the site boundary) which supports the feature for all necessary stages of its breeding cycle (courtship, nesting, feeding).	There will be no effect on the ability of suitable habitats to support breeding common terns.	As for SZC alone.
Supporting habitat	Food availability	Maintain the distribution, abundance and availability of key food and prey items (for example, sandeel, sprat, coarse fish, crustacea, annelids) at preferred sizes.	Due to the small proportion of the foraging area experiencing thermal uplift or chemical exceedance, and the variety of prey types and foraging strategies available to breeding common tern, the water discharge activities of SZC alone, will not compromise the maintenance of the distribution, abundance and availability of key food and prey items of common tern. The applicant notes that it seems likely that the SZB outlet provides an important	As for SZC alone.

Attribute	Sub-attribute	Target	Outcome of SZC alone assessment	Outcome of SZC+SZB assessment
			foraging resource for common terns from the Minsmere colony. The FRR system of SZB discharges via the SZB cooling water outlet, around 150m offshore. The FRR system of SZC will discharge via 2 outlets, around 400m offshore, separate from the cooling water system discharge (3km offshore). It is likely that common terns will forage around the SZC FRR system outlets in the same way that they have been recorded to do around the SZB outlets.	
Water quality	Contaminants	Reduce aqueous contaminants to levels equating to high status according to Annex VIII and good status according to Annex X of the Water Framework Directive, avoiding deterioration from existing levels.	There will be mixing zones in which the EQS/PNEC values for TRO, bromoform and hydrazine will be exceeded. However, these will not be large enough to result in deterioration in water quality at a scale which will affect the breeding common tern feature. The decay of biota discharged by the FRR system will not lead to the release of un-ionised ammonia to the extent that there will be a deterioration in water quality that	As for SZC alone.

Attribute	Sub-attribute	Target	Outcome of SZC alone assessment	Outcome of SZC+SZB assessment
			will affect the breeding common tern feature.	
Water quality	Dissolved oxygen (DO)	Maintain the DO concentration at levels equating to high ecological status, avoiding deterioration from existing levels.	The decay of dead and moribund biota discharged by the FRR system will not lead to a deterioration from existing levels of DO concentration.	
Water quality	Nutrients	Maintain water quality at mean winter dissolved inorganic nitrogen levels where biological indicators of eutrophication (opportunistic macroalgal and phytoplankton blooms) do not affect the integrity of the site and features avoiding deterioration from existing levels.	Discharges from the cooling water and FRR systems will not lead to increases in dissolved inorganic nitrogen levels to the extent that indicators of eutrophication affect the integrity of the site.	As for SZC alone.
Water quality	Turbidity	Maintain natural levels of turbidity (for example, concentrations of suspended sediment, plankton and other material) across the habitat.	Organic enrichment will not lead to any increase in turbidity.	As for SZC alone.

8.8. Red-throated diver (non-breeding)

The cooling water system and FRR system of SZC discharge directly into the Outer Thames Estuary SPA, which includes non-breeding red-throated diver as a qualifying feature. Consequently, the Outer Thames Estuary SPA was identified by the applicant and considered appropriate for assessment.

An ecological narrative for the feature is given in Environment Agency (2022c; Annex 3).

The following appropriate assessment will assess the potential for an adverse effect alone on the integrity of the Outer Thames Estuary SPA from direct and indirect effects on non-breeding red-throated diver, resulting from the cooling water system and FRR system discharges.

8.8.1. Designated sites

The applicant considered that non-breeding red-throated diver were present in the Outer Thames Estuary SPA from September to March (NNB GenCo, 2021b; shadow HRA), based on the work of Furness (2015). NE's Senior Specialist in Marine Ornithology confirmed that these months were appropriate for use in our HRAR (email dated 9 November, 2021).

The information that the applicant provided to support the HRAR (NNB GenCo, 2021b; shadow HRA), and NE's supplementary advice on conservation objectives tell us that:

- the Outer Thames Estuary SPA comprises 3 discrete sections, a southern section between Walton-on-the-Naze and Margate, a north-western section which abuts the coast between the Felixstowe in the south and Great Yarmouth in the north, and a north-western section, centred around 30km offshore from Lowestoft (see Figure 4 in Environment Agency, 2022a; Annex 1). The main development site will discharge into the north-western section

8.8.2. Species condition summary

As part of the assessment, we should consider the status of the qualifying features of the site, the site condition and the prevailing environmental conditions. We will also consider any threats or degradations of the species and its supporting habitats for the designated sites.

The information that the applicant provided to support the HRAR (NNB GenCo, 2021b; shadow HRA), and NE's supplementary advice on conservation objectives (Marine site detail (naturalengland.org.uk)) tell us that:

- when first classified in 2010, the Outer Thames Estuary SPA supported an estimated 6,446 non-breeding red-throated divers, representing approximately 38% of the non-breeding population estimated for Great Britain. Recent surveys have estimated the current SPA population at 18,079 overwintering individuals (peak mean 2012/3 to 2017/18), but this apparent increase may be due to improved survey techniques, such as digital aerial imagery, and previous counts may have been underestimates. However, it is considered that the SPA supports the same proportion of red-throated diver in the UK and is considered of international importance
- aerial surveys of the SPA in 2018 provided separate estimates of the abundance and densities of red-throated divers in each of the 3 SPA sections. The southern section held the bulk of the SPA population with densities estimated to be almost twice as high as those in the north-western section during the second survey visit (when peak numbers occurred) and over 5 times higher during the first survey visit. The peak abundance within the north-western SPA section was estimated as 4,587 (95% CI 2,499 to 7,114) individuals, representing 21% of the peak estimate for the entire SPA (22,280, 95% CI 15,611 to 29,784). During the first survey visit, when numbers across the SPA were lower, the abundance in the north-western SPA section represented 7% of the SPA total
- similar differences in the densities of red-throated divers between the 3 discrete SPA sections were also noted during the earlier aerial surveys, with the southern section again holding the bulk of the SPA population during 2 surveys undertaken in January and February in 2013. Furthermore, distribution maps for both the 2013 and 2018 surveys indicate that relative to the overall densities within the north-western SPA section, densities in the coastal waters immediately adjacent to the main development site tend to be low to moderate
- the applicant recorded red-throated diver abundance and behaviour during coastal vantage point surveys from March 2011 to April 2012, using 12 vantage points in the vicinity of Sizewell, from Orfordness north to a location approximately 0.5km north of the main development site. These surveys were conducted every 2 weeks over the winter period (October to March), with each survey at each vantage point being 45 minutes duration. A total of 5,056 divers were recorded during the survey period, of which 3,997 were commuting through the survey area and 1,059 were foraging or resting on the sea. The highest number of divers were seen in March and April 2011, and again in December 2011 to April 2012, with smaller numbers from August to October 2011 and none from May to July 2011

- overall, the highest numbers of red-throated diver were recorded from the most southern vantage point at Orfordness (vantage point number 12), although relatively few of the birds recorded from this location were foraging or loafing. The highest numbers of foraging and loafing birds were recorded near Thorpeness and south of the main development site, and also at Orfordness (vantage point number 11)
- further red-throated diver surveys were undertaken during the winter period (October to March) in 2012 to 2013 and 2013 to 2014 at 15 vantage points along the coastline between Dunwich (approximately 6km north of the main development site) and Orfordness (approximately 16km south of the main development site). As well as the addition of 3 more northerly vantage point locations, these later surveys also incorporated coverage of dawn and dusk periods at the 4 vantage points closest to the main development site, but otherwise followed the same methods as used in the 2011to 2012 surveys
- a total of 2,543 sightings were recorded during the 2012 to 2013 surveys (mostly in February and March, with 19% and 67% of records, respectively) and 4,497 sightings during 2013 to 2014 surveys (mostly in December, January and February with 46%, 23% and 28% of records, respectively), with a maximum single count of 700 birds at Dunwich in December 2013
- during the 2012 to 2013 and 2013 to 2014 winter surveys, red-throated divers were recorded out to a maximum distance of 3km (considered to be the limit for the shore-based survey method used), but with few records from beyond 2km (reflecting the problems in locating and identifying divers at this distance). Only 5.7% of all records were within 500m of the shore, while 40% and 54% were between 500m and 1km and 1km and 2km, respectively. Therefore, even allowing for the increased area of sea within these wider distance bands, densities are clearly relatively low within 500m of the shore (bearing in mind that detectability of birds also declines with distance from the shore and is likely to be relatively low at distances beyond 1km)

8.8.3. Conservation objectives

Links to the full conservation objectives for the SPAs identified here are provided in Environment Agency (2022b; Annex 2), and the appropriate assessment will be concluded against the relevant conservation objectives provided.

8.8.4. Supporting habitats

Supporting habitats listed for non-breeding red-throated diver in Outer Thames Estuary SPA (Marine site detail (naturalengland.org.uk)) are:

- circalittoral rock

- intertidal sand and muddy sand
- subtidal coarse sediment
- subtidal mixed sediment
- subtidal mud
- subtidal sand
- water column

8.8.5. Discussion

Risks carried through to appropriate assessment for the non-breeding red-throated diver feature of the Outer Thames Estuary SPA are:

- change in thermal regime
- toxic contamination (chemical)
- nutrient enrichment

Change in thermal regime

Absolute water temperatures

There is no potential for non-breeding red-throated diver to be directly harmed by elevated water temperatures when SZC is operating alone or when SZC and SZB are operating in combination (section 8.3.1).

Thermal uplift

There is no potential for an adverse effect on non-breeding red-throated diver through thermal uplift from SZC alone or SZC and SZB in combination.

The ≥3°C thermal uplift (98th percentile) plumes from SZB alone, SZC alone, and SZC and SZB in combination all lie entirely within the north-western section of the Outer Thames Estuary SPA (as can be seen in maps showing breeding common tern foraging areas, for example, Figure 50). Although the density of red-throated divers (number of individuals per unit area) has been observed to be 2 to 5 times higher in the southern section of the Outer Thames Estuary SPA than in the north-western section, within which densities are lower near the coast, the north-western section is still clearly used by, and therefore of importance to, the non-breeding red-throated diver feature.

The applicant noted that "there is likely to be interchange of birds between the SPA and other North Sea wintering grounds, such as the Wadden Sea" (NNB GenCo, 2021b; shadow HRA). Nehls and others (2018) report home ranges of wintering red-throated divers as extending over several thousand square kilometres in the German

North Sea. In its 'Supplementary Advice on Conservation Objectives', Natural England notes that "red-throated diver are highly mobile, and may move between sandy bays, sandbanks and the mouths of estuaries," (Marine site detail (naturalengland.org.uk)). This wide-ranging behaviour is likely to make the SPA non-breeding red-throated diver population relatively insensitive to localised changes in prey availability, such as may occur from avoidance of areas of thermal uplift. It seems that red-throated divers may also move between areas within the SPA. If this were the case, the same individuals would not necessarily remain within the north-western section throughout the non-breeding period. This would mean that if there were any effects, they would be somewhat diluted as individuals would not be expected to remain within the immediate area of the ≥3°C thermal uplift (98th percentile) plumes for prolonged periods of time. Further resilience will result from the species being an opportunistic feeder, with diet composition depending on local availability of prey rather than food specialisation. If prey fish avoid an area of thermal uplift, the red-throated divers have the ability to relocate, to follow their prey fish, or to exploit a different resource elsewhere.

The Outer Thames Estuary SPA covers such a large area (3,924.5km²) that the proportion of the entire SPA within the ≥3°C thermal uplift (98th percentile) plumes is very low for SZB alone (0.3%), SZC alone (<0.1%) and SZC and SZB in combination (0.6%) (Table 27).

Even if the areas of the annual ≥3°C thermal uplift (98th percentile) plumes for SZB alone, SZC alone, and SZC and SZB in combination (12.6km², 3.1km² and 22.0km²; NNB GenCo, 2020b) are expressed as a percentage of the area of the north-western section of the SPA alone (1,212.5km²), the values remain low, being 1.0% for SZB alone, 0.3% for SZC alone, and 1.8% for SZC and SZB in combination. Due to the mobility of red-throated divers, considering the plume size relative to the combined area of all SAC sections is the more appropriate approach.

The percentage of the Outer Thames Estuary SPA that would be experiencing ≥3°C thermal uplift at any given point in time (as illustrated by the instantaneous plumes) would generally be lower still than the area of the ≥3°C thermal uplift (98th percentile) plumes (section 8.1.1, Table 27).

Due to the very small proportion of the Outer Thames Estuary that will be affected by thermal uplift and the wide-ranging foraging behaviour of non-breeding red-throated diver within (and potentially beyond) the SPA, any avoidance of areas of thermal uplift will not adversely affect the non-breeding red-throated diver feature.

Toxic contamination (chemical)

Direct effects

There are no direct effects of toxic contamination (chemical) on the non-breeding red-throated diver feature of the Outer Thames Estuary SPA, from either SZC alone, or SZC and SZB in combination. This is due to the very low proportion of the Outer Thames Estuary SPA within which EQS or PNEC values are exceeded for TRO, bromoform or hydrazine, coupled with the precautionary nature of the EQS/PNEC thresholds (section 8.3.2, Table 27).

When SZC is operating alone, the areas of exceedance for TRO, bromoform, chronic hydrazine or acute hydrazine all extend across <0.1% of the total surface area of the Outer Thames Estuary SPA (Table 27). This is also true for SZC and SZB in combination, with the exception of the TRO ≥ EQS 10µg/l plume which covers 0.19% of the Outer Thames Estuary SPA (Table 27).

Indirect effects

There are no indirect effects of toxic contamination (chemical) on the non-breeding red-throated diver feature of the Outer Thames Estuary SPA, from either SZC alone, or SZC and SZB in combination. This is due to the very low proportion of the Outer Thames Estuary SPA within which EQS or PNEC values are exceeded for TRO, bromoform or hydrazine, coupled with the precautionary nature of the EQS/PNEC thresholds (section 8.3.2, Table 27).

There is no potential for bioaccumulation of TRO, bromoform or hydrazine to affect the non-breeding red-throated diver feature of the Outer Thames Estuary SPA (section 8.3.2).

Changes in nutrients/eutrophication

Direct effects

There are no source-receptor pathways by which organic or nutrient enrichment from SZC alone or SZC and SZB in combination can directly affect the non-breeding red-throated diver feature of the Outer Thames Estuary SPA (section 8.3.3).

Indirect effects

There are no indirect effects of organic enrichment on the non-breeding red-throated diver feature of the Outer Thames Estuary SPA, from either SZC alone or SZC and SZB in combination (section 8.3.3).

Changes in nutrient enrichment, un-ionised ammonia and dissolved oxygen levels resulting from the operation of SZC alone or SZC and SZB in combination will not lead to any indirect effects on the non-breeding red-throated diver feature of the Outer Thames Estuary SPA (section 8.3.3).

Supporting habitats

There will be no adverse effects on the supporting habitats for the red-throated diver feature of the Outer Thames Estuary SPA as a result of the operation of SZC alone, or SZC and SZB in combination.

Sandbanks within the SPA are important foraging grounds for red-throated diver, as they provide suitable hunting depths, support many of the prey species, and act as nursery grounds for those prey species (Marine site detail (naturalengland.org.uk)). However, all foraging takes place within the water column over the subtidal supporting habitats (circalittoral rock, intertidal sand and muddy sand, subtidal coarse sediment, subtidal mixed sediment, subtidal mud, subtidal sand). It is through pressures in the water column that SZC alone or SZC and SZB in combination may potentially affect the non-breeding red-throated diver feature. This assessment therefore considers the potential for the water discharge activities of SZC alone or SZC and SZB in combination to affect the ability of the water column habitat to support the non-breeding red-throated diver feature.

Given the wide-ranging behaviour of non-breeding red-throated divers and the low proportion of the Outer Thames Estuary SPA that will be affected by the water discharge activities of SZB alone or SZC and SZB in combination, any effects on the water column of the Outer Thames Estuary SPA will not adversely affect the non-breeding red-throated diver feature (Table 43).

Table 43: The sensitivities of the water column supporting habitat for Outer Thames Estuary SPA non-breeding red-throated diver foraging in the Outer Thames Estuary SPA, as described in NE Advice on Operations, together with the expected effects as a result of SZC alone, and SZC and SZB in combination

Pressure (from NE advice on operations)	Supporting habitat	Sensitivity	Effect of SZC alone	Effect of SZC+SZB
Increases in temperature	Water column	Classified as 'not relevant' in NE Advice on Operations but considered here due to the nature of the water discharge activity.	No effect. While thermal uplift may potentially affect the water column within the Outer Thames Estuary SPA, non-breeding red-throated diver will be unaffected due to the uplift forming such a small percentage of the SPA coupled with their wide-ranging and opportunistic foraging behaviour.	No effect. As for SZC alone.
Other substances (solid, liquid or gas)	Water column	Not assessed	No effect. The percentage of the surface area of the Outer Thames Estuary SPA experiencing chemical exceedances is very low and the EQS/PNEC thresholds used are precautionary with regard to direct or indirect, effects on non-breeding red-throated diver and so the feature will be unaffected.	No effect. As for SZC alone.

Pressure (from NE advice on operations)	Supporting habitat	Sensitivity	Effect of SZC alone	Effect of SZC+SZB
Nutrient enrichment	Water column	Sensitive	No effect. Nutrient enrichment, from SZC alone, will be insufficient to lead to opportunistic macroalgal or phytoplankton blooms and the ability of the water column habitat to support the foraging behaviour of the non-breeding red-throated diver feature will be unaffected.	No effect. As for SZC alone.
Changes in suspended solids (water clarity)	Water column	Sensitive	No effect. There is no potential for nutrient enrichment to increase turbidity, so the ability of the water column habitat to support the foraging behaviour of the non-breeding red-throated diver feature will be unaffected.	No effect. As for SZC alone.

8.8.6. Conclusion

We have considered the relevant risks associated with the discharges, from SZC alone, and from SZC and SZB in combination, that are the subject of this application, on the red-throated diver (non-breeding) feature of the Outer Thames Estuary SPA, in light of the designated sites' conservation objectives and supplementary advice on conservation objectives (Table 44).

Water discharge activities from SZC will take place within the north-western section of the Outer Thames Estuary SPA. Although the density of red-throated divers has been observed to be lower in the southern section than in the north-western section, the north-western section is used by, and is of importance to, the non-breeding red-throated diver feature. The scale of impacts from the discharges from the cooling water system and the FRR system, compared to the extensive home range and opportunistic diet of the non-breeding red-throated diver feature, allows us to conclude that there will be **no adverse effect** on this qualifying feature from the water discharge activities of SZC alone, in terms of maintaining or restoring the:

- extent and distribution of the habitats of the qualifying features
- structure and function of the habitats of the qualifying features
- supporting processes on which the habitats of the qualifying features rely
- populations of each of the qualifying features
- distribution of qualifying features within the site

SZB is expected to continue to operate until 2035, although there is potential for an extension of SZB's operational lifetime by 20 years to 2055 at the latest. Consequently, SZC and SZB may be operating in combination for between 2 and 22 years. However, the scale of impacts from the discharges from the cooling water systems and the FRR systems of SZC and SZB in combination, compared to the extensive home range and opportunistic diet of the non-breeding red-throated diver feature allows us to conclude (irrespective of the date of SZB decommissioning) that there will be **no adverse effect** on this qualifying feature from the water discharge activities of SZC and SZB in combination, in terms of maintaining or restoring the:

- extent and distribution of the habitats of the qualifying features
- structure and function of the habitats of the qualifying features
- supporting processes on which the habitats of the qualifying features rely
- populations of each of the qualifying features
- distribution of qualifying features within the site

Table 44: The outcome of our appropriate assessment of the impact of water discharge activities from the operation of SZC alone, and SZC and SZB in combination, on targets contained within Natural England's Supplementary Advice on Conservation Objectives for the non-breeding red-throated diver feature of the Outer Thames Estuary SPA (the table only shows targets which may be affected by water discharge activities)

Pressure (from NE advice on Operations)	Attribute/sub-attribute	Target	Outcome of SZC alone assessment	Outcome of SZC+SZB assessment
Breeding population	Abundance	Maintain the size of the non-breeding population at a level which is at or above 18,079 individuals, whilst avoiding deterioration from its current level as indicated by the latest mean peak count or equivalent.	None of the attributes below will be adversely affected and so there will be no effect on abundance of the non-breeding red-throated diver feature.	As for SZC alone.
Supporting habitat	Extent and distribution of supporting habitat for the non-breeding season	Maintain the extent, distribution and availability of suitable habitat (either within or outside the site boundary) which supports the feature for all necessary stages of the non-breeding/wintering period (moulting, roosting, loafing, feeding) at the following levels: Subtidal sand (220,295.55); Subtidal coarse sediment (73,606.64); Subtidal mixed sediments (62,100.63ha); Subtidal	There will be no effect on the ability of suitable habitats to support the non-breeding red-throated diver feature.	As for SZC alone.

Pressure (from NE advice on Operations)	Attribute/sub-attribute	Target	Outcome of SZC alone assessment	Outcome of SZC+SZB assessment
		mud (12,549.14ha); Circalittoral rock (335.2ha); and Water column.		
Supporting habitat	Food availability	Maintain the distribution, abundance and availability of key main food and prey items (for example, fish) at preferred sizes.	Due to the small proportion of the Outer Thames Estuary SPA experiencing thermal uplift or chemical exceedance, the distribution, abundance and availability of key food and prey items of non-breeding red-throated diver will be maintained.	As for SZC alone.
Water quality	Contaminants	Reduce aqueous contaminants to levels equating to high status according to Annex VIII and good status according to Annex X of the Water Framework Directive, avoiding deterioration from existing levels.	There will be mixing zones in which the EQS/PNEC values for TRO, bromoform and hydrazine will be exceeded. However, these will not be large enough to result in deterioration in water quality at a scale which will affect the non-breeding red-throated diver feature. The decay of biota discharged by the FRR system will not lead to the release of un-ionised ammonia to the extent that there will be a deterioration in water quality that	As for SZC alone.

Pressure (from NE advice on Operations)	Attribute/sub-attribute	Target	Outcome of SZC alone assessment	Outcome of SZC+SZB assessment
			will affect the non-breeding red-throated diver feature.	
Water quality	Dissolved oxygen (DO)	Maintain the dissolved oxygen (DO) concentration at levels equating to high ecological status (specifically ≥ 5.7mg per litre (at 35 salinity) for 95% of the year), avoiding deterioration from existing levels.	The decay of dead and moribund biota discharged by the FRR system will not lead to a deterioration from existing levels of DO concentration.	
Water quality	Nutrients	Maintain water quality at mean winter dissolved inorganic nitrogen levels where biological indicators of eutrophication (opportunistic macroalgal and phytoplankton blooms) do not affect the integrity of the site and features avoiding deterioration from existing levels.	Discharges from the cooling water and FRR systems will not lead to increases in dissolved inorganic nitrogen levels to the extent that indicators of eutrophication affect the integrity of the site.	As for SZC alone.
Water quality	Turbidity	Maintain natural levels of turbidity (for example, concentrations of suspended sediment, plankton and other material) across the habitat.	Organic enrichment will not lead to any increase in turbidity.	As for SZC alone.

8.9. Harbour porpoise

The following site with harbour porpoise as a qualifying feature has been identified by the applicant and considered appropriate for assessment:

- Southern North Sea SAC

An ecological narrative for the feature is given in Environment Agency (2022c; Annex 3).

The following appropriate assessment will assess the potential for an adverse effect alone on the integrity of this site from direct and indirect effects on the harbour porpoise feature, resulting from the cooling water system and FRR system discharges.

8.9.1. Designated sites

SZC discharges directly into the Southern North Sea SAC. The information that the applicant provided to support the HRA (NNB GenCo, 2021b; shadow HRA), the Joint Nature Conservation Committee's description of the Southern North Sea SAC and JNCC and NE (2019) tells us that:

- the Southern North Sea SAC is an area of importance for harbour porpoise. This site includes key winter and summer habitat for this species

- the site has been recognised as an area with persistent high densities of harbour porpoise. The site has an area of 36,951km^2, covering both winter and summer habitats of importance to harbour porpoise, with approximately 27,018km^2 of the site being important in the summer and 12,697km^2 of the site being important in the winter period. The Sizewell C main development site is located within the winter area of the site (Figure 58)

Although sites of seasonal importance have been identified, it is the site as a whole that is designated, and harbour porpoise can use summer and winter sites throughout the year.

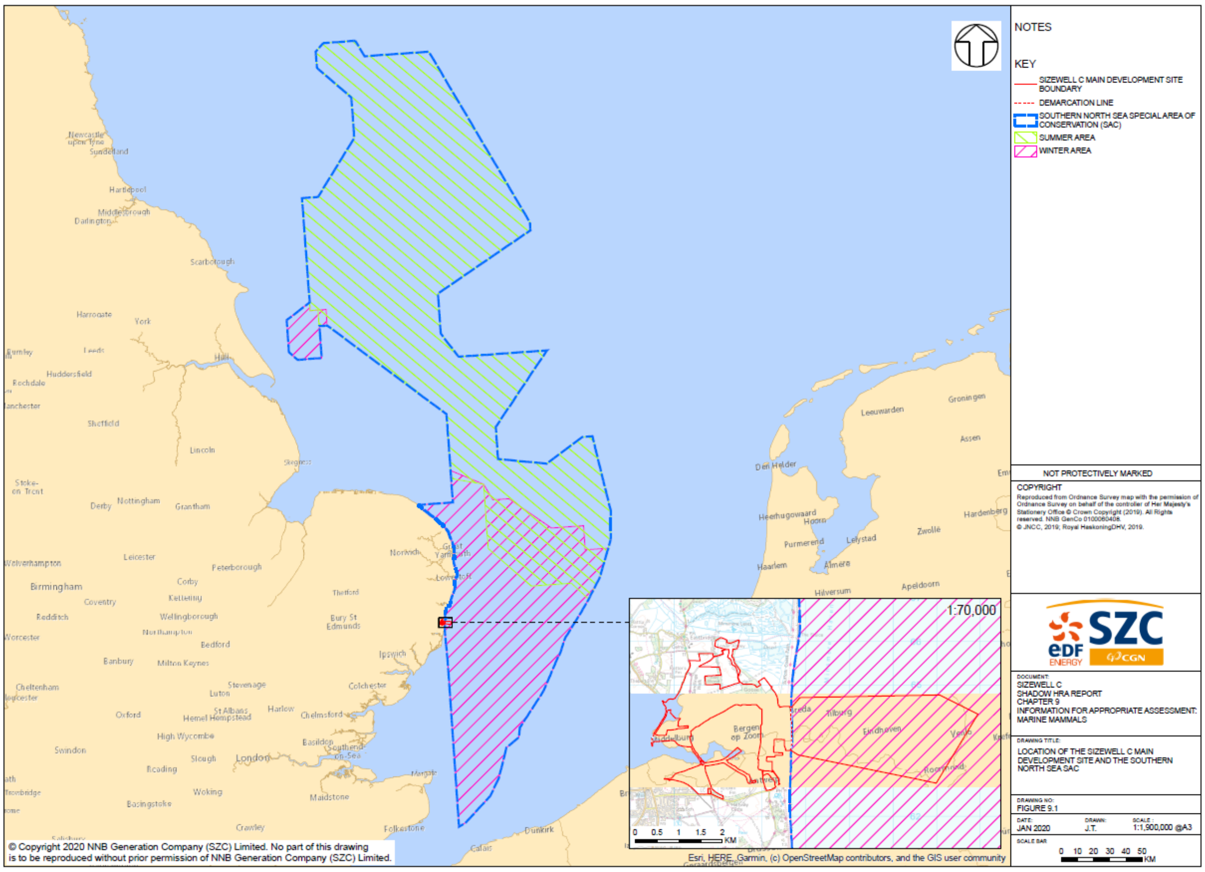

Figure 58: The Southern North Sea Special Area of Conservation for harbour porpoise showing areas of particular importance in summer and winter. Reproduced from Figure 9.1 in NNB GenCo (2021b; shadow HRA)

8.9.2. Species condition summary

As part of the assessment, we will consider the status of the qualifying features of the site, the site condition, and the prevailing environmental conditions. We will also consider any threats or degradations of the species and its supporting habitats of the designated sites.

The information that the applicant provided to support the HRA (NNB GenCo, 2021b; shadow HRA), and NE's supplementary advice on conservation objectives (Marine site detail (naturalengland.org.uk)) tells us that:

- harbour porpoise within the eastern north Atlantic is typically considered to be part of a continuous population that extends from the French coastline to Northern Norway and Iceland. For conservation purposes the population is divided into smaller management units known as MUs. The main Sizewell C development is within the North Sea MU
- the area supports an estimated 17.5% of the UK North Sea MU population. Approximately two-thirds of the site, the northern part, is recognised as

important for porpoises during the summer season, while the southern part supports persistently higher densities during the winter
- the SCANS-III survey, which was undertaken in 2016, estimates that the number of harbour porpoise in the North Sea MU was 343,373, with a density estimate of 0.52 per km^2. The Sizewell C development is specifically within SCANS-III survey block L and the estimate of harbour porpoise numbers within this block is 19,064, with an estimated density of 0.607 per km^2
- harbour porpoises in UK waters are considered part of a wider European population and due to the mobile nature of this species, the concept of a 'site population' may not be appropriate. Assessments of effects of plans or projects (for example, HRA) need to consider population estimates at the MU level, to account for daily and seasonal movements of the animals

8.9.3. Conservation objectives

The conservation objectives for the Southern North Sea SAC are to ensure that the integrity of the site is maintained and that it makes the best possible contribution to maintaining favourable conservation status for harbour porpoise in UK waters.

In the context of natural change, this will be achieved by ensuring that:

- harbour porpoise is a viable component of the site
- there is no significant disturbance of the species
- the condition of supporting habitats and processes, and the availability of prey is maintained

JNCC and NE (2019) and the applicant (NNB GenCo, 2021b; shadow HRA) provide clarification on these objectives:

- **Harbour porpoise is a viable component of the site**

  This conservation objective is designed to minimise the risk of injury and killing or other factors that could restrict the survivability and reproductive potential of harbour porpoise using the site. Specifically, this objective is primarily concerned with operations that would result in unacceptable levels of such impacts on harbour porpoise using the site. Unacceptable levels can be defined as those having an impact on the favourable conservation status of the populations of the species in their natural range.

  Harbour porpoise are considered to a viable component of the site if they are able to live successfully within it. This site has been selected primarily based on the long-term, relatively higher densities of porpoise in contrast to other areas of the North Sea. The implication is that the SAC provides relatively good foraging habitat and may also be used for breeding and calving.

However, because the number of harbour porpoise using the site naturally varies there is no exact value for the number of animals expected within the site.

- **There is no significant disturbance of the species**

  The disturbance of harbour porpoise typically, but not exclusively, originates from operations that cause underwater noise, including activities such as seismic surveys, pile driving and sonar.

  Disturbance of harbour porpoise may lead to displacement from an area, and the temporary loss of habitat.

  Activities within the Southern North Sea SAC should be managed to ensure that the animals' potential usage of the site is maintained and any disturbance should not lead to the exclusion of harbour porpoise from a significant portion of the site for a significant period of time. Disturbance is considered 'significant' if it leads to the exclusion of harbour porpoise from a significant portion of the site.

  The draft SNCB advice/guidance for the assessment of significant noise disturbance on harbour porpoise in the Southern North Sea SAC is that:

  "Noise disturbance within an SAC from a plan/project individually or in combination is significant if it excludes harbour porpoise from more than:

  1. 20% of the seasonal component of the Southern North Sea SAC in any given day

  2. an average of 10% of the relevant area of the site over a season"

- **The condition of supporting habitats and processes, and the availability of prey is maintained**

  Supporting habitats, in this context, means the characteristics of the seabed and water column. Supporting processes encompass the movements and physical properties of the habitat. The maintenance of these supporting habitats and processes contributes to ensuring that prey stays within the site and is available to harbour porpoise using the site. Harbour porpoise are strongly reliant on the availability of prey species year-round due to their high energy demands, and their distribution and condition may strongly reflect the availability and energy density of prey.

  This conservation objective is designed to ensure that harbour porpoise are able to access food resources year round, and that activities occurring in the Southern North Sea SAC will not affect this.

8.9.4. Supporting habitats

Supporting habitats of importance for harbour porpoise in the Southern North Sea SAC include:

- seabed
- water column

8.9.5. Discussion

Risks carried through to appropriate assessment for the harbour porpoise feature of the Southern North Sea SAC are:

- change in thermal regime
- toxic contamination (chemical)
- nutrient enrichment

The operation of SZC alone is the focus for this permit determination. However, as SZC and SZB discharge directly into the Southern North Sea SAC, the possibility of in-combination effects from SZC and SZB will also be considered within the following discussion.

Change in thermal regime

Absolute water temperatures

There is no potential for harbour porpoise to be directly harmed by elevated water temperatures when SZC is operating alone, or when SZC and SZB are operating in combination (section 8.3.1).

Thermal uplift

There is no potential for an adverse effect on the harbour porpoise feature of the Southern North Sea SAC through thermal uplift from SZC alone or SZC and SZB in combination due to the low proportion of the Southern North Sea SAC that is affected. Furthermore, due to the thermal plume lying entirely within the Southern North Sea SAC, any prey displaced would still be available to foraging harbour porpoise (section 8.3.1).

In addition to the information presented in section 8.3.1, comparing the annual ≥2°C thermal uplift (100th percentile) plume size to criteria proposed for noise disturbance (section 8.9.3), the area affected by thermal uplift is well below the 20% threshold of effect at any one time, and the 10% seasonal component of the site on average over the season. The area affected by thermal uplift is therefore so small that any prey avoidance, or alteration of biological communities, that may result would be over such a low proportion of the potential foraging area of the highly mobile harbour porpoise that there would be no adverse effect on the feature. The high mobility of harbour porpoise is such that individuals using the Southern North Sea SAC may roam widely across the North Sea Management Unit. In any case, due to the thermal plume lying entirely within the Southern North Sea SAC, any prey displaced would still be available to foraging harbour porpoise.

The number of porpoises near to SZC at any one point in time will naturally vary due to the mobility of the animals. However, multiplying the density of harbour porpoise in the vicinity of SZC (0.607 per km^2, section 8.9.2) by the area of the ≥2°C (100th percentile) plume (section 8.1.1) can give an estimate of numbers of individuals within the plumes; these being 57 for SZB alone, 102 for SZC alone, and 137 for SZC and SZB combined (rounding up to whole animals). These values represent 0.02%, 0.03% and 0.04% of the North Sea Management Unit reference population of 343,373 (section 8.9.2).

Toxic contamination (chemical)

Direct effects

There are no direct effects of toxic contamination (chemical) on the harbour porpoise feature of the Southern North Sea SAC from either SZC alone or SZC and SZB in combination. This is due to the low proportion of the Southern North Sea SAC within which EQS or PNEC values are exceeded for TRO, bromoform or hydrazine. Additionally, the mobility of harbour porpoise means that little time would be spent within an exceedance plume, were a porpoise to enter (section 8.3.2).

In addition to the information presented in section 8.3.2, comparing the TRO exceedance plume size to criteria proposed for noise disturbance (see section 8.9.3), the area affected by TRO exceedance is well below the 20% threshold of effect at any one time, and the 10% seasonal component of the site on average over the winter season. It is important to remember that chlorine dosing is unlikely to be necessary throughout the winter as it will only take place when water temperature exceeds 10°C (section 6.2.2).

The Greater Sizewell Bay area lies within the area of the Southern North Sea SAC identified as being of greater importance to harbour porpoise in winter months, defined as October to March, inclusive, in JNCC and NE (2019). However, chlorination may occur during this period, with mean monthly temperatures being above 10°C in October and November (from Table 7 in NNB GenCo, 2020a; TR302). Also, although there may be more porpoises here during winter months, they can use the area year-round.

At any one time, the instantaneous plume size will generally be smaller than the 95th percentile plume (section 8.1.1) and so the chances of porpoises encountering the plume are low. Due to their mobility, harbour porpoise would also not be expected to remain within the plume for prolonged periods of time.

The number of porpoises near to SZC at any one point in time will naturally vary due to the mobility of the animals. However, multiplying the density of harbour porpoise in the vicinity of SZC (0.607 per km^2, section 8.9.2) by the area of the TRO exceedance plumes (Table 15) can give an estimate of numbers of individuals within the plumes; these being 3 for SZB alone, 3 for SZC alone, and 5 for SZC and SZB in combination (rounding up to whole animals). These values represent 0.0007%, 0.0006% and 0.001% of the North Sea Management Unit reference population of 343,373 (section 8.9.2).

TRO exceedance plumes (Table 15) are larger than those of bromoform (Table 16) and hydrazine (Table 17). Given the precautionary nature of the TRO EQS and the bromoform and hydrazine PNECs with regard to potential effects on marine mammals, the TRO plume represents a worst-case assessment of potential direct effects. The conclusion of no adverse effect for TRO therefore also holds for bromoform and hydrazine. As it derives from chlorine dosing, bromoform will also only be discharged when the sea temperature is >10°C and so would not be expected to be released during the colder winter months, when Greater Sizewell Bay is of increased importance to the harbour porpoise feature.

Indirect effects

There are no indirect effects of toxic contamination (chemical) on the harbour porpoise feature of the Southern North Sea SAC, from either SZC alone or SZC and SZB in combination. This is due to the low proportion of the Southern North Sea SAC that would be affected, and the precautionary nature of the EQS and PNEC values. Furthermore, due to the exceedance plumes lying entirely within the Southern North Sea SAC, any prey displaced would still be available to foraging harbour porpoise (section 8.3.2).

There is no potential for bioaccumulation of TRO, bromoform or hydrazine to affect the harbour porpoise feature (section 8.3.2).

In addition to the information presented in the ‘Overarching discussion: total residual oxidants (TRO)’: Indirect effects section, at <0.1% of the surface area of the Southern North Sea SAC, the TRO exceedance plumes for SZB alone, SZC alone, and SZC and SZB in combination, form well below the 20% threshold of effect at any one time, and the 10% seasonal component of the site on average over the winter season (see section 8.9.3). Chlorine dosing is unlikely to be necessary throughout the winter (October to March, inclusive), as it will only be required when water temperature exceeds 10°C (section 6.2.2).

The Greater Sizewell Bay area lies within the area of the Southern North Sea SAC identified as being of greater importance to harbour porpoise in winter months, defined as October to March, inclusive, in JNCC and NE (2019). However, chlorination may occur during this period, with mean monthly temperatures being above 10°C in October and November (Table 2). Also, although there may be more porpoises here during winter months, they can use the area year-round. As it derives from chlorine dosing, bromoform will also only be discharged when the sea temperature is >10°C.

The number of porpoises near SZC at any one point in time will naturally vary due to the mobility of the animals, but multiplying the density of harbour porpoise in the vicinity of SZC by the area of the TRO exceedance plumes gives estimates of 3 individual porpoises within the plume for SZB alone, 3 for SZC alone, and 5 porpoises within the plume for SZC and SZB in combination (rounding up to whole animals) (0.0007%, 0.0006% and 0.001% of the North Sea Management Unit reference population, section 8.9.2).

The TRO exceedance plumes (Table 15) are larger than those of bromoform (Table 16) or hydrazine (Table 17) and so the TRO plume represents a worst-case assessment of potential indirect effects of toxic contamination (chemical) and the conclusion of no adverse effect for TRO therefore also holds for both bromoform and hydrazine.

Changes in nutrients/eutrophication

Maximum potential area of organic exceedance

Direct effects

There is no source-receptor pathway by which organic enrichment can have a direct effect on the harbour porpoise feature (section 8.3.3).

Indirect effects

Particle tracking models indicate that dispersal of dead/moribund biota will be greater than indicated by the maximum potential area of organic exceedance plume approximation, resulting in a correspondingly reduced contribution of carbon/m²/year within the Southern North Sea SAC. In addition, the pathways by which the dead/moribund biota may affect food chains, and the precautionary nature of both particle tracking modelling and the calculation of the maximum potential area of organic exceedance plume approximation, mean that there will be no adverse effect on the harbour porpoise feature as an indirect result of organic enrichment (section 8.3.3).

Nutrient enrichment, un-ionised ammonia and dissolved oxygen

Direct effects

There are no source-receptor pathways by which nutrient enrichment, un-ionised ammonia or dissolved oxygen levels can directly affect the harbour porpoise feature of the Southern North Sea SAC (section 8.3.3).

Indirect effects

Nutrient enrichment from SZC alone, or SZC and SZB in combination, will not be sufficient to increase phytoplankton production to the extent that there is an increase in turbidity. Consequently, there will be no indirect effects on the harbour porpoise feature due to nutrient enrichment resulting from the operation of SZC alone or from SZC and SZB in combination (section 8.3.3).

Un-ionised ammonia resulting from biota discharged from the FRR systems of SZC alone, or SZC and SZB in combination, will not be sufficiently concentrated to result in avoidance behaviour by prey species. Consequently, there will be no indirect effects on the harbour porpoise feature of the Southern North Sea SAC resulting from un-ionised ammonia levels due to nutrient enrichment from the operation of SZC alone or from SZC and SZB in combination (section 8.3.3).

Any reduction in dissolved oxygen levels caused by biota discharged from the FRR systems of SZC alone or SZC and SZB in combination will not be sufficient to result in avoidance behaviour by prey species. Consequently, there will be no indirect effects on the harbour porpoise feature of the Southern North Sea SAC resulting from changes in dissolved oxygen levels caused by nutrient enrichment from SZC alone or from SZC and SZB in combination (section 8.3.3).

Supporting habitats

There will be no adverse effects on the seabed or water column supporting habitats of the harbour porpoise feature of the Southern North Sea SAC as a result of the operation of SZC alone or SZC and SZB in combination.

Organic and nutrient enrichment will not affect the seabed to the degree that there will be a negative effect on harbour porpoise.

Foraging takes place in the water column supporting habitat, but given the small size of thermal and chemical plumes from either SZC alone or SZC and SZB in combination, as well as the low level of nutrient input relative to tidal dynamics, pressures from change in thermal regime, toxic effects (chemical) and nutrient enrichment/eutrophication will have no effect on the ability of the water column to support the harbour porpoise feature of the Southern North Sea SAC.

The water discharge activity of SZC does not pose a risk to harbour porpoise through bioaccumulation.

8.9.6. Conclusion

We have considered the relevant risks associated with the discharges, from SZC alone, and from SZC and SZB in combination, that are the subject of this application, on the harbour porpoise feature of the Southern North Sea SAC in light of the designated site's conservation objectives and supplementary advice on conservation objectives (Table 45).

The relatively small size of the areas of thermal and chemical exceedance, and the relatively low level of organic input, compared to the size of the Southern North Sea SAC allows us to conclude that there will be **no adverse effect** on this qualifying feature from the water discharge activities of SZC alone in terms of ensuring that:

- harbour porpoise is a viable component of the site
- there is no significant disturbance of the species
- the condition of supporting habitats and processes, and the availability of prey is maintained

SZB is expected to continue to operate until 2035, although there is potential for an extension of SZB's operational lifetime by 20 years to 2055 at the latest. Consequently, SZC and SZB may be operating in combination for between 2 and 22 years. However, the relatively small size of the areas of thermal and chemical exceedance, and the relatively low level of organic input, compared to the size of the Southern North Sea SAC allows us to conclude that (irrespective of the date of SZB decommissioning) there will be **no adverse effect** on this qualifying feature from the water discharge activities of SZC and SZB in combination in terms of ensuring that:

- harbour porpoise is a viable component of the site
- there is no significant disturbance of the species
- the condition of supporting habitats and processes, and the availability of prey is maintained

An in-combination assessment will be carried out in section 9 and the integrity test conclusions will be reached in section 10.1.7.

Table 45: The outcome of our appropriate assessment of the impact of water discharge activities from the operation of SZC alone, and SZC and SZB in combination, on targets contained within JNCC and NE (2019) for the harbour porpoise feature of the Southern North Sea SAC (the table only shows pressures resulting from water discharge activities)

Pressure	Impact	Current relative level of risk impact	Outcome of SZC alone assessment	Outcome of SZC+SZB assessment
Contaminants	Effects on water and prey quality	**High**	Due to the small proportion of the Southern North Sea SAC experiencing thermal uplift or chemical exceedance, and the low level of organic input relative to the size of the SAC, the water discharge activities of SZC alone, will not have an effect on water quality of sufficient magnitude to affect the harbour porpoise feature or its supporting habitats. Prey quality will also not be affected.	As for SZC alone.
Contaminants	Bioaccumulation through contaminated prey ingestion leading to health issues for example, on reproduction	**High**	There is no risk of bioaccumulation of TRO, chlorinated by-products, or hydrazine discharged by SZC alone.	As for SZC alone.

9. In-combination assessment for WDA operational permit

Regulation 63 of The Conservation of Habitats and Species Regulations 2017 requires the competent authority to consider within the HRAR, any permission, plans or projects (including Environment Agency permissions and plans/projects) that are likely to have a significant effect on a European site, either alone or in-combination with other permissions, plans or projects (PPP). Where permissions indicate a likely significant effect, these will be assessed in-combination with each other and with other relevant plans and projects. The alone and in-combination test is also carried out at the appropriate assessment stage.

For this assessment, a very high level and precautionary LSE stage was carried out considering a simple source-receptor pathway link due to the bespoke detailed modelling submitted with the application and associated detailed assessment work that was carried out for this HRAR. This is in line with the Bagmoore Wind Case law:

> "If the absence of risk in the plan can only be demonstrated after a detailed investigation, or expert opinion, that is an indicator that a risk exists and the authority must move from preliminary examination to appropriate assessment."

Therefore, the focus of the in-combination assessment for this HRAR is at the appropriate assessment stage. It will assess the risks that are relevant to the operational WDA permit to determine whether there are any in-combination effects possible from the PPP identified and described here that could result in an adverse effect on site integrity.

The risks identified in the alone appropriate assessment are:

- change in thermal regime
- toxic contamination (chemical)
- changes in nutrients/eutrophication

In-combination effects can be one of the following:

- additive - the total effect of a number of effects is equal to the sum of the individual effects
- synergistic - the effect of the interaction of a number of effects is greater than the sum of the individual effects
- neutralistic - the effects counteract each other, reducing the overall effect
- overlapping - affecting the same spatial area of a feature and/or the same attributes of the feature. For example, the mixing zones of 2 separate discharges overlap
- discrete - affecting different areas and different attributes of the feature. For example, 2 separate discharges affect geographically discrete areas of a habitat within a site

In-combination, the total area of habitat affected may be unacceptable in terms of site integrity.

The assessment will consider the following (taken from PINS advice note 10, v8 2017):

- projects that are under construction
- permitted application(s) not yet implemented
- submitted application(s) not yet determined
- projects on the National Infrastructure's programme of projects
- projects identified in the relevant development plan (and emerging development plans – with appropriate weight being given as they move closer to adoption), recognising that much information on any relevant proposals will be limited and the degree of uncertainty which may be present

This will also include within project or interlinked decisions in-combination from the SZC project itself, where applicable.

The key aspects to consider for in-combination effects are:

- the temporal and geographic boundaries of the effects of activities
- the interactions between the activities and the overall ecosystems
- the environmental effects of the project, and past and future projects and activities
- the thresholds of sensitivity of the existing environment

To be considered within the in-combination assessment other permissions, plans or projects should meet the following criteria:

- generate their own residual impacts of at least minor significance
- be likely to be constructed or operate over similar time periods
- be spatially linked to the proposed development (for example, using the same local road network)

9.1. Identifying sites and designated features to consider in the in-combination assessment

The alone assessment concluded that for the following sites the specified features had effects that were of sufficient magnitude to trigger an in-combination assessment. Please note that for all other sites identified at the LSE stage and considered during the alone assessment, an in-combination affect has been ruled out due to lack of connectivity or connectivity being too low impact and too small to result in a conceivable effect.

- Alde-Ore Estuary SPA: Little tern, Sandwich tern, lesser black-backed gull
- Alde-Ore Estuary Ramsar: Little tern, lesser black-backed gull
- Minsmere-Walberswick SPA: Little tern
- Outer Thames Estuary SPA: Little tern, common tern and red-throated diver
- Southern North Sea SAC: Harbour porpoise
- The Wash and North Norfolk Coast SAC: Harbour seal

For the other features on these sites, it is considered that there is no connectivity, or any connectivity would be of low-impact and too small to result in a conceivable effect, and therefore no in-combination assessment is required.

This assessment will have regard to the in-combination assessment carried out by the applicant in its information report to inform the HRAR for the permits for the operational phase of SZC (predicted to start in 2033) and the potential for interaction with other PPP, both within project and issued by other competent authorities for the water quality risks outlined.

The SZC project will pose a number of other risks that cannot be considered within our permit process. Such risks include disturbance in the marine environment, alteration of coastal processes or collision risk, and these will be considered within the DCO process (see NNB GenCo, 2020h; Shadow habitats regulations assessment Volume 1: Screening and appropriate assessment).

9.2. Identifying relevant PPP

To ensure that the list of PPP to be considered for the in-combination assessment was appropriate we have had regard to:

- if there is a potential pathway or mechanism for in-combination effects. If none could be identified, then the PPP will not be considered.
- whether the PPP was a construction or works project that is now complete - if so, the PPP will have already been considered as part of the prevailing environmental conditions (through monitoring of environmental parameters such as temperature and nutrients) and effectively taken into consideration in the alone assessment. As a result, it will not be considered further in the in-combination assessment to avoid double counting
- whether the PPP is an ongoing permission and also those that could potentially be revoked or changed in future - if so, the PPP has been considered in the in-combination assessment if a potential pathway or mechanism for in-combination effects could be identified

Identified mechanisms for in-combination effects for the operational WDA permit include:

- zones of overlap between similar effects on an interest feature arising from different PPPs (for instance overlapping nutrient enrichment)
- zones of overlap of different types of effect arising from different PPPs (for example, thermal plumes and toxic plumes overlapping)
- the cumulative effects of different PPPs acting in different locations on the same interest feature, leading to potential adverse effects on the interest feature in terms of the proportion of the total resource of that interest feature within the site that is affected

9.3. Assessment of the potential for in-combination effects between the 3 SZC operational permits

An in-combination assessment is required to determine if there is the potential for an adverse effect on site integrity when considering the 3 operational permits currently being considered (water discharge activities (WDA), radioactive substances activities (RSA) and combustion activities (CA)) and between the differing work streams of the operational WDA permit.

The information that we have used in this in-combination assessment is considered to be the best available at the time of the determination of the operational permit applications to allow the HRAR to be concluded.

When the construction permits are submitted, further information will become available at that point. This will allow a construction permit focused HRAR to be carried out when those permit applications are determined.

Table 46: Screening for potential combined effect between the 3 operational permits by potential effect associated with the permission

Source of potential effect	Operational CA[1]	Operational RSA[2]	Operational WDA[3]
Discharges to atmosphere	Yes	Yes	No
Discharges to marine environment	No	Yes	Yes
Discharges to freshwater environment	No	No	No

[1] Combustion activities (CA) permit application (reference: EPR/MP3731AC/A001)

[2] Radioactive substances activities (RSA) permit application (reference: EPR/HB3091DJ/A001)

[3] Water discharge activities (WDA) permit application (reference: EPR/CB3997AD/A001)

Table 47: Screening for potential combined effect between the 3 operational permits by risks associated with the permission

Risks	Operational CA[1]	Operational RSA[2]	Operational WDA[3]
Radioactive substances	No	Yes	No
Nutrient enrichment	Yes	No	Yes
Acidification	Yes	No	No
Toxic effect of pollutants (chemicals)	Yes	No	Yes
Disturbance (noise)	Yes	No	No
Thermal effects	No	No	Yes

[1] Combustion activities (CA) permit application (reference: EPR/MP3731AC/A001)

[2] Radioactive substances activities (RSA) permit application (reference: EPR/HB3091DJ/A001)

[3] Water discharge activities (WDA) permit application (reference: EPR/CB3997AD/A001)

The following information was provided by the applicant in response to a schedule 5 information request (NNB GenCo, 2021M, Sch 5. No.5):

> "Although an analysis of combined effects strictly requires consideration of all potential risks/effect pathways together, in this case there is merit in initially considering the effect of the operational RSA permit individually for the following reasons:
>
> - there is a single relevant risk/effect pathway (radioactive substances) associated with this permit
> - this risk/effect pathway is not relevant to the other permits
> - the assessment of this pathway within the HRA process comprises the application of accepted, quantified screening criteria (meaning that there is a clear threshold below which likely significant effect can be excluded)"

The RSA permit will therefore no longer be considered within this in-combination assessment. See Book 1 Radioactive substances activity HRAR for proposed Sizewell C nuclear power station further details.

The applicant provided the following assessment in its Schedule 5 response (NNB GenCo, 2021M, Sch 5. No.5). The applicant refers to Table 1.1 and this has been replicated in Table 46 and Table 47 of our assessment. The applicant also refers to a section of their Shadow HRA Report for the operational permit. This is section 5 of NNB GenCo (2020i; combustion activity permit application):

“As illustrated in [Table 1.1] there is potential for interaction between different risk/effect pathways related to the operational CA permit and the operational WDA permit.

The Shadow HRA Report for the operational WDA permit (NNB GenCo, 2021b; shadow HRA) concludes …that the potential effects of the operational WDA permit activities are confined to the marine environment …

Conversely, the potential effects of the operational CA permit activities (air quality and noise) are confined to the terrestrial environment. While aerial emissions could disperse to the marine environment, and therefore represent a theoretical potential for effect, in reality there is no effect pathway to marine mammal and migratory fish qualifying interest features of Special Areas of Conservation (SACs) or to marine supporting habitats of bird qualifying features of Special Protection Areas (SPAs).

The conclusion regarding the lack of a realistic effect pathway is reached on the basis of the assessment of sensitivity to aerial concentrations of ammonia, NO_x and SO_2 and nutrient nitrogen and acid deposition reported in the Air Pollution Information System (APIS) which confirms these features and habitats are not exposed or sensitive to this effect pathway (as reported in more detail in the Shadow HRA Report for the operational CA permit)

The operational combustion activities have no potential to generate underwater noise and, therefore, there is no potential for either a direct effect on marine mammal qualifying features of SACs or an indirect effect on the fish prey species for marine birds or marine mammals of SPAs and SACs.

A combined effect on designated sites can, therefore, be ruled out on a precautionary basis, beyond reasonable scientific doubt, due to an absence of spatial overlap of emissions and discharges arising from activities under these permits, as shown in [Table 1.1] (i.e. there is no potential for the effects arising from the permits to interact to cause an combined effect that is different to that identified in the Shadow HRAs that form part of the permit applications)”

We agree that, based on the information provided, there is no potential for in-combination effects between the 3 operational permits.

9.4. Assessment of the potential for in-combination effects between the differing waste streams of the SZC operational WDA permit

The operational permit has 8 waste streams (A-H). See the introduction section for a descriptor of these waste streams. The applicant provided the following information (Table 48).

Table 48: Potential in-combination effects between the waste streams of the WDA permit

Risks	Thermal plume Waste stream A - F	Chemical plume Waste stream A - F	STW Waste stream G	FRR system Waste stream H
Thermal effects	Yes	No	No	No
Toxic effect of chemicals	No	Yes	No	No
Nutrient enrichment	No	No	Yes	Yes
Un-ionised ammonia	No	No	Yes	Yes

This section will consider the potential for in-combination between the differing waste streams. The focus will be on the indirect effects on prey species rather than on the direct effects on the features themselves as available data for chlorine (TRO), hydrazine and bromoform do not indicate that these substances have the potential to be highly bio-accumulative in aquatic organisms. This assumption is explained further in section 8.3.2 and summarised as follows.

9.4.1. Synergistic effects of temperature and TRO plumes

The inter-relationship of the TRO and thermal plumes is not predicted to increase the significance of effects as concluded for these pressures acting alone (NNB GenCo, 2021M, Sch 5. No.5).

In NNB GenCo (2021M, Sch 5 No.5), and the references cited in it, the applicant tells us that:

- temperature elevation has been shown to increase toxicity of chlorine TRO in fish, with an approximate halving of the median lethal concentration (LC50) of TRO being observed with an increase of temperature between 10°C and 20°C. For invertebrates, a 5°C increase in temperature more than halved the LC50 concentration of free chlorine and chloramine in 30-minute exposures in the rotifer *Brachionus plicatilis*, larvae of the American lobster *Homarus americanus*, and American oyster larvae *Crassostrea virginica*. However, the studies reviewed report temperature effects on toxicity in acute studies with durations of hours to a few days and with exposure concentrations in the hundreds of micrograms - significantly greater than the predicted exposure concentrations at SZC. In the same review, in some cases fish were reported to actively avoid much lower TRO concentrations than would be lethal over several days' continuous exposure. This can be explained by the fact that TRO is more of an irritant than a pollutant and easily detected via the gills

- at the immediate point of discharge, the maximum predicted temperatures at the surface are between 7.5°C and 8°C above ambient. As a 98th percentile, the 5°C above ambient temperature contour is 30.6ha (0.306km²) in a relatively symmetrical position around the outlets. Overlapping this area, TRO concentrations above 50µg/l and 20µg/l occur over sea surface areas of approximately 9ha (0.09km²) and 98 ha (0.98km²), respectively as a 95th percentile
- absolute temperature uplifts of 28°C (98th percentile) occur over a very small area (0.11ha, 0.0011km²) at the sea surface. Absolute thermal uplifts of >23°C occurs over an area of 89.6 ha (0.896km²) at the surface, and 25.6ha (0.256km²) at the seabed) as a 98th percentile
- the most sensitive species in the individual assessments showed effect thresholds at ca. 20µg/l. It is therefore unlikely that the synergistic effects of TROs and modest temperature uplifts or absolute temperature would cause adverse effects to extend beyond the TRO EQS contour (10µg/l). In the very small areas of the thermal plume with temperatures of 5°C above background and in which TRO concentrations are >20µg/l, increased TRO toxicity may occur
- the conditions under which synergistic effects could arise are transient. Moreover, the exposure times of actively mobile organisms or those passively moving with the tides would be very short. Consequently, while there is the potential for synergistic effects, such an effect would be restricted to a very localised area and would be limited in duration, with fish prey species exposed to such effects over a very limited time only due to their high mobility

It is highly unlikely that the inter-relationship between thermal and chlorinated discharges would increase the significance of the effects of localised displacement, beyond the effects predicted for the pressures individually. This conclusion applies to all fish receptors assessed. Consequently, the inter-relationship of the TRO and thermal plumes is not predicted to increase the significance of effects as concluded for these pressures acting alone.

9.4.2. Synergistic effects of temperature and chlorinated by-products (bromoform)

The TRO exceedance plume is larger than the bromoform exceedance plume and has been used as a worst-case scenario within the appropriate assessment. As with TRO, the conditions under which synergistic effects could arise are transient and the exposure times of actively mobile organisms or those passively moving with the tides would be shorter still than for TRO, due to the smaller plume area. Consequently, while there is the potential for synergistic effects, such effects would be restricted to a very localised area and would be limited in duration, with fish prey species exposed to such effects over a very limited time only due to their high mobility. The inter-relationship of the bromoform and thermal plumes is not predicted to increase the significance of effects as concluded for these pressures acting alone.

9.4.3. Synergistic effects between temperature and hydrazine

Hydrazine toxicity has been shown to increase with elevated temperatures. In NNB GenCo (2021M, Sch 5. No.5), the applicant states that a 25 to 40% decrease in 96-h LC50 of hydrazine for bluegill occurs with a 5˚C to 11˚C increase in temperature, but that lethal concentrations are over 1mg/l and, therefore, more than 14,000 times higher than the potential hydrazine concentration at the initial discharge point of the cooling water before mixing (69ng/l). The applicant also states that sublethal concentrations based on altered behaviour are approximately 1,400 times higher than the potential hydrazine concentration at the initial discharge point (NNB GenCo, 2021M, Sch 5. No.5).

The inter-relationship of the hydrazine and thermal plumes is therefore not predicted to increase the significance of effects concluded for the pressures alone. It is highly unlikely that this inter-relationship would increase the significance of the effects of localised displacement, beyond the effects predicted for the individual pressures. This conclusion applies to all fish receptors assessed.

9.4.4. Conclusion

In relation to the potential for synergistic effects between the thermal and chemical plumes, it is important to consider the precautionary basis for the assessment of the potential effects. The predicted spatial distributions of the chemical plumes are encompassed by that of the 98th percentile thermal plumes (or at least substantially overlapping in the case of the 3°C uplift and TRO for SZC). Considering the potential for a reduction in food availability within the areas of thermal uplift means that any synergistic effect between the chemical and thermal plumes would not affect the conclusions of the assessment (because the potential reduction in food availability is applied irrespective of whether it is assumed to be due to the effects of thermal uplift alone or thermal uplift combined with the chemical plumes).

It is therefore possible to conclude no in-combination effect between the risks identified in this in-combination assessment of toxic contamination from the discharge of TRO, bromoform and hydrazine and change in thermal regime.

9.5. In-combination assessment of other plans and projects

There is a requirement under the Habitats Regulations to carry out an in-combination assessment with plans and projects we have issued and those issued by other competent authorities. This would include a requirement to assess the potential for in-combination effects within the SZC project, including permissions that may be required during construction.

9.5.1. Assessment of the potential for in-combination effects between the operational WDA permit and construction permits for SZC not yet applied for

The construction permits associated with the project and regulated by us through the same EPR legislation have not yet been applied for and, as such, some information about the potential effects of the construction phase is not currently available as some design work is still being carried out.

Where information is available, either through the permitting process or through the DCO application, this information will be considered to allow an in-combination assessment to be carried out for the operational permits. However, we are taking into consideration the construction discharges as provided by the applicant in its H1 assessment (NNB GenCo, 2021a: TR193) and a series of schedule 5 information requests, but we have not reviewed these in detail and no construction permit applications have been made at present.

That being said, where broad principles are known, these will be considered for the in-combination assessment below.

The current timeline for the SZC project as a whole is shown in Figure 59.

It is predicted that there will be 11 years of construction at the main development site. With commissioning of the first unit due to start in year 8, operation of the first unit of the two-unit plant is predicted to be in year 11 with the second unit becoming operational in year 12.

The permit currently applied for covers the operational discharge and hot functional testing (as described in section 1).

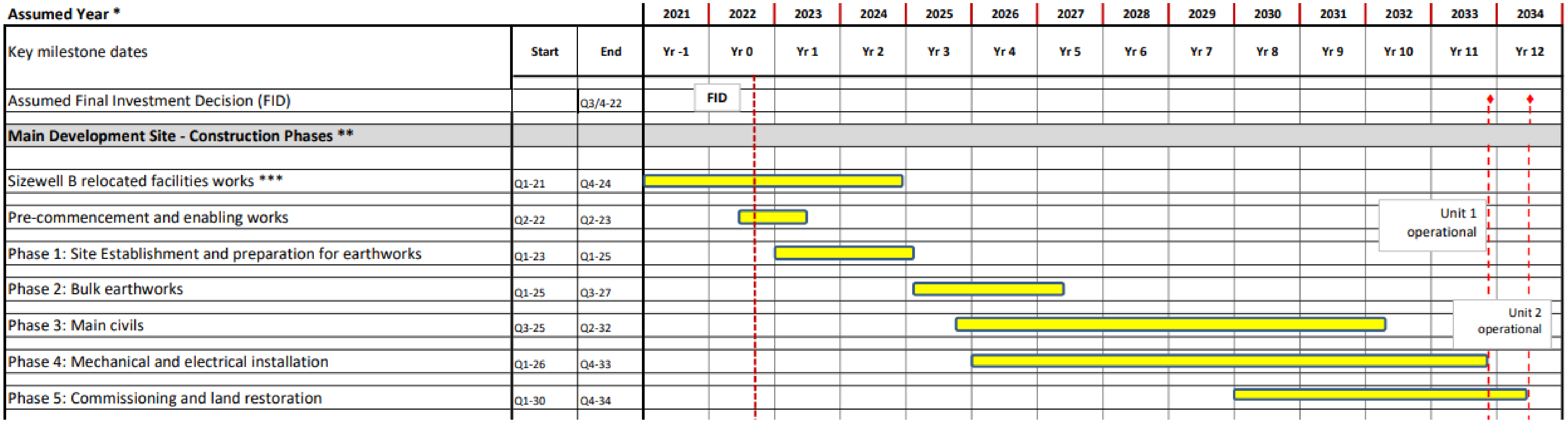

Figure 59: Proposed construction schedule for SZC (NNB GenCo, 2021M, Sch 5. No. 5)

From the information provided there will be a potential temporal overlap of up to a year between the operation of one unit and the continued construction of the second unit, and 5 years' overlap between commissioning and construction.

This assessment will therefore need to consider if there can be any in-combination effects because of the temporal overlap.

In addition, it will need to consider if there is any potential for residual effects from the construction discharges to act in-combination with the operational discharges.

The main effluent outlets for the operational WDA will be approximately 3km offshore in Greater Sizewell Bay (GSB) at National Grid references (NGR) TM 51080 64125 and TM 51155 64125. There will also be 2 outlets associated with the FRR system located approximately 400m offshore (NNB GenCo, 2020g; TR520) at NGR TM47980 64000 for FRR system outlet 1 and TM 47980 64254 for FRR system outlet 2 (Figure 60).

The construction discharge, which is not part of this permit application, will use an outlet next to the FRR system discharge point for Unit 2 (Figure 60). The combined drainage outlet (CDO, also called combined site drain and abbreviated CSD on Figure 60) at NGR TM 47980 64340 would include discharges from the construction site and those during cold commissioning. Prior to the establishment of the CDO and sewage treatment plant, we understand that wastewater would be tankered off-site for appropriate disposal.

It can therefore be seen that the discharge point for the construction and operational phases of the project are located over 2.5km apart. However, both discharge directly into the Outer Thames Estuary SPA and the Southern North Sea SAC (Environment Agency, 2022a; Annex 1).

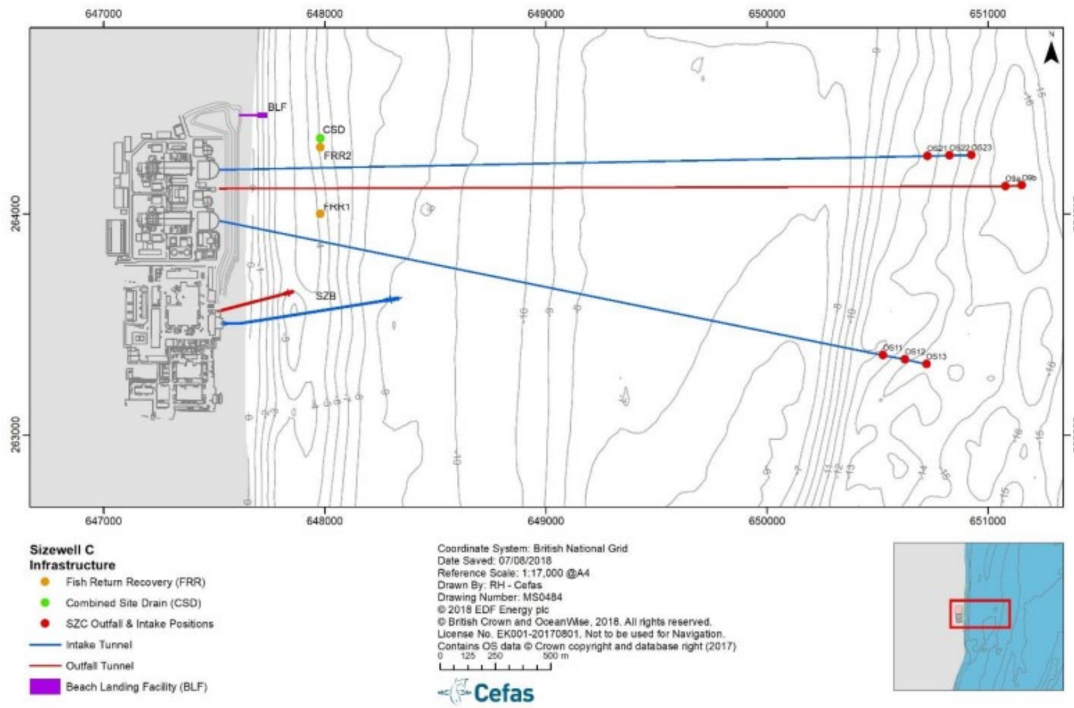

Figure 60: Map of SZC infrastructure (NNB GenCo. 2021a; TR193, Figure 1.4.3)

This assessment will use the information that is available at the time to reach its conclusions. Where new information becomes available as designs are finalised, this will be used within the construction permit application process. Please note that as part of this HRAR assessment, we are taking the construction discharges as provided by the applicant in its H1 assessment (NNB GenCo, 2021a: TR193), but we have not reviewed these in detail and no permit applications have been made.

Section 2.2 of the H1 Screening Assessment (NNB GenCo, 2021a: TR193) lists the following contaminants of concern for the CDO:

- groundwater from the dewatering system which contains metals, ammoniacal nitrogen, dissolved inorganic nitrogen (DIN) and phosphate with a maximum flow rate of 124l/s in the first 28 days and thereafter at 15l/s
- treated sewage discharge which contains ammoniacal nitrogen, DIN and phosphate from permanent treatment units with a total flow rate of 13.3l/s
- effluent from tunnel excavations potentially containing residual amounts of tunnel boring machine (TBM) soil conditioning chemicals and variable
- quantities of groundwater containing metals, ammoniacal nitrogen and DIN

According to the H1 assessment, construction work is also likely to contribute concrete wash water to site discharges, which will need to be assessed as part of the construction permit, but have not been included in the H1 assessment (NNB GenCo, 2021a: TR193).

During the early part of the commissioning phase, conditioning chemicals will also be discharged through the CDO. The chemicals present may include hydrazine, metals, and various organic and inorganic chemicals (NNB GenCo, 2021a: TR193). According to section 7.2 of the H1 assessment, as no operational cooling system will be available for the disposal and dilution of the commissioning phase effluents during the cold flush testing for construction of the first EPR, the only available discharge route for this wastewater stream will be through the CDO.

The H1 assessment (NNB GenCo, 2021a: TR193) does not mention the proposed desalination plant or any discharges associated with it. Some details of the proposed desalination plant are provided in NNB GenCo (2021h; TR552) which was submitted as part of the DCO process.

As with the H1 assessment, we have not had the opportunity to review this report and modelling in detail and no permit applications have been submitted. According to NNB GenCo (2021h; TR552), the desalination plant will operate between October 2023 and June 2028, or at the latest before operations commence at SZC. The proposed outlet is located close to the outlet of the proposed FRR system outlet, while the intake is proposed to be approximately 100m north-east of the outlet location (Figure 61).

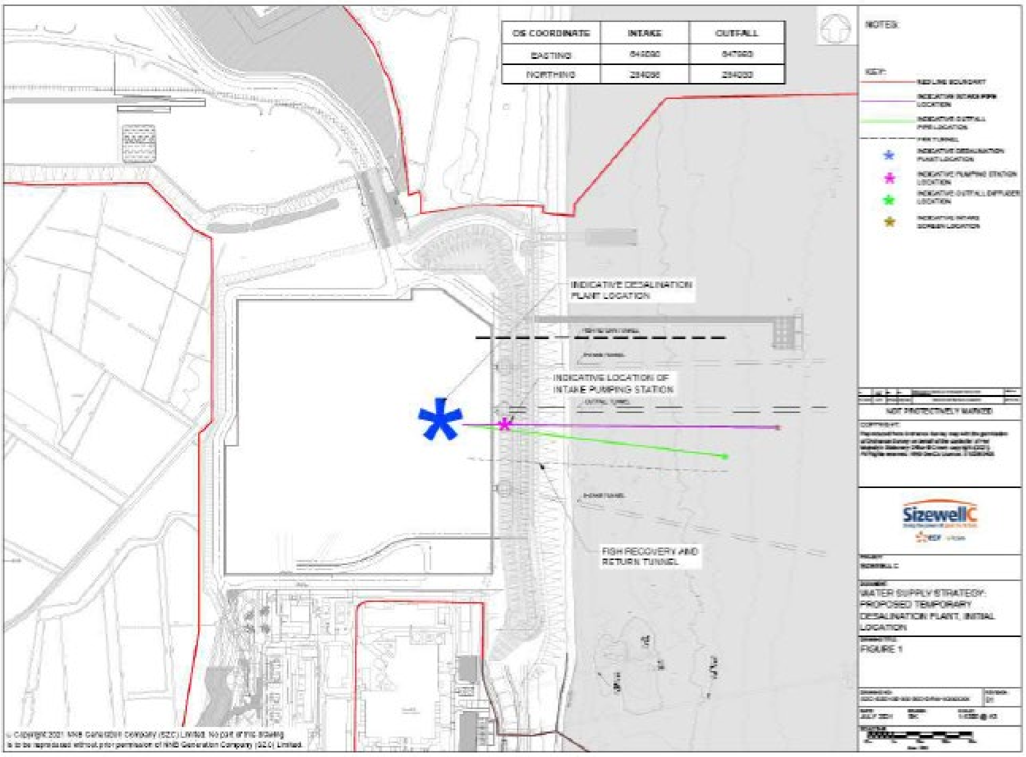

Figure 61: Indicative construction phase desalination intake and outlet plan (Figure 201 from NNB GenCo, 2021h; TR552)

The construction discharges could potentially give rise to the following risks that need to be considered in combination:

- toxic contamination
- nutrient enrichment or eutrophication

It is our understanding that there will be no thermal discharge during construction until hot functional testing begins, and this testing is already being considered in the operational permit. This does not therefore need to be considered in combination.

There are potentially different additional risks at the construction phase; these will be considered when the construction permits are applied for and will go through the HRA process.

9.5.2. Consideration of combined effects with construction-related water discharge activities

The applicant provided the following information as part of a schedule 5 information request (NNB GenCo, 2021M, Sch 5. No.5) in relation to the consideration of combined effects with construction-related water discharge activities:

> “During the initial dewatering activities through the construction phase, the volume of groundwater to be disposed of has been estimated to be 300,000 m^3. Chromium, copper, zinc and iron in the groundwater exceed EQS or equivalent values and fail the initial Test 1 of screening on the H1 Environmental Risk Assessment (NNB GenCo, 2021a: TR193). Taking account of subsequent dilution upon discharge, further detailed assessment of chromium and zinc was required (using CORMIX modelling).
>
> The CORMIX modelling predicted that for zinc the outlet plume would no longer be detectable above background concentrations within 3m. For chromium the outlet plume would fall below the EQS within 25m.
>
> The H1 Environmental Risk Assessment (NNB GenCo, 2021a; TR193) also assesses the biochemical oxygen demand (BOD), dissolved oxygen, un-ionised ammonia and microbiology elements associated with the construction discharge. This shows that all these elements would be diluted to environmentally acceptable standards within metres of the discharge point.
>
> A daily BOD of 121kg was calculated for sewage discharge and contributions from groundwater, which is equivalent to an oxygen requirement of 40.6kg. This demand is very small relative to oxygen transfer as part of the daily exchange for Greater Sizewell Bay.
>
> The contribution of dissolved inorganic nitrogen (DIN) and phosphorus from the construction discharges (including additional inputs during commissioning) were assessed. The exchange with the wider environment is much greater than the maximum proposed discharges during construction, so that no change in phytoplankton growth beyond natural variability would be observed.
>
> Un-ionised ammonia is expected to be present in the groundwater and sewage discharges; however, the maximum distance to achieve a value below the EQS was 6.3m.

> Modelling was undertaken to predict the distance from the CDO discharge point at which enough dilution of the sewage treatment discharge would occur to be within microbiological standard levels. The sewage discharge plume would be buoyant and therefore occur on the sea surface. The modelling shows that a concentration of Enterococci is likely to exceed the bathing water standard within a worst case of 460m of the discharge, without UV treatment.
>
> The above summary indicates that the construction phase discharges are predicted to have a highly localised effect on water quality and are temporary discharges."

Based on the information provided, we agree with the applicant's conclusions, presented here as best available information, that there is no potential for an adverse in combination effect between construction and the operational permit for chemical or nutrients/eutrophication. This is due to the relatively small mixing zones modelled for the construction discharges and therefore no resulting physical overlap. The areas the applicant has modelled are so small that we consider that there is no additive effect either.

However, we have not fully reviewed the details of the construction discharges and predicted plumes. These will be considered further for HRA purposes when the construction permits are applied for, and more detailed information is provided by the applicant.

We consider this the best available information for this in-combination assessment.

9.5.3. Assessment of the potential for in-combination effects between SZC and operational SZB water quality effects

Although SZB is an existing project and could therefore be considered in the 'baseline', as the prevailing environmental conditions, we will consider the effects 'in-combination' as SZB is due to be decommissioned during the lifetime of the operational SZC permits and so the baseline will change.

The locations of the operational outlets for the SZC WDA and the SZB WDA are over 2.5km apart, with the SZB outlet much closer to shore (see Figure 1). The SZB outlet does, therefore, have the potential to interact with some of the coastal sites that SZC does not. This is not, however, the focus for this assessment, as there is no source-receptor pathway for SZC plumes to interact with the coastal sites, so no in-combination effects are possible. The only features of identified sites that are relevant are those for marine mammals and seabirds. Minsmere Sluice does provide a source-receptor pathway, but as shown in the 'Discussions of risks of each site' section neither the thermal nor chemical plumes reach the sluice outlet and the potential for increase in nutrients will not be significant against background levels.

The seabird and harbour porpoise assessment (section 8) assessed the potential for an adverse effect from the cooling water and FRR system discharges of SZC alone and compared this to the baseline. Coastal waters are currently receiving thermal and chemical inputs from the cooling water system discharges of the existing SZB power station, as well as organic input from the FRR system discharge of SZB. The baseline is therefore referred to as ‘SZB alone’ in section 8.

The conclusion from the detailed assessment within the seabird and harbour porpoise chapter (section 8) was that there was no adverse effect in combination between SZC and SZB.

In addition to the in-combination effects examined in the seabird and harbour porpoise chapter, the possibility of another in-combination effect exists for seabirds, should they feed at the SZC FRR system outfalls while SZC and SZB are both operational. Fish discharged via SZC FRR system outlets may be an attractive food source for seabirds. This is of particular relevance to the lesser black-backed gulls of the Alde-Ore Estuary SAC and Ramsar, due to their generalist diet which can include fishery discards. The FRR outlets may also potentially attract terns, with the applicant noting that the SZB outfall is likely to provide an important foraging resource for common terns (NNB GenCo, 2021b; shadow HRA).

The 2 SZC FRR system outlets will be located around 400m offshore, discharging into subtidal waters at approximately 4m depth (NNB GenCo, 2020g; TR520). The SZB outlet is around 200m offshore.

When SZC is operating alone, the FRR system discharge points will be outside of the TRO and bromoform exceedance plumes (Figure 8, Figure 10). However, when SZC and SZB are both operating, seabirds feeding or loafing at the SZC FRR system outlets may be within the mixing zones for TRO and bromoform discharged from SZB (Figure 9, Figure 11).

Using our ‘reasonable worst-case scenario’ for monthly amounts of impinged biota (Appendix B), during the months when breeding seabird features are present (April to August), we would expect average daily discharges of fish to be no more than 1,911kg (April), 399kg (May), 389kg (June), 158kg (July) and 178kg (August), of which 1,687kg (April), 259kg (May), 250kg (June), 88kg (July) and 87kg (August) would not have survived passage through the FRR system. During these 5 months, maximum daily discharges of fish are not expected to exceed 10,207kg (9,590kg of which would not have survived passage through the FRR system). The high maximum daily amounts result from a relatively consistent influx of Atlantic herring in early to mid-April. This discharge will be split between the 2 FRR system outfalls, which are around 250m apart from each other. The daily discharge estimates are for a full 24-hour period and so a proportion of the biota will be discharged at night, when breeding seabird features are not foraging. The amount of biota discharged may well be smaller than our ‘reasonable worst-case scenario’, which includes precautionary multiplication factors to account for overflowing or missing samples (Appendix B). Based on sampling data alone, without the precautionary multiplication factors, average daily discharges of fish are somewhat lower, being 1,284kg (April), 231kg (May), 95kg (June), 69kg (July) and 64kg (August), of which 1,114kg (April), 146kg (May), 59kg (June), 42kg (July) and 33kg (August) would not have survived passage through the FRR system).

Although the SZC FRR system outlets are a similar depth (around 4m) and distance offshore to the SZB outlet, the volume of water discharged by the SZC FRR system outlets is just 0.3m³/s, compared to 51.5m³/s for SZB. The volume and velocity of the SZB cooling water, together with its buoyancy, will bring a high proportion of discharged fish near to the surface and within reach of the breeding seabird features with their relatively shallow dive depths of 0.5 to 1m for lesser black-backed gull (NNB GenCo, 2021b; shadow HRA), up to 0.3m for little tern, up to 1.5m for Sandwich tern (Eglington and Perrow, 2014) and 1 to 2m for common tern (Natural England, 2012). This is much less likely to be the case at the SZC FRR system outlets. The water from the FRR system will not experience thermal uplift and so will not be as buoyant as the SZB cooling water. Live, but disorientated, fish are likely to recover before reaching the sea surface, and only a proportion of the dead biomass will reach the surface at the discharge point. Although the amount of biomass discharged by the SZC FRR systems may be significant at times, particularly in the spring and early summer during periods when herring are plentiful, the attractiveness of the location as a consistently favourable foraging location will be lessened by the variability of the discharge, by its division between 2 discharge points, and by the fact that only a proportion of the biomass will be available to shallow-diving breeding seabird features. These are also likely to be competing with other, undesignated species of seabird, including the kittiwakes from the colonies on the SZA intake and outfall structures. The amount of biomass discharged, and therefore the FRR system outlets' value as a foraging location, is also likely to be much lower in July and August than earlier in the breeding season.

Furthermore, the TRO EQS is precautionary for seabirds. Although LC50s for European plaice and Dover sole have been recorded as 28µg/l, this was with 96 hours' continuous exposure (section 8.3.2). Seabirds will not be exposed for such long periods of time and will have less direct contact than fish, which contact via the skin and the gill surface. Breeding seabirds will also periodically be returning to the nest. Terns and lesser black-backed gulls will be exposed when diving for food, with gulls potentially also exposed when loafing or foraging on the sea surface. The 28µg/l LC50 for the flatfish species also refers to an absolute concentration, whereas the TRO EQS of ≥ 10µg/l is set as a 95th percentile. This means that within the exceedance plume, concentrations of TRO of ≥ 10µg/l are experienced for 5% or more of the time. TRO concentrations at the SZC FRR system outlets will be lower than lesser black-backed gulls and common terns experience when feeding directly in the SZB outfall, with the southern outlet being >200m from the SZB outfall and the northern outfall being >500m from the SZB outfall (Figure 60).

Although the FRR system discharge may be attractive to lesser black-backed gulls, it is unlikely to be as attractive as the current SZB outlet. This, combined with the precautionary nature of the EQS, means that if preferential feeding around the FRR system outfalls does occur, this will not adversely affect the breeding seabird features when SZC and SZB are operating in combination (there is no indirect risk to breeding seabirds through the bioaccumulation of TRO, bromoform or hydrazine). There will be no adverse effect when SZC is operating alone, as the FRR system outfalls are outside of SZC's TRO ≥ EQS plume.

9.5.4. Assessment of other non-SZC related PPP in combination with SZC operational WDA water quality effects

When considering the potential for an in-combination effect with other non-SZC related PPP the principles outlined above must be followed.

Our assessment will take account of PPP with:

- overlapping zones of influence (ZOI) with similar effects associated with the WDA, for example, effects leading to nutrient enrichment
- overlapping ZOI with different types of effect associated with the WDA, for example, toxic contamination interacting with change in thermal regime
- cumulative effects on the same interest features from effects associated with the WDA in different locations within the European site

These effects are limited to toxic contamination, nutrient enrichment and change in thermal regime.

To illustrate this, we would only consider other PPP that would pose a risk to the little tern through nutrient enrichment, toxic contamination or change in thermal regime within its defined foraging ranges. PPP that pose a different effect, such as disturbance, or are located at sea and beyond their normal foraging range, would not be relevant for an in-combination assessment.

9.5.5. Identifying PPP issued by other competent authorities

Permissions, plans and projects were identified by the applicant in its report to inform the HRA; a review of permits issued by us as a competent authority; and through our consultation with other relevant competent authorities carried out in June 2021. The list of competent authorities we consulted is as follows:

Local authorities

Suffolk County Council
East Suffolk Council
Norfolk County Council
Lincolnshire County Council
South Holland District Council
Boston Borough Council
East Riding of Yorkshire
Hull City Council

Inshore Fisheries and Conservation Authorities (IFCA)

Eastern IFCA

Defra organisations

Natural England

Marine Management Organisation

Of the competent authorities identified, we received responses from:
Eastern IFCA
East Suffolk Council
North Lincolnshire Council
North Norfolk District Council
Hull City Council

For the remaining competent authorities, it must be assumed that there are no relevant PPP to be considered in combination.

The applicant also identified PPPs that it considered were relevant for an in-combination assessment in Appendix B of NNB GenCo (2021b; shadow HRA).

PPP that have the potential to cause toxic contamination, nutrient enrichment or change in thermal regime will be considered in this in-combination assessment.

9.5.6. In-combination assessment with off-shore wind farms

A number of off-shore wind farms are relevant PPPs for an in-combination assessment. These are either subject to ongoing maintenance or have the potential to be constructed while SZC is operational. There is the potential that construction or works to maintain the foundation of the wind turbines or array cables could disturb sediments and re-mobilise toxins where they are present, resulting in the associated risk of toxic contamination. This will be assessed in line with the precautionary principle.

Due to the off-shore location of the wind farms, and SZC's small in-shore ZOI, the in-combination assessment will only consider whether the wind farms have the potential for a cumulative effect from toxic contamination on the same interest features being considered in the WDA assessment. The sites and features are:

- Outer Thames Estuary SPA: common tern, little tern and red-throated diver
- Alde-Ore SPA: little tern, Sandwich Tern, lesser black-backed gull
- Alde-Ore Ramsar: little tern, lesser black-backed gull
- Minsmere-Walberswick SPA: little tern
- Southern North Sea SAC: harbour porpoise
- Wash and North Norfolk Coast SAC: harbour seal

The applicant states in Table 9.5 of NNB GenCo (2021b; shadow HRA) that modelling carried out for the construction of Norfolk Vanguard Offshore Wind Farm demonstrated that:

> "the majority of the sediment released during seabed preparation would be coarse and would fall within minutes/tens of minutes to the seabed as a highly turbid dynamic plume upon its discharge."

This can also be assumed to be the case for the construction of all the wind farms identified in this in-combination assessment, with significantly less sediment expected to be released during occasional maintenance of the wind farm infrastructure.

Little terns have a very localised foraging range, with a mean maximum distance of 5km (Table 13). It is therefore possible to discount little tern from this cumulative in-combination assessment, as there is no potential for off-shore wind farms to impact their breeding population.

Common tern have the potential to forage up to 27km from their nesting sites (mean maximum + SD) and sandwich tern 57.5km (mean maximum + SD). Lesser black-backed gulls have an extensive foraging range of up to 236km (mean maximum + SD) (Table 13).

As neither the Sandwich tern, common tern nor lesser black-backed gulls dive deeper than 2m when feeding, it is unlikely that they will encounter any toxic contaminants that could be remobilised through the maintenance works or construction works at the seabed (see section 8 for further discussion). It is therefore possible to discount Sandwich tern, lesser black-backed gull and common tern from this cumulative in-combination assessment, as there is no potential for off-shore wind farms to impact their breeding population.

Red-throated divers have an extensive foraging range, with the whole of the Outer Thames SPA assumed to be the foraging area for its population, and they can descend as far as 10m below the surface to catch small fish (NNB GenCo, 2021b; shadow HRA). The overall vulnerability of the red-throated diver to toxic contamination is “considered to be low to moderate.” (Outer Thames Estuary SPA Conservation Advice Package).

Harbour porpoise is present throughout Southern North Sea SAC and will be considered further.

Harbour seal travel along the coast between the Wash and North Norfolk SAC and the Thames Estuary, which provides an important role in maintaining or restoring the harbour seal population of The Wash and North Norfolk Coast. As the wind farms tend to be located offshore, they are outside the coastal corridor that the seals favour, so harbour seals will not be considered further.

Those wind farms identified for ongoing maintenance can be discounted from the cumulative impact assessment as any changes to water quality would be very localised, temporary and for a short duration, with normal conditions returning rapidly following the cessation of activity. It is unlikely that they would have an impact on the vulnerable features of the European sites in combination with SZC, and it is considered that any impact would be too small to result in a conceivable effect.

The following PPP will not be considered further:

East Anglia ONE Ltd (MLA/2018/00550, MLA/2018/00551): Operations and Maintenance Marine Licence applications for Generation and Transmission Assets. Licence to commence on 1 August 2019 and expire by May 2045.

Construction of East Anglia ONE wind farm was completed in July 2020 and is now fully operational. It is located 43km from the Suffolk Coast within the Outer Thames Estuary and Southern North Sea SAC.

London Array Offshore Wind Farm (MLA/2018/00042): ongoing maintenance. Granted in 2017, ongoing to 2039. Licences are for small-scale operational maintenance activities for an existing offshore wind farm located 20km off the Kent coast within the Outer Thames SPA and Southern North Sea SAC.

Kentish Flats Offshore Wind Farm and Extension (MLA/2019/00156, MLA/2019/00158): ongoing maintenance activities. The Kentish Flats Extension is located to the west and south of the first Kentish Flats Wind Farm. It lies more than 7 kilometres off the coast of Herne Bay and Whitstable within the Outer Thames SPA.

Greater Gabbard Offshore Wind Farm (MLA/2016/00206, MLA/2016/00275/1): ongoing maintenance of the wind farm, including inter-array cable maintenance, operations and maintenance. Located 20km off the coast of Suffolk within the Outer Thames SPA and Southern North Sea SAC.

9.5.7. In-combination assessment of wind farms that have obtained their Development Consent Orders (DCOs) but are not yet constructed

The following wind farms have been granted their DCOs, and it is anticipated that construction would be complete prior to the commissioning of SZC.

East Anglia THREE Offshore Wind Farm: development of an offshore wind farm with an approximate capacity of 1,200MW off the coast of East Anglia, within the area known as Zone 5, under the Round 3 Offshore Wind Licensing Arrangements. It will be located 36km from Lowestoft and 42km from Southwold. Offshore export cables will connect the proposed East Anglia THREE wind farm site to shore, making landfall at Bawdsey. From landfall, the cables will be routed underground to an onshore substation, which will, in turn, connect into the national electricity grid via a National Grid substation and cable sealing end compounds, the latter to be owned and operated by National Grid.

A decision on the application for a Development Consent Order for East Anglia THREE Offshore Wind Farm was taken on 07 August 2017 and has now been issued.

The proposed wind farm is within the Outer Thames SPA and Southern North Sea SAC, consideration will therefore be given as to whether a cumulative in-combination effect could occur between this PPP and SZC.

The Secretary of State’s HRA of the DCO application did not identify a risk from the release of contaminants during the construction of the East Anglia THREE offshore wind farm for either the Outer Thames Estuary SPA or the Southern North Sea SAC.

It can therefore be concluded that there would be no potential for a cumulative in-combination effect on the red-throated diver of the Outer Thames Estuary SPA and harbour porpoise of the Southern North Sea SAC.

Norfolk Boreas Offshore Wind Farm (EN010087): proposed Offshore Wind Farm with a maximum capacity of 1.8GW. The centre of Norfolk Boreas is approximately 94km north-east of Great Yarmouth and is located on the outermost boundary of the Southern North Sea SAC and outside the SPA boundary into which the operational SZC will discharge.

The Secretary of State granted the DCO for this application on 10 December 2021.

The Secretary of State's HRA of the DCO application did not identify a risk from toxic contamination for the Southern North Sea SAC. It is therefore possible to conclude no cumulative in-combination effect on the harbour porpoise of the Southern North Sea SAC.

Ørsted Hornsea Project Three (EN10080): development of an offshore wind farm with an approximate capacity of up to 2,400MW off the coast of Norfolk. This is within the area known as Zone 4, under the Round 3 offshore wind licensing arrangements established by The Crown Estate.

A decision on the application for a DCO for Hornsea Project Three Offshore Wind Farm was taken on 31 December 2020 and has now been issued. Construction works have yet to commence.

The Secretary of State's HRA for the DCO did not identify any risks from the construction of the PPP resulting in toxic contamination. A risk was identified from potential sources of pollution during construction, for example from "vessel movements, use of drilling meds and storage of chemicals." The SoS concluded that "increased risk of pollution from the project alone would not have an adverse effect on the Annex II harbour porpoise features of the Southern North Sea SAC." This risk was not considered in the in-combination assessment. It is anticipated that the wind farm will be constructed prior to the operation of SZC.

9.5.8. In-combination assessment of wind farms that have applied for DCOs but are not yet granted

The following wind farms are awaiting the outcome of their DCO applications. It is anticipated that if they are granted construction, they would be complete prior to the commissioning of SZC.

East Anglia ONE North Offshore Wind Farm (EN10077): an offshore wind farm which could consist of up to 67 turbines, generators and associated infrastructure, with an installed capacity of up to 800MW, located 36km from Lowestoft and 42km from Southwold. Offshore export cables will connect the proposed East Anglia ONE North wind farm site to shore, making landfall in the vicinity of Sizewell.

The examining authority issued a recommendation report to the Secretary of State on 6 October 2021. The Secretary of State has set a new deadline for the decision for this application - 31 March 2022.

The proposed wind farm is within the Outer Thames SPA and Southern North Sea SAC. Consideration will therefore be given as to whether a cumulative in-combination effect could occur between this PPP and SZC.

Chapter 8 of the Environmental Statement to support the DCO application for this PPP considers the deterioration of water quality due to re-suspension of sediment bound contaminants and concludes as follows:

> "Considering the negligible magnitude of effect, low receptor sensitivity … and the localised nature of the impact …, the re-suspension of contaminated sediment from construction activities is considered to have a negligible impact on water quality."

The same conclusion was reached for the release of contaminated sediment as a result of scour around foundation structures.

It can therefore be concluded that there would be no potential for a cumulative in-combination effect on the red-throated diver of the Outer Thames Estuary SPA and harbour porpoise of the South North Sea SAC.

East Anglia TWO Offshore Wind Farm (EN10078): An offshore wind farm which could consist of up to 75 turbines, generators and associated infrastructure, with an installed capacity of up to 900MW, located 37km from Lowestoft and 32km from Southwold.

The examining authority issued a recommendation report to the Secretary of State on 6 October 2021. The Secretary of State has set a new deadline for the decision for this application - 31 March 2022.

The proposed wind farm is within the Outer Thames SPA and Southern North Sea SAC. Consideration will therefore be given as to whether a cumulative in-combination effect could occur between this PPP and SZC.

Chapter 8 of the Environmental Statement to support the DCO application for this PPP considers the deterioration of water quality due to re-suspension of sediment bound contaminants and concludes as follows:

> "Considering the negligible magnitude of effect, low receptor sensitivity … and the localised nature of the impact …, the re-suspension of contaminated sediment from construction activities is considered to have a negligible impact on water quality."

The same conclusion was reached for the release of contaminated sediment as a result of scour around foundation structures.

It can therefore be concluded that there would be no potential for a cumulative in-combination effect on the red-throated diver of the Outer Thames Estuary SPA and harbour porpoise of the Southern North Sea SAC.

Norfolk Vanguard (EN010079): proposed offshore wind farm with an approximate capacity of 1,800MW off the coast of Norfolk. The centre of Norfolk Vanguard West is

67km from the Bacton coast and 63km from the Gorleston coast at their nearest point. The centre of Norfolk Vanguard East is 98km from the Bacton coast and 86km from the Gorleston coast at their nearest point. Norfolk Vanguard West is approximately 295km^2, Norfolk Vanguard East being 297km^2.

The Secretary for State granted the Development Consent Order on 1 July 2020, however this was quashed in February 2021. The DCO process is still ongoing, with the applicant submitting further information on 8 December 2021.

The proposed wind farm is located within the Southern North Sea SAC, but outside the Outer Thames Estuary SPA boundary into which the operational WDA will discharge.

Chapter 9 of the Environmental Statement to support the DCO application for this PPP considers the deterioration of water quality due to re-suspension of sediment bound contaminants and concludes as follows:

> "As a result of the low magnitude of effect and low receptor sensitivity …, the re-suspension of contaminated sediment from construction activities is considered to be of negligible significance."

The same conclusion was reached for the release of contaminated sediment as a result of scour around foundation structures.

It can therefore be concluded that there would be no potential for a cumulative in-combination effect on the harbour porpoise feature of Southern North Sea SAC.

9.5.9. In-combination assessment with other PPP with direct connectivity to SZC

The following are non-offshore wind farm PPP identified for consideration in combination by the applicant and other competent authorities.

SZB decommissioning – desilting works: planned decommissioning of SZB power station. Decommissioning is anticipated to commence in 2035. Current licence for de-silting and maintenance works is consented and is currently due to expire in December 2035.

The desilting activity is normally carried out during statutory outages at 3-year intervals. It takes approximately 12 days to complete the work, with de-silting occurring intermittently during this period.

There is a potential temporal overlap of 2 years until the licence expires in 2035. The infrequent nature of the desilting and its duration mean that any in-combination effects are considered to be insignificant. If a new licence is required, further consideration of HRA issues will need to be considered through any marine licence application.

Sizewell A decommissioning: the site is currently being de-fuelled. The current licence is for the maintenance of offshore intake and outlet structures which was completed in 2017.

Further applications are expected, however, during the decommissioning period. The Sizewell A Environmental Management Plan provides an update on the activities undertaken in the last 12 months in addition to details of the agreed mitigation measures accessible via the Office for Nuclear Regulation website.

There is an existing discharge under the Environmental Permitting Regulations, Environmental Permit via the SZA cooling water outlet to the North Sea. Discharges under this permit include rainwater and secondary treated effluent from the SZA and SZB site sewage treatment plant. This will have been considered as part of the nutrient/organic enrichment assessment (PR4CS1516 variation issued July 2021) of any baseline assessment.

9.5.10. PPP considered to be in-scope for consideration

North Norfolk Local Plan: This was highlighted for consideration by another competent authority as maybe needing in-combination assessment, as the emerging North Norfolk Local Plan 2016-2036 proposes a significant amount of residential growth within North Norfolk (11,611 houses over the plan period to 2036). This growth is expected to result in significant in-combination impact on European sites with regard to visitor pressure.

The impacts of visitors resulting in recreational pressure are being considered under the DCO. The PPP is not relevant for an in-combination assessment with operational WDA assessment. There is no connectivity between the plan and the impacts to the marine environment being considered in our HRAR.

Marine plans: The following section on marine plans is taken from information the applicant provided within its response to Schedule 5 number 5 (NNB GenCo, 2021M, Sch 5. No.5):

> "In-combination assessment with the East Inshore and Offshore marine plans:
>
> The East Inshore and Offshore marine plans are the relevant marine plans for consideration of the potential for in-combination effects with the Sizewell C Project. The Marine Management Organisation's (MMO) appropriate assessment of the marine plans (2013)14 shows the area covered by these marine plans (reproduced below) (Figure 62).

Figure 62: Location of East Inshore and East Offshore Marine Plan Areas from the MMO

The MMO's appropriate assessment records that a screening process reviewed the draft marine plan policies for LSE via identified ecological impact pathways to identify those policies likely to have a significant effect on European sites and therefore which needed to be subject to appropriate assessment. Three 'screening criteria' questions were considered as part of the screening process:

1. is the policy general or 'criteria-based' such that it has no specific, discernible implications for activities (that is, it does not direct, influence, or clarify the nature and location of activities) within the marine plan areas? The MMO states that policies within the plan which are so general in nature (i.e., they are statements of general policy and there is no discernible link between the policy and effects on individual sites) are not subject to an appropriate assessment

2. has the policy been subject to previous HRA (for example, encapsulated with a sectoral plan such as Round 3 offshore wind)? Policies in the plan which are not statements of general policy and which relate to activities that have not previously been subject to HRA were assessed as part of the MMO's appropriate assessment

3. does the policy change what was previously assessed or bring greater clarity to elements such as the location of cable alignments or landfalls? Following on from question (2), this question tests whether or not a policy related to an activity which has been previously subject to HRA changes the impact that the activity will have

The MMO's appropriate assessment for the marine plans concludes that, without mitigation, it is not possible to conclude that there will be no adverse effect upon the integrity of any of the relevant European sites identified in the screening review. The following overriding reasons were quoted for that conclusion:

- because the draft marine plan policies are strategic in nature, it is not possible to quantify their influence on "individual authorisation and enforcement decisions within the East Inshore and East Offshore Marine Plan areas"
- it is not possible at a strategic level to identify specific effects on European sites arising from the implementation of future individual plans or projects
- even where there is pre-existing information on the potential effects of certain types of activity, it is not possible to fully identify the effects of future plans and projects of a similar kind. For some emerging sectors (tidal energy generation and carbon capture and storage are given as examples), there is very little or no previous development in the marine plan areas and, therefore, lack of understanding of their potential impacts
- similar reasons as those captured above prevent the identification of specific effects on European sites arising from the influence of the draft plan policies in-combination with the influence of other draft plan policies. The MMO's appropriate assessment notes that this is typical of all strategic coastal and offshore plans but is particularly the case for the draft marine plans given their broad spatial extent and multi-sectoral nature

In light of the above conclusion (that adverse effect on integrity cannot be excluded), the MMO's appropriate assessment considers mitigation measures. This concludes that "the main mitigation measure identified is that, as a matter of law, a project or plan will be required to undergo a project-level HRA where there is a likelihood of a significant effect on a European site".

The MMO's appropriate assessment therefore defers any detailed consideration of the effects of activities arising from authorisation and enforcement decisions which are influenced and directed by draft plan policies (whether alone or in combination with other draft plan policies) to the point when "the specific nature and scope of the individual plan or project has been identified".

The appropriate assessment goes on to state that "any adverse effects arising from authorisation and enforcement decisions which are influenced by relevant draft plan policies can be identified and suitably mitigated at the individual project level" and that "through appropriate consideration at the individual project level, the influence of policies scoped into this appropriate assessment and for which adverse effect on site integrity cannot be excluded will be mitigated".

The appropriate assessment also identifies a further mitigation measure - 'Iterative Plan Review' (IPR) process. This is described as a phased and iterative approach to implementation of the marine plans, with monitoring work connected with developments being fed into the next phases of plan implementation, providing assurances that developments affecting the marine plan area are being managed to avoid adverse effects (especially in-combination effects).

The MMO's overall conclusion is that "taking into account the mitigation measures outlined above and in particular future project level appropriate assessments, this assessment concludes that there will be no adverse effect on the integrity of a European site arising from the draft plans".

Given the findings of the MMO's appropriate assessment for the marine plans, it is not feasible to undertake meaningful assessment of the potential for in-combination effect with the operational permits for the Sizewell C Project. However, on the basis of the findings of the HRA process for the marine plans, it can be concluded that the MMO is satisfied that there is a suitable mechanism to conclude that adverse effect on integrity can be excluded due to the implementation of the marine plans.

A document providing a checklist against the policies in the East Inshore and East Offshore Marine Plans to test and demonstrate the Sizewell C Project's compliance the polices was submitted to the DCO examination (REP7-074). The checklist demonstrates that the Sizewell C Project area does not coincide with many of the spatially explicit marine plan policies.

On this basis, given the very localised zone of influence of the activities included in the operational permits relative to the spatial extent of the area covered by the marine plans, it is reasonable to conclude that adverse effect on designated sites will not arise. In light of the mitigation approach identified for the marine plans, it would be necessary for developments undertaken in line with the marine policies to demonstrate that their impacts could be successfully mitigated to the point where no adverse effect could be demonstrated, alone and in-combination with other plans and projects (including the Sizewell C Project)."

We agree with these conclusions reached by NNBGenCo.

Suffolk Shoreline Management Plan 7: Lowestoft Ness to Felixstowe Landguard Point. The Sizewell C project lies within Policy Development Zone (PDZ) 4: Dunwich Cliffs to Thorpeness, sub management zone MIN13.1. The policy within this Policy Unit is to hold the line (HTL).

The SMP is outside of the ZOI of SZC and there are not expected to be any activities associated with this PPP that would result in change in thermal regime, toxic contamination or nutrient enrichment. There is therefore no potential for an in-combination effect.

The PPP is not relevant for an in-combination assessment with operational WDA assessment.

9.5.11. PPP that are considered outside of the scope of an in-combination assessment

Commercial fisheries: The removal of fish by the cooling water was highlighted by another competent authority as maybe needing to be considered. However, the intake of SZC and the potential to entrap biota including fish is being considered under the DCO and a conclusion will be reached by the Department for Business, Energy and Industrial Strategy (BEIS) as the relevant competent authority.

The PPP is not relevant for an in-combination assessment with operational WDA assessment, as the plan or projects will have concluded before the operational permits start in 2033.

ABP Lowestoft (MLA/2016/00181/1): Maintenance dredge material disposal. Licence granted August 2016, discharging conditions ongoing until March 2026, not relevant for an in-combination assessment.

ABP Lowestoft (MLA/2019/00036): Refurbishment and Resurfacing of Slipway in Lowestoft Inner Harbour Area. Consented. Licence expired January 2020, not relevant for an in-combination assessment.

Environment Agency (EIA/2018/00052)**:** Great Yarmouth Flood Defence Scheme – works were undertaken over a 2-year period beginning in 2019 to maintain existing tidal flood defences along the Rivers Yare and Bure. Due to be completed December 2022, not relevant for an in-combination assessment.

Galloper Wind Farm Ltd (MLA/2016/00463/1): Construction of Galloper Operation and Maintenance Base at Harwich. Completed and operational, not relevant for an in-combination assessment.

Greater Gabbard Offshore Wind Ltd (MLA/2019/00065): Pontoon instalment at Lowestoft. Consented. Works completed in 2019, not relevant for an in-combination assessment.

Greater Gabbard Offshore Wind Ltd (MLA/2019/00363)**:** Reinstatement of Safe Fishing Environment, Cable Protection and Scour Remediation works. The works were completed in 2020, not relevant for an in-combination assessment.

Harwich Haven Approach Channel Deepening (MLA/2019/00371): Application submitted August 2019. Timeline for dredging activity is January 2021 to December 2023, not relevant for an in-combination assessment.

Extension of Inner Gabbard (MLA/2019/00371)**:** East Disposal site. Application submitted August 2019. Timeline for disposal activity is January 2021 to December 2023, not relevant for an in-combination assessment.

London Array Offshore Wind Farm (MLA/2017/00096/1): Ongoing maintenance. Licence granted. Completed 30 September 2020, not relevant for an in-combination assessment.

Suffolk Yacht Harbour (MLA/2018/00469)**:** Levington Saltmarsh Restoration and beneficial use of dredgings project. Consent granted on 1 February 2019, expires 31 March 2024, not relevant for an in-combination assessment.

Great Yarmouth Third River Crossing (TR010043)**:** A new highway crossing of River Yare, Great Yarmouth, connecting Harfrey's Roundabout to the west of the River Yare with South Denes Road to the east of the River Yare.

In September 2020, the Secretary of State for Transport granted the Development Consent Order application to construct, operate and maintain the bridge and its approaches. Following confirmation of the DCO, the government approved the final business case for the project and construction started in January 2021. The bridge is due to open for use in early 2023, not relevant for an in-combination assessment.

9.5.12. PPP that are outside of the scope of an in-combination assessment – not enough information available or not certain to proceed

The following PPP were identified for inclusion in an in-combination assessment, however they have yet to apply for the necessary PPP. They are therefore not certain or there is not enough information available and, as a result, fall out of the requirement for an in-combination assessment.

Lagoon Hull is still in the concept stage, therefore it is not certain enough to fall under consideration as a plan or project, as defined by PINS advice note 10, v8 2017, as relevant for in-combination assessment.

Offshore grid connection: options/scenarios as set out in the AECOM report commissioned by Crown Estate - East Coast Grid Spatial Study Summary Report (21.4MB) (thecrownestate.co.uk). This includes grid options not far away from Sizewell C.

The study has identified the key terrestrial and marine constraints within the east coast region in order to: (i) establish an understanding of the study area's spatial context, in particular key spatial constraints, including settlement, environmental designations and other land or sea, (ii) evaluate the risks which these constraints present to future offshore wind deployment under radial and coordinated models, and (iii) consider if adopting a more coordinated or integrated approach to offshore wind grid connections in this region could mitigate these risks.

It appears that the project is not yet fully developed for risks to be considered at this stage.

North Falls Offshore Wind Farm (formerly known as Greater Gabbard Extension): agreement for lease with the Crown Estate was signed in autumn 2020, securing an option to extend the existing wind farm. Located 27km from Suffolk coast. Cable landfall is planned at Sizewell, adjacent to the Greater Gabbard landfall site. The project is now in the early stages of development, with the aim of achieving a Development Consent Order (DCO) in 2025.

There is currently not enough information to carry out an in-combination assessment.

Five Estuaries Offshore Wind Farm (formerly known as Galloper Wind Farm extension project): agreement for lease with the Crown Estate was signed in August 2020. While the project is an extension of the existing Galloper Wind Farm it will be progressed as a national infrastructure energy project on its own merit. It is currently in an early stage of development, with an anticipated operational date around 2030.

There is currently not enough information to carry out an in-combination assessment.

Nautilus Interconnector, National Grid Ventures: Proposed second interconnector between Great Britain and Belgium. It would create 1.4 gigawatts high voltage direct current. Elia and NGIHL are conducting a bilateral feasibility study and more information will be available in the future development plans. Connecting in the Leiston area is the preferred option for connection. Further detailed consideration of siting options is being considered. The project is currently at the scoping stage, the application is expected to be submitted to the Planning Inspectorate Q2 2023.

There is currently not enough information to carry out an in-combination assessment.

EuroLink Interconnector, National Grid Ventures: EuroLink is a proposal to build a high-voltage direct current (HVDC) transmission cable between the UK and the Netherlands. The capacity of the link will be 1,400MW and the project is still in the very early stages of development.

There is currently not enough information to carry out an in-combination assessment.

9.6. In-combination assessment summary

This in-combination assessment has considered the potential for in-combination effects between other relevant PPP for the WDA permit risks of change in thermal regime, toxic contamination (chemicals) and nutrient/organic enrichment.

This included considering the effect between the 3 operational EPR permits being applied for (WDA, RSR and CA) and between the different waste streams for the operational WDA.

Construction of the power station will require additional EPR permits, which haven’t yet been applied for. We are taking the construction discharges as provided by the applicant in its H1 assessment (NNB GenCo, 2021a: TR193), but we have not reviewed these in detail. When the permits are applied for, they will be subject to HRA.

This in-combination assessment has concluded, from the information currently available, that there are no in-combination effects between operational and construction permits.

9.6.1. Change in thermal regime

The only PPP where there is potential for in-combination effects for change in thermal regime is with SZB. For the relevant sites and features (seabirds and mammals), this was assessed in detail in the seabird and harbour porpoise features chapter (section 8). This concluded that there was no adverse effect on the relevant features of the European sites.

9.6.2. Toxic contamination (chemical)

The in-combination assessment considered other PPP that might contribute to in-combination effects; of these the only risk was with the potential for re-suspension of contaminants from construction for offshore wind farms. However, we were able to discount these effects, as any changes to water quality would be very localised, temporary and for a short duration, with normal conditions returning rapidly once activity stopped.

While this is a risk, it is considered that there is no potential for an in-combination effect with SZC.

9.6.3. Nutrient and organic enrichment

The only PPP that requires an in-combination assessment for nutrient or organic enrichment is Sizewell A and B STW outlet (section 9.5.9).

The operational WDA alone assessment was carried out in the context of the prevailing environmental conditions with current water quality, including SZA and SZB, considered within this baseline. The SACO for the Outer Thames Estuary SPA provides a target for the supporting habitat of the designated marine birds to "maintain water quality at mean winter dissolved inorganic nitrogen levels where biological indicators of eutrophication (opportunistic macroalgae and phytoplankton blooms) do not affect the integrity of the site and features, avoiding deterioration from existing."

There are no indicators of eutrophication within the Outer Thames Estuary SPA, and modelling has shown that there will be no deterioration in water quality from the operational WDA, in the context of the prevailing environmental conditions.

There is no potential for an in-combination effect with SZC.

9.7. In-combination assessment conclusion

It is therefore considered that there is no adverse effect in combination between the SZC operational WDA permit and other PPP on the following sites:

- Alde-Ore Estuary SPA
- Alde-Ore Estuary Ramsar
- Minsmere-Walberswick SPA
- Outer Thames Estuary SPA
- Southern North Sea SAC
- The Wash and North Norfolk Coast SAC

10. Conclusion of the appropriate assessment

The appropriate assessment for the operational WDA has been carried out in section 6 which described the methodology, section 7 which described the risks for each site, and in section 8 which considered water quality effects on seabird and harbour porpoise features. The potential for in-combination effects was covered in section 9.

The results of the appropriate assessment will be considered in the integrity tests set out here in section 10.1.

10.1. European site integrity test

Article 6(3) of the Habitats Directive requires that a competent authority “shall agree to the plan or project only after having ascertained that it will not adversely affect the integrity of the site concerned.”

Managing Natura advice (Commission Notice C (2018)) explains the concept of the “integrity of the site” at section 4.6.4 as the “coherent sum of the site’s ecological structure, function and ecological processes, across its whole area, which enables it to sustain the habitats, complex of habitats and/or populations of species for which the site is designated.” The following section takes the information already assessed and reaches conclusions on European site integrity.

10.1.1. Alde Ore and Butley Estuaries SAC

This integrity test is concluded with regard to the conservation objectives provided in Environment Agency (2022b; Annex 2).

Full consideration will be given to the targets provided in the supplementary advice on conservation objectives relating to water quality which are summarised below and can also be accessed through the following link Alde Ore and Estuaries SAC.

- reduce aqueous contaminants to levels equating to Annex VIII and good status according to Annex X of the Water Framework Directive, avoiding deterioration from existing levels (year-round)
- maintain the dissolved oxygen (DO) concentration at levels equating to high ecological status [of the Water Framework Directive], avoiding deterioration from existing levels (year-round)
- maintain water quality at mean winter dissolved inorganic nitrogen levels where biological indicators of eutrophication (opportunistic macroalgal and phytoplankton blooms) do not affect the integrity of the site and features avoiding deterioration from existing levels (year-round)
- maintain natural levels of turbidity (for example …plankton and other material) across the habitat (year-round)

This appropriate assessment has determined that, for those aspects of the permit where a likely significant effect was identified, the operational WDA will not breach the relevant assessment criteria for the following:

- change in thermal regime
- toxic contamination
- nutrient enrichment or eutrophication, including potential for increased turbidity

We considered impacts on the freshwater features due to potential connectivity between the operational WDA and the features of the SAC.

A conclusion of no adverse effect was made alone and in combination for the following designated features of the Alde Ore and Butley Estuaries SAC:

- Atlantic salt meadows
- estuaries
- mudflats and sandflats not covered by seawater at low tide

Conclusions of no adverse effect in combination were based on the best available information from the applicant for within project effects from the construction of SZC. Full in-combination assessments will be carried out when applications are made for discharges into the marine environment associated with the construction of SZC.

For change in thermal regime, we concluded that the extent of the Sizewell C plume would not reach the site as it is located over 12km to the north of the SAC.

For toxic contamination, the modelled plumes are offshore and there is no connectivity with the site or estuary features.

For nutrient enrichment, our assessment showed that there is no predicted increase in organic or nutrient enrichment in the Greater Sizewell Bay Area and therefore there will be no effect on the site or estuary features.

Managing Natura advice (Commission Notice C(2018)) explains the concept of the "integrity of the site" at section 4.6.4 as the "coherent sum of the site's ecological structure, function and ecological processes, across its whole area, which enables it to sustain the habitats, complex of habitats and/or populations of species for which the site is designated."

We do not believe that the operational WDA permit will impact upon the Alde Ore and Butley Estuaries SAC ecological structure, function and ecological processes across its whole area.

We were able to reach this conclusion due to the modelling results confirming that the effects identified would not reach the SAC and would therefore be unable to undermine the achievement of the conservation objectives. Site integrity cannot be considered to be adversely affected if the findings of an appropriate assessment demonstrate that the conservation objectives will not be undermined alone or in combination with other PPP.

10.1.2. Alde-Ore Estuary SPA and Ramsar

This integrity test is concluded with regard to the conservation objectives provided in Environment Agency (2022b; Annex 2). As there are no conservation objectives for the Ramsar site, we will consider the integrity test for both sites together.

Full consideration will be given to the targets provided in the supplementary advice on conservation objectives relating to water quality which are summarised below and can also be accessed through the following link [Alde Ore SPA:]

- reduce aqueous contaminants to levels equating to Annex VIII and good status according to Annex X of the Water Framework Directive, avoiding deterioration from existing levels (year-round)
- maintain the dissolved oxygen (DO) concentration at levels equating to high ecological status [of the Water Framework Directive], avoiding deterioration from existing levels (year-round)
- maintain water quality at mean winter dissolved inorganic nitrogen levels where biological indicators of eutrophication (opportunistic macroalgal and phytoplankton blooms) do not affect the integrity of the site and features avoiding deterioration from existing levels (year-round)
- maintain natural levels of turbidity (for example, …plankton and other material) across the habitat (year-round)

This appropriate assessment has determined that, for those aspects of the permit where a likely significant effect was identified, the operational WDA will not breach the relevant assessment criteria for the following:

- change in thermal regime
- toxic contamination
- nutrient enrichment or eutrophication, including potential for increased turbidity

A conclusion of no adverse effect was made alone and in combination for the following features as bespoke modelling showed there was no connectivity between the discharges and the site.

Therefore, the following SPA features which are found in the estuary will not be adversely affected:

- avocet
- marsh harrier
- ruff
- redshank

The following Ramsar features found in the estuary will not be adversely affected:

- avocet
- redshank
- waterbird assemblage (wintering)
- wetland bird assemblage (breeding)
- wetland invertebrate assemblage
- wetland plant assemblage

Consideration was given to functional linkage between the marine bird species of the Alde-Ore Estuary SPA and Ramsar and the area of the Outer Thames Estuary SPA into which the operational SZC discharges. A conclusion of no adverse effect was made alone and in combination in the seabird and harbour porpoise chapter (section 8) for the following functionally linked designated features of the SPA and Ramsar which forage offshore:

- little tern
- Sandwich tern
- lesser black-backed gull (SPA and Ramsar)

Conclusions of no adverse effect in combination were based on the best available information from the applicant for within-project effects from the construction of SZC. Full in-combination assessments will be carried out when applications are made for discharges into the marine environment associated with the construction of SZC.

For aqueous contaminants, we concluded that there will be mixing zones in which the EQS/PNEC values for TRO, bromoform and hydrazine will be exceeded. However, these will not be large enough to result in deterioration in water quality at a scale which will affect the breeding Sandwich tern and little tern feature or reach the Alde-Ore SPA site itself.

The decay of biota discharged by the FRR system will not lead to the release of un-ionised ammonia to the extent that there will be a deterioration in water quality that will affect the breeding little tern, lesser black-backed gull and Sandwich tern features or affect the water quality in the Alde-Ore Estuary SPA and Ramsar itself.

For dissolved oxygen, we concluded that the decay of dead and moribund biota discharged by the FRR system will not lead to a deterioration from existing levels of DO concentration in the offshore marine environment or within the Alde-Ore Estuary SPA and Ramsar.

For dissolved inorganic nitrogen, we concluded that discharges from the cooling water and FRR systems will not lead to increases in dissolved inorganic nitrogen levels to the extent that indicators of eutrophication affect in the offshore marine environment or within the Alde-Ore Estuary SPA and Ramsar.

For turbidity, we concluded that discharges of nutrients from the cooling water and FRR systems will not lead to significant increases in turbidity in the offshore marine environment or within the Alde-Ore Estuary SPA and Ramsar.

These conclusions were also reached when considering the overlapping operation of SZC and SZB for the offshore foraging birds.

Despite the decline in numbers of breeding pairs of little tern since the site was designated (from 48 pairs to no longer being regularly occupied), the scale of impacts from the discharges from the cooling water system and the FRR system, compared to the foraging area of the feature, allows us to conclude that there will be no adverse effect alone or in combination on the little tern feature of the SPA.

Despite the considerable decline in numbers of breeding pairs of Sandwich tern, from 100 to 300 breeding pairs (1993 to 1996) to less than 10, and often no, breeding pairs per year (1997 to 2009), the scale of impacts from the discharges from the cooling water system and the FRR system, together with the flexibility in foraging behaviour of the feature, allows us to conclude that there will be no adverse effect alone or in combination on the Sandwich tern feature of the SPA.

Despite the considerable decline in numbers of breeding pairs of lesser black-backed gulls since the site was designated (from >14,000 to <2,000 breeding pairs), the scale of impacts from the discharges from the cooling water system and the FRR system, compared to the foraging range and generalist diet of the feature, allows us to conclude that there will be no adverse effect alone or in combination on the lesser black-backed gull feature of the SPA and Ramsar.

Managing Natura advice (Commission Notice C (2018)) explains the concept of the "integrity of the site" at section 4.6.4 as the "coherent sum of the site's ecological structure, function and ecological processes, across its whole area, which enables it to sustain the habitats, complex of habitats and/or populations of species for which the site is designated."

We do not believe that the operational WDA permit will impact the Alde-Ore Estuary SPA's ecological structure, function and ecological processes across its whole area due to impacts on the foraging birds functionally linked to the SPA or Ramsar.

We were able to reach this conclusion due to the modelling results confirming that the effects identified would be low impact and too small to undermine the achievement of the conservation objectives. Site integrity cannot be considered to be adversely affected if the findings of an appropriate assessment demonstrate that the conservation objectives will not be undermined alone or in combination with other PPP.

10.1.3. Benacre to Easton Bavents SPA

This integrity test is concluded with regard to the conservation objectives provided in Environment Agency (2022b; Annex 2).

Full consideration will be given to the targets provided in the supplementary advice on conservation objectives relating to water quality found through the following link Benacre to Easton Bavents SPA.

This appropriate assessment has determined that, for those aspects of the permit where a likely significant effect was identified, the operational WDA will not breach the relevant assessment criteria for the following:

- change in thermal regime
- toxic contamination
- nutrient enrichment or eutrophication, including potential for increased turbidity

Consideration was given to functional linkage between the little tern of the Benacre to Easton Bavents SPA and the area of the Outer Thames Estuary SPA into which the operational SZC discharges.

Conclusions of no adverse effect in combination were based on the best available information from the applicant for within-project effects from the construction of SZC. Full in-combination assessments will be carried out when applications are made for discharges into the marine environment associated with the construction of SZC.

Managing Natura advice (Commission Notice C (2018)) explains the concept of the "integrity of the site" at section 4.6.4 as the "coherent sum of the site's ecological structure, function and ecological processes, across its whole area, which enables it to sustain the habitats, complex of habitats and/or populations of species for which the site is designated."

We do not believe that the operational WDA permit will impact on the Benacre to Easton Bavents SPA's ecological structure, function and ecological processes across its whole area.

We were able to reach this conclusion due to the modelling results confirming that the effects identified would not reach the SPA and would therefore be unable to undermine the achievement of the conservation objectives. Site integrity cannot be considered to be adversely affected if the findings of an appropriate assessment demonstrate that the conservation objectives will not be undermined alone or in combination with other PPP.

10.1.4. Minsmere-Walberswick SPA and Ramsar

This integrity test is concluded with regard to the conservation objectives provided in Environment Agency (2022b; Annex 2). There are no separate conservation objectives for the Ramsar site, so we consider the freshwater features are adequately protected by considering the freshwater SPA features. For the details of the specific Ramsar features, please see Environment Agency (2022b; Annex 2).

Full consideration will be given to the targets provided in the supplementary advice on conservation objectives relating to water quality found via the following link Marine site detail (naturalengland.org.uk). These are relevant for the coastal and freshwater supporting habitats:

- reduce aqueous contaminants to levels equating to Annex VIII and good status according to Annex X of the Water Framework Directive, avoiding deterioration from existing levels (year round)

- maintain the dissolved oxygen (DO) concentration at levels equating to high ecological status [of the Water Framework Directive], avoiding deterioration from existing levels (year round)
- maintain water quality at mean winter dissolved inorganic nitrogen levels where biological indicators of eutrophication (opportunistic macroalgal and phytoplankton blooms) do not affect the integrity of the site and features avoiding deterioration from existing levels (year round)
- maintain natural levels of turbidity (for example plankton and other material) across the habitat (year round)

This appropriate assessment has determined that, for those aspects of the permit where a likely significant effect was identified, the operational WDA will not breach the relevant assessment criteria for the following:

- change in thermal regime
- toxic contamination
- nutrient enrichment or eutrophication, including potential for increased turbidity

Consideration was given to functional linkage between the little tern of the Minsmere-Walberswick SPA and the area of the Outer Thames Estuary SPA into which the operational SZC discharges. A conclusion of no adverse effect was made alone and in combination in section 8.

We considered impacts on the freshwater features due to a potential connectivity between the operational WDA via the Minsmere Sluice. This is discussed in further detail in the 'Discussion of risks for each site' section. We concluded that although there is connectivity between the sites and the point of discharge via the Minsmere Sluice, the thermal and chemical plumes are located so far offshore that they will not reach the sluice intake. The nutrient and organic enrichment risks from the STW and FRR system discharges will not cause a deterioration in water quality in the marine environment and will therefore not alter the water quality of the freshwater environment or have indirect effects on eels as prey items of bittern. This led to a conclusion of no adverse effect alone and in combination.

A conclusion of no adverse effect was made alone and in combination for the following designated features of the SPA:

- hen harrier
- teal
- greater white-fronted goose
- avocet
- marsh harrier
- shoveler
- gadwall

A conclusion of no adverse effect was made alone and in combination for the following designated features of the Ramsar:

- mosaic of marine, freshwater, marshland and associated habitats
- wetland bird assemblage – breeding
- wetland invertebrate assemblage

Conclusions of no adverse effect in combination were based on the best available information from the applicant for within-project effects from the operation and construction of SZC. Full in-combination assessments will be carried out when applications are made for discharges into the marine environment associated with the construction of SZC.

For the areas offshore that are considered functionally linked for little tern, we concluded the following.

For aqueous contaminants, we concluded that there will be mixing zones in which the EQS/PNEC values for TRO, bromoform and hydrazine will be exceeded. However, these will not be large enough to result in deterioration in water quality at a scale which will affect the breeding little tern feature.

The decay of biota discharged by the FRR system will not lead to the release of un-ionised ammonia to the extent that there will be a deterioration in water quality that will affect the breeding little tern feature.

For dissolved oxygen, we concluded that the decay of dead and moribund biota discharged by the FRR system will not lead to a deterioration from existing levels of DO concentration within the offshore foraging areas functionally linked to the Minsmere-Walberswick SPA.

For dissolved inorganic nitrogen, we concluded that discharges from the cooling water and FRR systems will not lead to increases in dissolved inorganic nitrogen levels to the extent that indicators of eutrophication affect the offshore foraging areas functionally linked to the Minsmere-Walberswick SPA.

For turbidity, we concluded that discharges from the cooling water and FRR systems will not lead to significant increases in turbidity associated with potential nutrient increase within the offshore foraging areas functionally linked to the Minsmere-Walberswick SPA.

Similarly, we determined that there is minimal interaction with the discharges from the cooling water systems and the FRR systems of SZC and SZB combined.

There has been a decline in numbers of breeding pairs of little tern since the site was designated, from 32 breeding pairs at the time of classification (1991) to 1.6 breeding pairs (5-year mean peak count 2014 to 2018). However, the scale and location of impacts from the discharges from the cooling water system and the FRR system, compared to the potential foraging area of the little tern and areas of its concentrated foraging activity, coupled with the transitory nesting behaviour and meta-population structure of the little tern, we were able to conclude that there will be no adverse effect alone or in combination on the Minsmere-Walberswick SPA.

Managing Natura advice (Commission Notice C (2018)) explains the concept of the “integrity of the site” at section 4.6.4 as the “coherent sum of the site’s ecological structure, function and ecological processes, across its whole area, which enables it to sustain the habitats, complex of habitats and/or populations of species for which the site is designated.”

We do not believe that the operational WDA permit will impact on the Minsmere-Walberswick SPA or Ramsar’s ecological structure, function and ecological processes across its whole area.

We were able to reach this conclusion due to the modelling results confirming that the effects identified above would be low-impact and too small to undermine the achievement of the conservation objectives. Site integrity cannot be considered to be adversely affected if the findings of an appropriate assessment demonstrate that the conservation objectives will not be undermined alone or in combination with other PPP.

10.1.5. Orfordness to Shingle Street SAC

This integrity test is concluded with regard to the conservation objectives provided in Environment Agency (2022b; Annex 2).

Full consideration will be given to the targets provided in the supplementary advice on conservation objectives relating to water quality found through the following link Orfordness to Shingle Street SAC.

This appropriate assessment has determined that, for those aspects of the permit where a likely significant effect was identified, the operational WDA will not breach the relevant assessment criteria for the following:

- change in thermal regime
- toxic contamination
- nutrient enrichment or eutrophication, including potential for increased turbidity

We considered impacts on the features due to potential connectivity between the operational WDA and the features of the SAC.

A conclusion of no adverse effect was made alone and in combination for the following designated features of the Alde Ore and Butley Estuaries SAC:

- coastal lagoons
- annual vegetation of drift lines
- perennial vegetation of stony banks; coastal shingle vegetation outside the reach of waves

Conclusions of no adverse effect in combination were based on the best available information from the applicant for within-project effects from the construction of SZC. Full in-combination assessments will be carried out when applications are made for discharges into the marine environment associated with the construction of SZC.

We concluded that for the annual vegetation of drift lines and perennial vegetation of stony banks features there is no effect pathway from the predicted thermal and chemical plumes or area of increased organic enrichment.

We concluded that while the salinity of the coastal lagoons is maintained by percolation through the shingle so there is potential connectivity, the chemical and thermal plumes and area of predicted nutrient enrichment are shown not to interact with the SAC boundary.

Managing Natura advice (Commission Notice C (2018)) explains the concept of the "integrity of the site" at section 4.6.4 as the "coherent sum of the site's ecological structure, function and ecological processes, across its whole area, which enables it to sustain the habitats, complex of habitats and/or populations of species for which the site is designated."

We do not believe that the operational WDA permit will impact upon the Orfordness to Shingle Street SAC ecological structure, function and ecological processes across its whole area.

We were able to reach this conclusion due to the modelling results confirming that the effects identified would not reach the SAC and would therefore be unable to undermine the achievement of the conservation objectives. Site integrity cannot be considered to be adversely affected if the findings of an appropriate assessment demonstrate that the conservation objectives will not be undermined alone or in combination with other PPP.

10.1.6. Outer Thames Estuary SPA

This integrity test is concluded with regard to the conservation objectives provided in Environment Agency (2022b; Annex 2).

Full consideration will be given to the targets provided in the supplementary advice on conservation objectives relating to water quality which can be accessed via the following link Outer Thames Estuary SPA:

- reduce aqueous contaminants to levels equating to high status … and good status … of the Water Framework Directive, avoiding deterioration from existing levels (year round)
- maintain the dissolved oxygen (DO) concentration at levels equating to high ecological status [of the Water Framework Directive], avoiding deterioration from existing levels (year round)
- maintain water quality at mean winter dissolved inorganic nitrogen levels where biological indicators of eutrophication (opportunistic macroalgal and phytoplankton

blooms) do not affect the integrity of the site and features, avoiding deterioration from existing levels (year round)

- maintain natural levels of turbidity (for example, plankton and other material) across the habitat (year round)

This appropriate assessment has determined that, for those aspects of the permit where a likely significant effect was identified, the operational WDA will not breach the relevant assessment criteria as set out in section 8 of this HRAR for the following:

- change in thermal regime
- toxic contamination
- nutrient enrichment or eutrophication, including potential for increased turbidity

A conclusion of no adverse effect was made alone and in combination for the following designated feature of the SPA:

- little tern
- common tern
- red-throated diver

Conclusions of no adverse effect in combination were based on the best available information from the applicant for within-project effects from the operation and construction of SZC. Full in-combination assessments will be carried out when applications are made for discharges into the marine environment associated with the construction of SZC.

For aqueous contaminants, we concluded that there will be mixing zones in which the EQS/PNEC values for TRO, bromoform and hydrazine will be exceeded. However, these will not be large enough to result in deterioration in water quality at a scale which will affect the breeding little tern feature.

The decay of biota discharged by the FRR system will not lead to the release of un-ionised ammonia to the extent that there will be a deterioration in water quality that will affect the features of the Outer Thames Estuary SPA.

For dissolved oxygen, we concluded that the decay of dead and moribund biota discharged by the FRR system will not lead to a deterioration from existing levels of DO concentration within the Outer Thames Estuary SPA.

For dissolved inorganic nitrogen, we concluded that discharges from the cooling water and FRR systems will not lead to increases in dissolved inorganic nitrogen levels to the extent that indicators of eutrophication affect the Outer Thames Estuary SPA.

For turbidity, we concluded that discharges from the cooling water and FRR systems will not lead to significant increases in turbidity within the Outer Thames Estuary SPA.

Similarly, we determined that there is minimal interaction with the discharges from the cooling water systems and the FRR systems of SZC and SZB combined.

There has been an overall decrease in numbers of breeding pairs of little tern since the site was designated, from 451 breeding pairs at, or near, the time of the constituent breeding colony's classification to 373 breeding pairs (2011 to 2015). However, the scale and location of impacts from the discharges from the cooling water system and the FRR system, compared to the potential foraging area and areas of concentrated foraging activity of all constituent colonies, coupled with the transitory nesting behaviour and meta-population structure of the feature, allows us to conclude that there will be no adverse effect alone or in combination on the little tern feature of the Outer Thames Estuary SPA.

Due to its relatively recent designation, population trends for the common tern (breeding) feature of the Outer Thames Estuary SPA are not available (Marine site detail (naturalengland.org.uk)). However, the scale and location of impacts from the discharges from the cooling water system and the FRR, compared to the potential foraging areas of all common tern colonies supported by the Outer Thames Estuary SPA, coupled with the relatively generalist diet and variety of foraging methods available to common terns, allows us to conclude that there will be no adverse effect on the comment tern feature of the SPA.

Water discharge activities from SZC will take place within the north-western section of the Outer Thames Estuary SPA. Although the density of red-throated divers has been observed to be lower in the southern section than in the north-western section, the north-western section is used by, and is of importance to, the non-breeding red-throated diver feature. The scale of impacts from the discharges from the cooling water system and the FRR system, compared to the extensive home range and opportunistic diet of the non-breeding red-throated diver feature, allows us to conclude that there will be no adverse effect on the red-throated diver feature of the Outer Thames Estuary SPA.

Managing Natura advice (Commission Notice C(2018)) explains the concept of the "integrity of the site" at section 4.6.4 as the "coherent sum of the site's ecological structure, function and ecological processes, across its whole area, which enables it to sustain the habitats, complex of habitats and/or populations of species for which the site is designated."

We do not believe that the operational WDA permit will impact on the Outer Thames Estuary SPA's ecological structure, function and ecological processes across its whole area.

We were able to reach this conclusion due to the modelling results confirming that the effects identified would be low impact and too small to undermine the achievement of the conservation objectives. Site integrity cannot be considered to be adversely affected if the findings of an appropriate assessment demonstrate that the conservation objectives will not be undermined alone or in combination with other PPP.

10.1.7. Southern North Sea SAC

This integrity test is concluded with regard to the conservation objectives provided in Environment Agency (2022b; Annex 2).

Full consideration will be given to pressures identified in the supplementary advice on conservation objectives relating to water summarised here and available via the following link Southern North Sea SAC and summarised below:

- effects on water and prey quality
- bioaccumulation through contaminated prey ingestion leading to health issues, for example, on reproduction

This appropriate assessment has determined that, for those aspects of the permit where a likely significant effect was identified, the operational WDA will not breach the relevant assessment criteria as set out in section 8 of this HRAR for the following:

- change in thermal regime
- toxic contamination
- nutrient enrichment or eutrophication

A conclusion of no adverse effect was made alone and in combination for the following designated feature of the:

- harbour porpoise

Conclusions of no adverse effect in combination were based on the best available information from the applicant for within-project effects from the operation and construction of SZC. Full in-combination assessments will be carried out when applications are made for discharges into the marine environment associated with the construction of SZC.

For water and prey quality, we have concluded that due to the small proportion of the Southern North Sea SAC experiencing thermal uplift or chemical exceedance, and the low level of organic input relative to the size of the SAC, the water discharge activities of SZC alone, will not have an effect on water quality of sufficient magnitude to affect the harbour porpoise feature or its supporting habitats. Prey quality will also not be affected.

We have concluded that there is no risk of bioaccumulation of TRO, chlorinated by-products, or hydrazine discharged by SZC alone.

Similarly, we determined that there is minimal interaction with the discharges from the cooling water systems and the FRR systems of SZB and SZC combined.

Managing Natura advice (Commission Notice C(2018)) explains the concept of the “integrity of the site” at section 4.6.4 as the “coherent sum of the site’s ecological structure, function and ecological processes, across its whole area, which enables it to sustain the habitats, complex of habitats and/or populations of species for which the site is designated."

We do not believe that the operational WDA permit will impact on the Southern North Sea SAC's ecological structure, function and ecological processes across its whole area.

We were able to reach this conclusion due to the modelling results confirming that the effects identified would be low impact and too small to undermine the achievement of the conservation objectives. Site integrity cannot be considered to be adversely affected if the findings of an appropriate assessment demonstrate that the conservation objectives will not be undermined alone or in combination with other PPP.

10.1.8. The Wash and North Norfolk Coast SAC

This integrity test is concluded with regard to the conservation objectives provided in Environment Agency (2022b; Annex 2).

This appropriate assessment has determined that, for those aspects of the permit where a likely significant effect was identified, the operational WDA will not breach the relevant assessment criteria as set out in section 7.6 of this HRAR for the following:

- change in thermal regime
- toxic contamination
- nutrient enrichment or eutrophication

Consideration was given to functional linkage between the harbour seal of the Wash and North Norfolk Coast SAC and the area into which the operational SZC discharges. A conclusion of no adverse effect was made alone and in combination in section 7.6 for the following functionally linked designated feature of the SPA which forages offshore:

- harbour seal

Conclusions of no adverse effect in combination were based on the best available information from the applicant for within-project effects from the operation and construction of SZC. Full in-combination assessments will be carried out when applications are made for discharges into the marine environment associated with the construction of SZC.

Thermal uplift and discharges of polluting chemicals, TRO, bromoform and hydrazine, will occur off the Sizewell coast, but the areas affected are small compared to the foraging area of harbour seals from The Wash and North Norfolk Coast SAC as it travels between the site and the Thames Estuary, which is considered to be functionally linked.

We conclude that here is no potential for nutrient enrichment to affect the ability of the water column habitat to support the foraging behaviour of the harbour seal feature.

The scale and location of impacts from the discharges from the cooling water system and the FRR system, together with the distance from haul-out sites within the SAC, allows us to conclude that there will be no adverse effect on the harbour seal feature of the Wash and North Norfolk Coast SAC.

Managing Natura advice (Commission Notice C(2018)) explains the concept of the "integrity of the site" at section 4.6.4 as the "coherent sum of the site's ecological structure, function and ecological processes, across its whole area, which enables it to sustain the habitats, complex of habitats and/or populations of species for which the site is designated."

We do not believe that the operational WDA permit will impact on the Wash and North Norfolk Coast SAC's ecological structure, function and ecological processes across its whole area.

We were able to reach this conclusion due to the modelling results confirming that the effects identified would be low impact and too small to undermine the achievement of the conservation objectives. Site integrity cannot be considered to be adversely affected if the findings of an appropriate assessment demonstrate that the conservation objectives will not be undermined alone or in combination with other PPP.

Appendix A

ETAS review of derived PNECs for hydrazine

Enquirer Section:

Enquiry Details

Background:

NNB Generation Company (NNB GenCo) propose to construct and operate new nuclear power stations within the UK. Primarily at Hinkley Point in Somerset, to be known as Hinkley Point C (HPC) and at Sizewell in Suffolk, to be known as Sizewell C (SZC). The construction and operation of these power stations will require various permissions from the Environment Agency.

During the commissioning and operation of these power stations the operator would like to discharge trade effluent contain concentrations of Hydrazine. In order to assess the environmental implications of these discharges NNB GenCo have investigated the toxicity of Hydrazine in order to propose a suitable Predicted No Effect Concentration (PNEC) as an appropriate environmental impact threshold.

NNB GenCo's investigations, conclusions and justifications are documented in several reports. Including:

- TR175 - Initial investigation of hydrazine toxicity to selected marine species, 2011
- TR387 - Investigation of Hydrazine Toxicity, 2020

NNB GenCo have proposed the following PNECs:

- A chronic PNEC of 0.4 ng/l (calculated as a mean) for assessing long term effects, and
- An acute PNEC of 4 ng/l (calculated as a 95^{th} percentile) for assessing short term effects.

They have also referred to research more recent assessments used in support of Canadian Federal Water Quality Guidelines (FWQGs) for hydrazine indicate concentrations below 200 ng/l have a low probability of adverse effects for marine life, whilst a freshwater threshold of 2.6 μg/l has been applied based on a greater availability of data in the freshwater environment (Environment Canada, 2013).

Enquiring:

1. Can we consider that the proposed PNEC concentration values stated by the NNB GenCo (and how they have been derived) are appropriate?
2. If not, what alternative PNEC concentration values should be considered as appropriate for use in our audit of the assessments?

What Guidance Document(s) Does This Relate To? (If Appropriate) Operational instruction 17_13 – Permitting of hazardous pollutants in discharges to surface waters.

Response section:

An Environmental Quality Standard (EQS) for the protection of aquatic life is not available for hydrazine. An EQS reflects the concentration of a substance above which there is the potential for an adverse effect on aquatic organisms based on consideration of the available toxicity data. Formal EQSs are only available for a relatively small number of substances. In situations where an EQS is not available for a substance of interest, but an indication of a concentration of potential concern in the environment is needed, a review of the available data on the substance can be undertaken to identify other relevant, available thresholds and also data on the aquatic toxicity of a substance. In the absence of a suitable threshold the available toxicity data can be used to derive a PNEC (Predicted No Effect Concentration) value to give an indication of a concentration of potential concern.

In the absence of an EQS for hydrazine a PNEC value was proposed by NNB of 4ng/l (acute exposure) and 0.4ng/l (chronic exposure). I have considered the information provided on the toxicity data and approach used to derive the PNEC value proposed. This data (outlined in submitted reports, eg TR357 and 445) indicated that the PNEC was derived based on consideration of the available aquatic toxicity data and application of an assessment factor to the lowest effect concentration located. The PNEC proposed is based on a toxicity study for the algal species Dunaliella tertiolecta for which an EC50 of 0.4ug/l was reported. An assessment factor of 100 was applied to derive the acute value of 4ng/l and an AF of 1000 to derive the chronic value of 0.4ng/l. Data was available for a range of species including algae/macrophytes, invertebrates and fish.

Alongside the toxicity data noted to have been considered by NNB I also considered the aquatic toxicity data collated in an Environment Canada report (2013) (https://www.ec.gc.ca/ese-ees/default.asp?lang=En&n=D66353C2-1#a8). Toxicity data for a wide range of species was included in this report including data for algae/macrophytes, invertebrates and fish. The data indicated that algae/macrophytes were the most sensitive species based on the available dataset. None of the endpoints noted in this report were below the lowest effect concentration noted in the data provided by NNB.

I undertook an additional data search to see if there was any additional data for hydrazine. Some additional information was located from an ECHA substance dossier but the data did not include a lower effect concentration than that which had been used to derive the PNEC proposed by NNB.

Assessment factors (AFs) were used to derive the proposed PNEC value. The use of AFs is an approach used in the derivation of EQSs and other environmental thresholds. They are applied to take account of the fact, for example, that toxicity data is not available for all species and endpoints. The size of the AF applied is dependent on the available dataset, eg the range of species and endpoints for which data is available and whether short term and long term exposure studies are available etc. The AFs used to derive the PNEC are broadly in line with the assessment factors noted in the guidance for deriving EQS values under the Water Framework Directive (Technical Guidance No 27 (2018) (https://rvs.rivm.nl/sites/default/files/2019-04/Guidance%20No%2027%20-%20Deriving%20Environmental%20Quality%20Standards%20-%20version%202018.pdf)

This is the guidance currently used when deriving EQSs in the UK. NNB have applied an AF of 100 to derive the acute value for hydrazine and an AF of 1000 to derive the chronic value. Based on the available data for hydrazine this is broadly in line with the AFs noted in the guidance. A difference however is that an additional AF of 10 has not been applied for the marine environment. Additional AFs are proposed in the derivation of EQSs for saltwater where there is limited data for saltwater species and are used to due to recognise greater species diversity in the marine environment. The additional AF has not been applied, with the argument given being that hydrazine is not persistent and bioaccumulative. This is not a specific reason noted in the guidance for not applying an additional AF. There could therefore be an argument that an additional AF should be applied in this case.

Based on consideration of the above:-

- Aquatic toxicity data is available for hydrazine for a range of species including algae, invertebrates and fish.
- Algae/macrophytes seem to be the most sensitive organisms based on the available toxicity data. The lowest effect concentration reported in the dataset located was for Dunaliella tertiolecta. An EC50 of 0.4ug/l was noted for this species. This was the lowest effect concentration for the dataset overall and the lowest effect concentration for algae/macrophytes.
- As this is the lowest value it seems appropriate to use this as the basis of the derivation of a PNEC based on the available data.
- The AFs used in the derivation of the PNEC are 100 for the acute value and 1000 for the chronic value. Based on the available toxicity data this is broadly in line with the guidance for EQS derivation. An additional AF of 10 was not applied. The argument noted ie hydrazine is not persistent or bioaccumulative is not a specific reason noted in the guidance for not applying an AF.
- Based on the available dataset however and the approach used, the PNEC proposed by NNB is based on the most sensitive toxicity endpoint available, the data is for saltwater algal species which seem more sensitive than invertebrates and fish. It could therefore be considered a reasonable screening value in the absence of an EQS.
- For information, the Canadian and ECHA values that have been derived differ from the proposed PNECs as different studies have been used as the basis of the threshold derived and different assessment factors have been applied. The PNECs proposed for hydrazine by NNB ie 0.4ng/l and 4ng/l are based on the lowest effect concentration available, ie the Dunaliella species and also uses a larger assessment factor than for the Canadian or ECHA values.
- The lowest effect concentration noted in the available toxicity data set was that for a marine algal species Dunaliella tertiolecta. This was used as the basis of the PNEC proposed. The data from this particular study indicated this was the most sensitive of the range of species studied. The latter included algae and also macroalgae, including a number of species of seaweed, invertebrates such as crustaceans and polychaetes as well as a number of fish species. Sabellaria is a type of polychaete and Corallina is a type of seaweed. Therefore although data was not available on the toxicity of hydrazine to these particular species, there was data for other species within these taxa. As the effect concentration for the algal species used to derive the PNEC, ie Dunaliella spp, was lower than the effect concentrations noted for polychaetes and other types of algae, and in addition a large assessment factor of 1000 has been applied, this suggests that the approach taken to derive the PNEC

would be considered precautionary for Sabellaria and Corallina based on the available data.

- mobile species such as fish and invertebrates are considered in the derivation of the PNEC, as data for a number of species within these taxa are available in the dataset for hydrazine. The impact of hydrazine on these species has therefore been considered in the derivation of the PNEC.
- The PNECs proposed for hydrazine do not take into consideration direct effects on birds. Effects of hydrazine on their prey is likely to be considered as the PNEC derived considered data on the effects on invertebrates and fish for example, but the specific effects on birds are not taken into account in these PNECs.

Appendix B

Fish recovery and return system discharge assessment methodology

Introduction

The proposed design for the cooling water system at SZC includes 2 measures which are proposed to work together to reduce the environmental impact of that water discharge activity (WDA). These measures are low velocity side entry intake heads (LVSE) and a fish recovery and return (FRR) system.

The FRR system is proposed to protect the power station’s cooling water system by reducing risks of blockage/biofouling. Within the system, the abstracted water will pass through a series of screens, any debris and biota larger than the screen mesh size will be trapped and removed or ‘impinged’.

Some of this biota will still be alive, and therefore the FRR system is proposed to return these individuals back to Greater Sizewell Bay. However, a proportion of this biota will not survive and this dead or moribund biota will also be returned to Greater Sizewell Bay. It is the discharge of this moribund biota that constitutes a WDA as it is considered a discharge of polluting matter under Schedule 21 of the Environmental Permitting Regulation (2016). The potential impacts on water quality and designated ecology must therefore be assessed as part of this HRAR.

This section describes the methodology used to estimate the amount of polluting matter to be discharged and what potential impacts this may have on relevant water quality elements. These quantitative results can then be considered qualitatively to determine whether the FRR system discharge would cause a deterioration (for example, under Water Framework Directive (WFD)), and to inform this HRAR.

Assessment process

The general steps involved in the assessment process are as follows:

1. Estimate the number of individuals that will be impinged within the Sizewell C cooling water system.

   This will use impingement sampling data collected from Sizewell B and apply scaling factors to take account of the differing volumes and intake designs.

2. Calculate the biomass of these impinged individuals.

3. Calculate the biomass of the individuals that will not survive the journey through the abstraction and FRR systems by applying appropriate ‘FRR system mortality rates’.

These will differ between the types of species impinged.

4. Conduct a literature review to understand the decay products of moribund organisms.
5. The daily loading of those breakdown products (nitrogen, phosphorus, un-ionised ammonia, biochemical oxygen demand (BOD), and organic carbon) is then calculated using the biomass from Step 3 and the literature values in Step 4.
6. These loadings can then be compared against a relevant standard (for example, EQS or equivalent) to estimate a 'mixing zone' for each element.

Estimating Sizewell C impingement (Step 1)

To support the application, the applicant submitted various reports to present a data analysis process to predict the number of individuals that will be impinged at SZC, using impingement sample data from the Comprehensive Impingement Monitoring Programme (CIMP) at Sizewell B (SZB):

NNB GenCo, 2020c. TR406 Sizewell C – Impingement predictions based upon specific cooling water system design. Revision 7. NNB Generation Company (SZC) Limited.

NNB GenCo, 2021i. TR339 Sizewell Comprehensive Impingement Monitoring Programme 2009 – 2017. NNB Generation Company (SZC) Limited.

NNB GenCo, 2021J. SPP111 Sizewell C impingement predictions corrected for Sizewell B raising factors and cooling water flow rates. Revision 2.

Vertical audit

We carried out a vertical audit on the data processing by the applicant as detailed within these reports. This audit is detailed in Environment Agency (2022f; TBS002) and involved correcting errors identified in this processing, and deriving, where appropriate, amended predictions of SZB impingement.

It should be noted that the results the applicant presented in support of its application have changed between the application being submitted in June 2020, and further information being submitted in August 2021. This is partly a result of the QA process we have undertaken, reporting our findings to the applicant, and the applicant correcting its analysis as a result. It is also due to the change to cooling water flow to account for auxiliary cooling water (ACW) and essential cooling water (ECWAs).

We have compared our results to those the applicant presented in NNB GenCo (2021i; TR339) and NNB GenCo (2021J; SPP111). Table 49 summarises how issues identified with the applicant's data processing have been addressed between our calculations and those presented in NNB GenCo (2021i; TR339) and NNB GenCo (2021J; SPP111).

Table 49: Summary of corrections made for identified data processing errors

Data Issue	TR339 v3	SPP111 v2	EA TBS002
Error in individual Pisces raw data files	Present	Corrected	Corrected
Factor up on number of screens or number of pumps	Screens	Pumps	Pumps
Account for ACW and ECW[1]	No	Yes	Yes
Treatment of overflowing bulk samples	Pisces included, Cefas excluded	All excluded	Pisces included, Cefas excluded[3]
Account for missing survey samples	No	Yes	Yes
Double counting of combined species	No	Yes	?[2]

[1]Auxiliary cooling water (ACW) and essential cooling water (ECW).

[2]We have not received the data needed to allow this check to be made.

[3]We have treated Pisces and Cefas overflowing samples differently to reflect how they were treated in TR339 v3, as the data set the QA is based is that from TR339 v3. To work from the raw data from SPP111 v2 would have necessitated repeating many parts of the QA.

A number of errors in data processing, made in NNB GenCo (2021i; TR339), have been identified, where the calculation method followed differs from that described in the report. These have been corrected in NNB GenCo (2021J; SPP111). Therefore, the results presented in NNB GenCo (2021J; SPP111) are in line with the methodology set out in NNB GenCo (2021i; TR339).

Differences between our calculations and results in NNB GenCo (2021i; TR339) and NNB GenCo (2021J; SPP111) are relatively small and reflect the relative insignificance of the errors identified.

Uncertainty analysis

No attempt was made to address the uncertainty in CIMP results due to overflowing bulk samples, in either NNB GenCo (2021i; TR339), NNB GenCo (2021J; SPP111) or our QA. As a high proportion of bulk samples collected overflowed, there is a significant source of uncertainty in the estimate of SZB and SZC impingement the applicant presented. For each overflowing bulk sample, the result obtained is less than the true value, and the degree by which the true value is underestimated is unknown.

Consequently, as part of our role in the DCO consultation, we requested a sensitivity analysis accounting for overflowing bulk samples among a number of other factors. The response to the request is set out in NNB GenCo (2021k; SPP116). However, we have undertaken the applicant's uncertainty analysis on our impingement estimates, which is documented in Environment Agency (2022g; TBS007).

The uncertainty analysis in Environment Agency (2022g; TBS007) sets out work aimed at quantifying the potential impact of the overflowing bulk samples on impingement predictions and allowed us to calculate a 'reasonable worst-case estimate' of impingement at SZC. The presence of the overflowing bulk samples means that we do not know the true impingement at SZB, which contributes to the uncertainty in the predicted impingement at SZC. We have arrived at an estimate of SZC impingement that we consider the true value is unlikely to exceed, therefore, we have termed it a 'reasonable worst case'.

Potential sources of uncertainty in the impingement estimate for SZC that we have not included in this uncertainty analysis include the different spatial locations of SZB and SZC abstraction intake. Fishing surveys found no significant spatial differences in the fish community, nor the fish length distributions for species other than sea bass, between the locations of the SZC and SZB intakes (NNB GenCo, 2020c; TR406). For sea bass, the applicant's SZC impingement prediction was reduced by 90% based on these findings (NNB GenCo, 2020c; TR406). We have not applied a similar adjustment in our analysis.

LVSE factor

As sample data from SZB is used to predict the impingement at SZC, a factor needs to be applied to account for the low velocity side entry (LVSE) intake designs at SZC (termed the LVSE factor). We have reviewed the work contained in the applicant's report (NNB GenCo, 2021L; SPP099) 'Predicted performance of the SZC LVSE intake heads, compared with the SZB intakes'.

In summary, we consider it unlikely that the true LVSE factor would be less than 1, but there is also evidence that the LVSE intake heads could act as an artificial reef and, therefore, be greater than 1. However, without any evidence or basis for a calculation otherwise, we have assumed an LVSE factor of 1 in our estimates of SZC impingement.

It is true that Environment Agency guidance (Environment Agency, 2010) is in favour of LVSE designs, as their configuration gives fish a chance to swim away from the intake if they wish to do so. However, in the present case, there is no reason to assume that they will wish to avoid the intake, without a behavioural cue of some sort.

Calculate the biomass of impinged individuals (Step2)

The Comprehensive Impingement Monitoring Programme (CIMP) provided fish and invertebrate numbers caught over 204 separate days during the period of 03/2009 to 10/2017 at SZB. This data was collected through a hybrid sampling method, with a bulk sample collected in the trash basket for 18-hours (overnight), followed by 6 one-hour samples collected from the drum screen channels in baskets. This data allowed biomass estimates to be calculated for 87 species, for each day of sampling, to give the impinged mass for one day (kg/24h).

This biomass data from SZB was then scaled up to estimate biomass impingement at SZC, following the methodology described in NNB GenCo (2020c; TR406). The SZC ‘volume scale’ estimate directly raises the SZB impingement weights by the ratio of cooling water flows. An additional scaling factor is also applied to account for the overflowing bulk samples. This scaling determines the SZC worst-case scenario.

These scaling factors are summarised in Table 50.

Table 50: Environment Agency revised method of predicting SZC impingement estimates from SZB CIMP data, as defined in Environment Agency (2022g; TBS007)

	SZC volume scale	Additional scaling SZC worst-case volume scale
Environment Agency factors	2.56 (132/51.5)	5
TR406 factors	2.56 (132/51.5)	N/A

To derive annual biomass estimates, the daily impingement estimates were bootstrapped to 5,000 iterations for each species and scaled up to an annual amount (multiplied by 365.25).

Results from the Environment Agency annual biomass estimates indicate that 11 species groups contribute to around 95% of the impinged baseline scenario at SZC, and 94% of the worst-case scenario (Table 51). Herring (Clupea harengus) and whiting (Merlangius merlangus) have the highest weight impinged. Environment Agency annual biomass impingement for SZC baseline and SZC worst case is estimated as 498,009kg and 1,051,455kg respectively.

The applicant’s impingement surveys at SZB were affected by a significant number of overflowing samples. In its application documents, no factor was applied to account for the impact of the overflowing samples. The Environment Agency baseline estimate replicates the method the applicant followed for figures reported in NNB GenCo (2021i; TR339), corrected for a number of errors in the applicant’s work, but treating bulk samples in the same way. We have arrived at an estimate of SZC impingement that we consider the true value is unlikely to exceed by applying a factor to overflowing samples, therefore, we have termed it a ‘reasonable worst case’.

Table 51: Species with the highest annual mass (kg) of impingement

Fish common name	Fish scientific name	SZC baseline	SZC worst case
Herring	Clupea harengus	256,353	487,414
Whiting	Merlangius merlangus	81,211	185,321
Sprat	Sprattus sprattus	49,076	124,604
European seabass	Dicentrarchus labrax	48,988	101,552
Common(brown)shrimp	Crangon crangon	10,150	23,858
Atlantic cod	Gadus morhua	7,177	10,578
Dab	Limanda limanda	4,861	12,798
Sole (Dover sole)	Solea solea	4,633	9,932
Epibenthic mix unidentified	-	4,280	9,757
Common prawn	Palaemon serratus	4,276	11,361
Thin lipped mullet	Liza ramada	3,907	12,150
	Overall total for all species:	498,009	1,051,455

Calculation of the biomass of moribund organisms from the FRR system (Step 3)

To calculate the biomass of individuals that will not survive the journey through the cooling water abstraction and FRR systems, we apply FRR system mortality rates to the biomass impingent estimates from Step 2 above.

Environment Agency (2022h; TBS004) provides the FRR system mortality rates we used during the HPC permit variation determination (following extensive review by us and our marine contractor, APEM LTD). It also details our review of the FRR system mortality rates used by the SZC project, and considers the differences in the FRR systems as provided by the applicant.

It then recommends a final set of FRR system mortality rates for each species in the impingement record at Sizewell B (SZB) (the basis for the SZC analysis), which are used in the process of calculating the predicted moribund biomass and any resulting water quality issues.

The FRR system mortality rates for the most common fish species captured in the SZB impingement data are provided in Table 52.

Table 52: Selected mortality rates to use in the Environment Agency's estimate of impact from the FRR system. Environment Agency values are from Environment Agency (2022h; TBS004)

Species	FRR system mortality factor used by applicant in Table 4 of NNB GenCo (2021k; SPP116)	FRR system mortality factor used by the Environment Agency for the HPC permit variation	FRR system mortality factor used by the Environment Agency for SZC
European sprat	1.000	1.000	1.000
Atlantic herring	1.000	1.000	1.000
Whiting	0.551	0.552	0.552
European seabass	0.551	0.608	0.608
Sand goby	0.206	0.200	0.206
Dover sole	0.206	0.200	0.206
European anchovy	1.000	NA	1.000
Dab	0.535	NA	0.535
Thin-lipped grey mullet	0.551	NA	1.00

Species	FRR system mortality factor used by applicant in Table 4 of NNB GenCo (2021k; SPP116)	FRR system mortality factor used by the Environment Agency for the HPC permit variation	FRR system mortality factor used by the Environment Agency for SZC
Flounder	0.231	0.200	0.231
Smelt (cucumber)	1.000	NA	1.000
European plaice	0.206	0.200	0.206
Atlantic cod	0.553	0.563	0.563
Thornback ray	0.206	0.545	0.545
Twaite shad	1.000	1.000	1.000
River lamprey	0.206	0.200	0.206
European eel	0.206	0.200	0.206
Horse mackerel	1.000	NA	1.000
Mackerel	1.000	NA	1.000
Tope	0.206	NA	1.000
Sea trout	1.000	1.000	1.000
Sea lamprey	0.206	0.200	0.206
Allis shad	1.000	1.000	1.000

Six biomass scenarios were run to determine the monthly average of all dead fish and invertebrates.

Table 53 defines the 6 biomass scenarios we assessed.

As a precautionary measure, the quarter 1 mean daily loading of moribund impinged fish was calculated along with the annual mean. The highest daily loadings of impinged fish and invertebrates occurred in Q1 at 6,063kg of dead biota per day. Upper 95% confidence limit values (u 95% c.I) were used for assessments where comparison is to an acute standard (for example, un-ionised ammonia). For nutrients assessment, annual average load is relevant as short-term acute events are not of concern.

Table 53: Environment Agency biomass scenarios, including both baseline and worst-case calculations for SZC

		Environment Agency baseline1		Environment Agency reasonable worst case2			
		Baseline no Invert u95	Baseline with Invert u95	Worst case no Invert	Worst case with Invert	Worst case no Invert u 95% c.I.	Worst case with Invert u 95% c.I.
Daily loading of impinged fish - Annual mean (kg)		1,661	1,773	2,257	2,505	3,835	4,083
Daily loading of impinged fish - Q1 mean (kg)		3,700	3,812	5,917	6,063	7,900	8,046

[1]Baseline: Our estimate of SZC impingement following the same calculation method as that used by the applicant. With no factor applied to overflowing samples.

[2]Worst-case: Our estimate of SZC impingement, arrived at after applying a factor to account for overflowing samples that we consider the true value is unlikely to exceed.

Conduct a literature review (Step 4)

In support of the application, the applicant provided a technical report on the influence of the fish recovery and return systems on water quality and ecological receptors (NNB GenCo (2020g; TR520). This documents the applicant's review of the current relevant literature. We have reviewed the literature cited and have found no more relevant sources, so the values provided in NNB GenCo (2020g; TR520) are accepted and used within our own analysis.

Calculate the daily loading of breakdown products and estimate mixing zones for each element (Steps 5 and 6).

We reviewed further the evidence provided in NNB GenCo (2020g; TR520) to determine whether the FRR system discharge would cause a deterioration of water quality to inform this HRAR.

To determine any deterioration or impacts, the assessment considered the potential effects on:

- nutrient concentrations
- un-ionised ammonia
- biochemical oxygen demand (BOD)
- and organic enrichment

Following our review, we replicated the same analysis as the one the applicant provided in NNB GenCo (2020g; TR520). However, our calculations were updated using several different evaluations of the potential biomass discharged from the FRR system outlet. This analysis is detailed in Environment Agency (2022i; TBS011) 'Potential water quality and ecological impact from the SZC FRR system discharge', but a summary for each element is provide here.

Calculation of nutrient inputs

The nutrient loads were predicted using published estimates in fish tissue (Gende and others, 2004; Walker and others, 2011). The average daily biomass was multiplied by the maximum estimates of phosphorus and nitrogen (for example, daily load x (0.5/100)) = kg P). It is estimated that the discharge of dead fish and invertebrates from the FRR system will result in an average of 142.9kg of dissolved inorganic nitrogen (DIN) and 20.4kg of phosphate per day.

Table 54 compares the nutrient input estimates using the reasonable worst-case with invertebrates annual mean and Q1 mean. The third column in this table shows the range of nutrient concentrations in fish tissue (as %) in the literature. In each case, the maximum concentration was applied, shown in bold.

Table 54: Phosphorus and nitrogen inputs based on estimates of nutrient tissue concentrations (Gende and others, 2004; Walker and others, 2011)

Scenario	Nutrient	% wet weight	Kg
4,083 (annual average)	Phosphorous	0.45-**0.5**	20.4
	Nitrogen	3.2-**3.5**	142.9
8,046 (Q1 average)	Phosphorous	0.45-**0.5**	40.2
	Nitrogen	3.2-**3.5**	281.6

Calculation of un-ionised ammonia

As applied in NNB GenCo (2020g; TR520), Timm and Jorgenson's (2002) study of cod tissue was used to derive an equation of ammonium ions (125mg/kg of NH_4 from cod tissue).

The calculated value of total ammonia was then used in the un-ionised ammonia calculator (NH3SEA) (with background conditions as described in NNB GenCo (2020g; TR520): pH 8.23, salinity 31.7, temperature 11.73°C) to derive a corresponding un-ionised ammonia discharge (NH_{3}-N per day).

The volume of seawater required to dilute this mass of ammonia to the environmental quality standard (EQS) was then calculated using the un-ionised ammonia (NH_3) EQS of 21µg/l and assumed background level of 1.6µg/l. Assuming this is equally mixed through the full depth of the water column (4m), this can be converted to an area that would be needed to dilute the un-ionised ammonia concentrations down to the EQS.

For example, using the reasonable worst case with invertebrates quarter 1 95th daily biomass value, of 8,046kg:

8,046kg/day x 125mg/kg of NH_4 from cod tissue = 1,005,688mg NH_{4}-N per day.

This converts to a corresponding un-ionised ammonia discharge of 28,534mg NH_{3}-N per day.

28,534mg NH_{3}-N x 1,000µg/mg = 28,533,644µg NH_{3}-N

28,533,644µg NH_{3}-N / (21µg/l – 1.6µg/l) = 1,470,806 litres

1,470,806l / 1,000l/m³ = 1,470.81m³

1,470.81m³ / 4m = 367.7m²

Table 55 presents the full range of results from each of the scenarios assessed, including with a temperature uplift to allow for the power station thermal discharge.

Calculation of biochemical oxygen demand (BOD)

To assess the BOD, the influence on the dissolved oxygen is calculated in terms of the amount of water required to meet the corresponding oxygen demand from that biological demand.

Stigebrandt (2001) concluded that there are 3.5kg of oxygen per kg of carbon. The dry/wet weight conversion is assumed to be 0.36 (Wang and others, 2013). Therefore, the estimate of BOD input (each day) was calculated by:

kg of biota/day x 3.5kg/kg C x 0.36 = kg BOD per day

OSPAR (1997) reports that a BOD of 1.5mg/l effectively produces 0.5mg/l O_2 reduction. Using this information, oxygen reduction in the receiving water can be calculated:

(kg BOD / 1.5mg/l) x 0.5mg/l = O_2 reduction kg/day

As defined in NNB GenCo (2020g; TR520), the background dissolved oxygen concentration level is 6.96mg/l O_2, therefore the amount of water containing this equivalent amount of O_2 can be calculated. Assuming this is equally mixed through the full depth of the water column (4m), this can be converted to the corresponding area.

This can then be compared to the daily tidal exchange for the Suffolk Coast waterbody to calculate the percentage of the total daily tidal exchange required to meet that oxygen demand. As defined by Dyer (1979), a daily volume exchange of 10% would be equivalent to 36,400,000m³.

In addition to daily exchange, daily reaeration at the sea surface contributes 3.2g/m^2/d (Hull and others, 2016). Therefore, the area required to replenish that oxygen demand can also be calculated.

For example, using the reasonable worst case with invertebrates quarter 1 95th daily biomass value of 8,046 kg:

8,046kg/day x 3.5 kg/kg C x 0.36 = 10,137.3kg BOD

(10,137.3kg BOD/1.5mg/l) x 0.5mg/l = 3,379.1kg/day O_2 reduction

3,379.1kg/day O_2 reduction x 1,000g/kg x 1,000mg/g = 3,379,113,322mg/day O_2 reduction

3,379,113,322mg/day O_2 reduction/6.96 mg/l background O_2 = 485,504,787.6 l

485,504,787.6 l /1,000 l/m³ = 485,504.8³

485,504.8m³/4m = 121,376.2m²

Corresponding to:

485,504.8m³/36,400,000m³ = 1.33% of daily exchange

Or

3,379.1kg/day O_2 reduction/0.0032kg/m²/day = 1,055,973m²

Table 55 presents the full range of results from each of the scenarios assessed.

Calculation of organic enrichment

Organic enrichment refers to carbon released by the decomposition of dead species. As proxy for an EQS, 100g organic carbon/m^2/year is an acceptable benchmark to assess the negative impacts of organic enrichment (Tyler-Waters and others, 2018). From Alves and others (2019) it is assumed that the carbon content of fish process waste is 64.7% of the dry weight and the carbon dry/wet weight conversion factor applied within this study is 0.48.

The daily carbon load is divided by the daily benchmark of carbon and converted to a daily value. If the daily carbon input were evenly spread, so that the release of carbon/m^2 occurred at the proxy EQS rate, the corresponding area can be considered the 'mixing zone' where a potential effect from this organic enrichment might be experienced.

Given that the Suffolk Coastal waterbody has an area of 146.53km^2, this 'mixing zone' can be compared with the area of the waterbody to consider the percentage of the waterbody that could see the effects of organic enrichment.

For example, using the reasonable worst-case with invertebrates quarter 1 95th daily biomass value, of 8,046kg:

8,045.5kg wet weight x 0.48 dry weight/wet weight) x 0.65 carbon kg/kg = 2,510.2kg carbon/day

2,510.2kg carbon/day/(100g organic carbon/m^2/year x (1kg /1,000g)/(365 days/1 year)) = 9,162,224.4m^2 affected

9,162,224.4m^2/146,530,000 x 100 = 6.25% of waterbody affected

Table 55 presents the full range of results from each of the scenarios assessed.

Results

Table 55 presents a summary of the predicted water quality effects of SZC's FRR system discharge. This table compares the results provided in NNB GenCo (2020g; TR520) to those we produced. The process in which these figures were calculated is identical to the analysis in NNB GenCo (2020g; TR520). However, the loadings of dead biota discharged from the FRR system have been revised and several scenarios have been considered, including:

- baseline scenario - daily loading, not including invertebrates, upper 95th percentile, annual mean and quarter 1 mean
- baseline scenario - daily loading, including invertebrates, upper 95th percentile, annual mean and quarter 1 mean
- worst-case scenario - daily loading, not including invertebrates, annual mean and quarter 1 mean
- worst-case scenario - daily loading, including invertebrates, annual mean and quarter 1 mean

- worst case scenario - daily loading, not including invertebrates, upper 95th percentile, annual mean and quarter 1 mean

- worst-case scenario - daily loading, including invertebrates, upper 95th percentile, annual mean and quarter 1 mean

There are a number of uncertainties in all of these calculations. The factors used to calculate the breakdown products are specific to one or a limited number of species or studies; they do not strictly apply to all fish/invertebrate species. In the absence of more or better data, it was considered acceptable to apply the factors universally.

This approach can be considered precautionary, as it assumes 100% of the biomass discharged will sink immediately and not be re-suspended or advected over a larger area. This is contrary to the particle tracking study in NNB GenCo (2021d; TR511), which predicted 12% of dead sprat would be transported away from the discharge point by tidal currents.

The approach also does not take account of accumulation, or consumption by detritivores. Our figures are thought to provide a worst-case acute impact. Given the location of SZC, dispersal could be significant.

As our calculations for organic enrichment using the reasonable worst-case with invertebrates scenario resulted in the largest potential area affected by the FRR system discharge, the organic enrichment is brought forward into the other chapters of this HRAR to assess the potential water quality impacts of the FRR system. This area is also called the ‘maximum potential area of organic exceedance’ to reflect the precautionary assumptions used in this analysis.

Table 55: Summary of the predicted water quality effects of SZC's FRR system discharge

		TR520	TR520	EA calculations					
		Cefas		EA Baseline		EA Worst Case			
		w/o LVSE u95	with LVSE u95	Baseline no Invert u95	Baseline with Invert u95	Worst case no Invert	Worst case with Invert	Worst case no Invert u 95% c.l.	Worst case with Invert u 95% c.l.
Daily loading of impinged fish - Annual mean		1498	535	1,661	1,773	2,257	2,505	3,835	4,083
Daily loading of impinged fish - Q1 mean		3326	1187	3,700	3,812	5,917	6,063	7,900	8,046
Nutrient input	Max Daily P content (kg)	7.5	2.7	8.3	8.9	11.3	12.5	19.2	20.4
	Max Daily N content (kg)	52.4	18.7	58.1	62.1	79.0	87.7	134.2	142.9
Un-ionised ammonia	Total NH_4 (mg)	415,780	148,434	462,478	476,515	739,685	757,842	987,531	1,005,688
	Unionised ammonia from calculator (mg)	11,797	4,211	13,122	13,520	20,998	21,502	28,018	28,534
	Volume required to dilute to the EQS (l)	608,073	217,082	676,368	696,898	1,082,379	1,108,335	1,444,251	1,470,806
	Area required (m^2 area)	**152.02**	**54.27**	**169.09**	**174.22**	**270.59**	**277.08**	**361.06**	**367.70**
	Unionised ammonia from calculator with temperature uplift (mg)	13,741	4,906	15,284	15,748	24,459	25,046	32,637	33,237
	Volume litres required to dilute to the EQS with temperature uplift (l)	708,303	252,864	787,855	811,768	1,260,790	1,291,023	1,682,309	1,713,242
	Area required with temperature uplift (m^2 area)	**177.1**	**63.2**	**197.0**	**202.9**	**315.2**	**322.8**	**420.6**	**428.3**
Influence on dissolved oxygen	kg of BOD	4,191	1,496	4,662	4,803	7,456	7,639	9,954	10,137
	kg/day O_2 reduction	1,397	499	1,554	1,601	2,485	2,546	3,318	3,379
	Area needed to meet oxygen demand through reaeration (m^2 area)	436,569	155,855	485,602	500,341	776,669	795,735	1,036,907	1,055,973
	Area needed to meet oxygen demand through reaeration (km^2 area)	**0.437**	**0.156**	**0.486**	**0.500**	**0.777**	**0.796**	**1.037**	**1.056**
Organic enrichment	kg of carbon/day	3,326	1,187	3,700	3,812	5,917	6,063	7,900	8,046
	Area affected (m^2 area)	3,787,922	1,352,291	4,213,358	4,341,246	6,738,825	6,904,248	8,996,802	9,162,224
	Area affected (km^2 area)	**3.79**	**1.35**	**4.21**	**4.34**	**6.74**	**6.90**	**9.00**	**9.16**
	Area affected (% WB)	**3%**	**1%**	**3%**	**3%**	**5%**	**5%**	**6%**	**6%**
	Ellipse length (m)	**5,334**	**3,187**	**5,626**	**5,710**	**7,115**	**7,201**	**8,220**	**8,296**
	Ellipse width (m)	**904**	**540**	**953**	**968**	**1,206**	**1,221**	**1,393**	**1,406**

Appendix C

Applicant’s H1 assessment conclusions

The applicant provided the following H1 assessment information within NNB GenCo (2021a; TR193).

Calculations for the maximum (24 hour) loadings

These are based on a discharge volume of 66m³/sec under maintenance conditions (with a single operational EPR). The outcomes are provided within Table 32 within the assessment, which is replicated below (Table 56).

Table 56: Table 32 and its footnotes from NNB GenCo (2021a; TR193) Screening MAC for large cooling water discharges for the maximum 24-hour loadings predicted for operational phase chemical discharges – bold underlined values indicate failure of the relevant test

Substance	EQS or surrogate value (µg/l)	Derivation of surrogate	Discharge + background (µg/l)	Max discharge /EQS <1
Boron[1]	7,000	Pre WFD EQS	4,656	0.67
Lithium hydroxide	65[2]	Mean background	90.2[2]	**<u>1.39</u>**[3]
Hydrazine	0.004	Acute PNEC	0.534[4,5]	**<u>131.5</u>**
Morpholine	28	Acute PNEC	16.18	0.58
Ethanolamine	160	Acute PNEC	4.34[5]	0.03
Nitrogen as N	980[6]	WFD 99th percentile	484.3[7]	0.49
Un-ionised ammonia (NH_3-N)	21	WFD AA-EQS	7.34[8]	0.35
Phosphates (PO_4-P)	33.5	Mean background	127	**<u>3.79</u>**
Suspended solids	74,000[3]	Mean background	154[5]	0.002

Substance	EQS or surrogate value (µg/l)	Derivation of surrogate	Discharge + background (µg/l)	Max discharge /EQS <1
BOD	2,000	Mean background	0.67[5,9]	0.0003
COD	239,000	Mean background	57.87[5]	0.00024
Aluminium	12	Mean background	20.19	**1.68**
Copper	3.76	WFD AA-EQS	4.76	**1.27**
Cadmium	1.5	WFD MAC-EQS	0.13	0.09
Chromium	32	WFD MAC-EQS	2.48	0.08
Iron	1,000	WFD AA-EQS	302	0.3
Manganese	2	Mean background	-	-
Mercury	0.07	WFD MAC-EQS	0.02[10]	0.29
Nickel	34	WFD MAC-EQS	1.17	0.03
Lead	14	WFD MAC-EQS	3.94	0.28
Zinc	6.8	WFD AA-EQS	46	**6.77**
Chloride	14,128,000	Mean background	78.9[5]	0.00
Sulphates	2,778,000	Mean background	350.7[5]	0.00
Sodium	10,400,000	Mean background	150[5]	0.00
ATMP	74	NOEC (96h fw11 algae)	7.89[5]	0.11

Substance	EQS or surrogate value (µg/l)	Derivation of surrogate	Discharge + background (µg/l)	Max discharge /EQS <1
HEDP	13	EC50 (96 h fw algae)	0.79[5]	0.06
Acetic Acid	301	LC50 48h fw crust	0.02[5]	0.00006
Phosphoric acid	200	LC50 72h fw algae	0.02[5]	0.0001
Sodium polyacrylate	180	LC50 96h fw algae;	7.01[5]	0.04
Acrylic acid	1.7	EC50 (96 h fw algae)	0.18[5]	0.1
Chlorine (TRO) bromoform	(10) 5	MAC-EQS	(150), 190	**(15)38**

Table explanation:

[1] Variable dissociation products of boric acid and other boron compounds in seawater so assessment focuses on equivalent boron concentration.

[2] Expressed as lithium.

[3] Figures in bold exceed the EQS or reference value.

[4] This loading does not include hydrazine from stream B+C because this would not be discharged except during start-up and shutdown when hydrazine from stream D would not be discharged.

[5] Discharge only does not include background or no background either measured or detected.

[6] It should be noted that a more specific methodology for deriving 99th percentile values based on a relationship between SPM and DIN is recommended in draft Environment Agency guidance and for an annual average SPM of 55.2mg/l would give a slightly lower value of 952µg/l as a 99th percentile but the screening here would only slightly change.

[7] This figure includes a calculated 4.4kg day from sanitary effluent derived by calculation from permitted 23mg/l N from STW discharge – stream G.

[8] These figures are back calculated from the un-ionised ammonia concentration derived from the un-ionised ammonia calculator using the NH4 concentration that results from the combined sanitary and conditioning inputs [69].

[9] The BOD value is derived from stream G based on a BOD5-atu concentration of 20mg/l and the derived concentration due to the discharge (0.67µg/l) is negligible relative to the site background (2.0mg/l) and not significant in terms of impact on dissolved oxygen when oxygen flux for vertically well mixed water column at site is considered.

[10] The mean is used in place of the 95th percentile as values below detection result in lower.

[11] fw represents freshwater species toxicity test data which determines PNEC.

Results of screening for discharges for the maximum 24-hour loadings

The applicant's Table 32 (Table 56) shows that for the 24-hour SZC operational discharge assessment, hydrazine, chlorine produced residual oxidants (TRO) and bromoform concentrations in the operational discharge will exceed the acute EQS/PNEC values and will therefore be taken forward for assessment via more detailed modelling in the appropriate assessment.

Other substances also appeared to fail the H1 screening, however they will not be considered further for the following reasons:

The operational 24-hour discharge concentrations for **copper and zinc** also exceed EQS assessment criteria. However, in each case, the actual discharge concentrations are at least 30 times below the relevant annual average EQS (and are also below their respective detection limits for analysis). It is therefore the high, derived 95th percentile background loadings that are responsible for these exceedances. Therefore, no measurable exceedance resulting from the discharge itself would be detectable (and so it was decided not to conduct additional assessment via modelling).

Lithium hydroxide, phosphate and aluminium do not have EQS or PNEC values, but instead reference site mean backgrounds, and so the 95th percentile load calculations which use site background 95th percentile values will invariably result in an exceedance of the relevant assessment values.

In the case of aluminium, the actual discharge contributes a sixtieth of the background, and for lithium hydroxide the equivalent lithium input from the proposed operational discharge is almost 300 times below the background. In neither case are these inputs considered of significance (and so were not carried through for additional assessment via modelling).

The phosphate input is several times above background, and as phosphate can contribute to nutrient status it will be given further consideration in the appropriate assessment via detailed modelling.

While not part of the H1 risk assessment, concentrations of other substances for which the 24-hour loading discharge concentration are present in the operational discharge at >40% of their EQS (or equivalent reference value via PNEC or background) are also considered here. These are **boron (boric acid), morpholine, DIN, and un-ionised ammonia.**

The boron background concentration in Sizewell seawater as a 95th percentile (as used in the 24-hour discharge calculation) is around 4,564µg/l. As the estimated discharge concentration of boron represents around one twentieth of this value, it is the background concentration that has the most influence on the scale of the cooling water discharge concentration relative to the EQS.

As the elevation of boron above the seawater background is relatively small, any influence will be localised to the area around the immediate discharge. As an essential element for many marine algal species, the low elevation of boron concentration expected in short-term discharges is likely to have negligible effects.

Morpholine was 58% of its derived PNEC for 24-hour discharges, but is a readily degradable chemical and has a low likelihood of bioconcentration (NNB GenCo, 2021a; TR193). This, together with its low toxicity, indicates that it would have negligible effects on marine species under this discharge scenario.

Un-ionised ammonia was 35% of its EQS. As temperature may influence the relative amount of un-ionised ammonia, the operational discharge has been further assessed considering temperature elevation. This will be considered further in the appropriate assessment via detailed modelling

The 24-hour discharge concentration of dissolved inorganic nitrogen was 49% of the site 99^{th} percentile winter standard for water bodies of intermediate turbidity. As the loading of dissolved inorganic nitrogen (DIN) may influence algal growth, this is will be considered further in the appropriate assessment via detailed modelling.

Average annual loadings

It is assumed within the presented H1 calculations that for average annual concentrations the cooling water discharge flow, into which all discharges are mixed, is 116m^3/s as a worst case under normal operational flow.

The outcomes are provided within Table 32 which is replicated here (Table 57).

Table 57: Table 33 and its footnotes from (NNB GenCo, 2021a; TR193), screening test for large cooling water discharges for average annual loadings predicted for operational phase discharges for 2 EPR units at SZC – bold underlined values indicate failure of test

Substance	EQS/surrogate value (µg/l)	Derivation of surrogate	Discharge concentration including background (µg/l)	Annual Discharge/EQS <1
Boron[1]	7,000	Pre WFD EQS	4,145.67	0.59
Lithium hydroxide	65[2]	Mean background	65[2]	**<u>1.00</u>**
Hydrazine	0.0004	Chronic PNEC	0.01[4]	**<u>16.6</u>**
Morpholine	17	Chronic PNEC	0.46[5]	0.03
Ethanolamine	160	Acute PNEC	0.25[5]	0.001
Nitrogen as N	980[6]	WFD 99th percentile	360.127	0.37
Un-ionised ammonia **(NH_3-N)**	21	WFD AA-EQS	0.96[8]	0.05
Phosphates	33	Mean background	33.57	**<u>1.00</u>**
Detergents	-	-	0.17[5,9]	0.2
Suspended solids	74,000[3]	Mean background	25.4[5]	0.0003
BOD	2000	Mean background	0.38[5,10]	0.0002
COD	239000	Mean background	1.38[5]	0.00001

Substance	EQS/surrogate value (µg/l)	Derivation of surrogate	Discharge concentration including background (µg/l)	Annual Discharge/EQS <1
Aluminium	12	Mean background	12	**1.00**
Cadmium	0.2	WFD AA-EQS	0.05	0.25
Copper	3.76	WFD AA-EQS	2.15	0.57
Chromium	0.6	WFD AA-EQS	0.57	0.95
Iron	1000	WFD AA-EQS	132.58	0.13
Manganese	2	Mean background	-	0.00
Mercury	0.07	WFD MAC-EQS	0.02	0.29
Nickel	8.6	WFD AA-EQS	0.79	0.09
Lead	1.3	WFD AA-EQS	1.0	**0.76**
Zinc	6.8	WFD AA-EQS	14.7	**2.16**
Chloride	14,128,000	Mean background	23.81[5,6]	-
Sulphates	2,778,000	Mean background	26.90[5]	-
Sodium	10,400,000	Mean background	14.32[5]	-
ATMP	74	NOEC 96h fw11 algae	2.49[5]	0.03

Substance	EQS/surrogate value (µg/l)	Derivation of surrogate	Discharge concentration including background (µg/l)	Annual Discharge/EQS <1
HEDP	13	NOEC 96h algae	0.24[5]	0.02
Acetic acid	62.8	NOEC 21d fw crust	0.004[5]	0.0001
Phosphoric acid	20	LC50 72h algae	0.003[5]	0.0002
Sodium polyacrylate	11.2	NOEC 72h fw crust	2.20[5]	0.20
Acrylic acid	0.34	NOEC 72 h fw algae	0.05[5]	0.13

Table explanation:

[1] Variable dissociation products of boric acid and other boron compounds in seawater so assessment focuses on equivalent boron concentration.

[2] Expressed as lithium.

[3] Figures in bold exceed the EQS or reference value.

[4] This loading does not include hydrazine from stream B+C because this would not be discharged except during start-up and shutdown when hydrazine from stream D would not be discharged.

[5] Discharge only does not include background or no background either measured or detected.

[6] It should be noted that a more specific methodology for deriving 99th percentile values based on a relationship between SPM and DIN is recommended in draft Environment Agency guidance and for an annual average SPM of 55.2mg/l would give a slightly lower value of 952µg/l as a 99th percentile, but the screening here would only slightly change.

[7] This figure includes a calculated 1,595kg/y from sanitary effluent derived by calculation from permitted 23mg/l N from STW discharge – stream G.

[8] These figures are back calculated from the un-ionised ammonia concentration derived from the un-ionised ammonia calculator using the NH4 concentration that results from the combined sanitary and conditioning inputs.

[9] Detergents are assumed to be non-ionic for cleaning reverse osmosis membranes (Beyer and others, 2017) and the PNEC is derived from Belanger and others, 2006 cited in Table 4.37 HERA, 2009 for most toxic alcohol ethoxylates with chain length C18 an added application factor of 10 is applied to this value as it is based on freshwater data.

[10] The BOD value is derived from stream G based on a BOD5-atu concentration of 20mg/l and the derived concentration due to the discharge (0.38µg/l) is negligible relative to the site background (2.0mg/l) and not significant in terms of impact on dissolved oxygen when oxygen flux for vertically well mixed water column at site is considered.

[11] fw represents freshwater species toxicity test data which determines PNEC.

Results of screening for discharges for the average annual loadings

As shown in Table 57 for annual loadings in the SZC operational cooling water discharge hydrazine, chlorine and bromoform again exceed relevant PNEC or EQS values in the screening assessment, and so will be considered further by detailed modelling in the appropriate assessment.

Discharges during the operational phase would also just exceed or equal the relevant annual average EQS/PNEC or background concentration **for lithium hydroxide, phosphates, aluminium, and zinc** (Table 57).

Lithium hydroxide, phosphate and aluminium do not have EQS or PNEC values, so instead reference site mean backgrounds. Therefore, the mean load calculations which use site background water quality mean values will invariably result in an exceedance.

In the case of aluminium and lithium hydroxide, the actual operational discharge concentrations are below the method detection limit (LOD) and are several orders of magnitude below the site background (so the discharge contributions would have negligible effects and do not warrant further assessment).

The phosphate discharge concentration is also below the method detection limit and although the discharge concentration is very low the input can contribute to nutrient status and increased primary production, so will be taken through to appropriate assessment.

Zinc fails the annual loading discharge assessment. However, it is the high background loading that is responsible for this exceedance and the actual discharge concentration would be below detection. Therefore, this input is considered to have negligible effects and was not considered via modelling.

In screening, copper and chromium were 57% and 95% of their respective annual average EQS values. However, for both, the predicted operational discharge concentrations are below method detection limits and are several orders of magnitude below their respective EQS (that is, site backgrounds are not included), therefore negligible likely effects are predicted.

As was the case for the 24-hour screening assessment, elevation of boron above the seawater background is relatively small and so any influence will be localised to the area around the immediate discharge. As an essential element for many marine algal species, the low elevation of boron concentration is likely to have negligible effects and therefore this is screened out of further assessment.

For the annual discharge screening assessment as DIN is at 37% of its background reference, it can contribute to nutrient status and increased primary production and will therefore be considered within the appropriate assessment.

Un-ionised ammonia concentration was low at 0.05% of its EQS, but was considered further in relation to the influence of temperature elevation on the percentage of un-ionised ammonia, and will be considered within the appropriate assessment.

Abbreviations

Term	Meaning
%ile	Percentile
AF	Assessment factors
BOD	Biochemical oxygen demand
CA	Combustion activity
Cefas	Centre for Environment, Fisheries and Aquaculture Science
CHP	Chlorinated by-products
COD	Chemical oxygen demand
Defra	Department for Environment, Food and Rural Affairs
DIN	Dissolved inorganic nitrogen
EDF	Électricité de France
EPR	Environmental Permitting Regulations
EQS	Environmental quality standard
EQSD	Environmental Quality Standards Directive
ETAS	Ecotoxicology advisory service
FRR system	Fish recovery and return system
HRA	Habitats regulations assessment
HRAR	Habitats regulations assessment report
IUCN	International Union for Conservation of Nature

Term	Meaning
LC50s	Lethal concentration 50
LSE	Likely significant effect
LWT	Lincolnshire Wildlife Trust
MAC	Maximum allowable concentration
PDV	Phocine distemper virus
PNEC	Predicted no effect concentration
PPP	Permissions, plans or projects
Ramsar	Wetland of international importance
RSA	Radioactive substances activity
RSR	Radioactive Substances Regulations
SAC	Special Area for Conservation
SCI	Sites of Community Importance
sHRA	Shadow habitats regulations assessment
SPA	Special Protection Area for birds
SSSI	Site of Special Scientific Interest
SZB	Sizewell B
SZC	Sizewell C
TraC	Transitional and coastal waters
WDA	Water discharge activity

Term	Meaning
WFD	Water Framework Directive
ZOI	Zones of influence

Glossary

Term	Meaning
100th percentile	Within a 100th percentile plume, a water quality threshold value will be met or exceeded for >0% of the relevant time period (for example, one year). Outside of the 100th percentile plume, the threshold value is never met or exceeded during that time period.
95th percentile:	Within a 95th percentile plume, a water quality threshold value will be met or exceeded for ≥5% of the relevant time period (for example, one year). Outside of the 95th percentile plume, conditions are below the threshold value for at least 95% of the time period.
99th percentile	Within a 99th percentile plume, a water quality threshold value will be met or exceeded for ≥1% of the relevant time period (for example, one year). Outside of the 99th percentile plume, conditions are below the threshold value for at least 99% of the time period.
Activity	A generic title for the practices or operations which require to be permitted (unless exempted from the need for a permit).
Admixture	The act of mixing or mingling.
Applicant	NNB Generation Company (SZC) Limited, the body applying for the WDA permit. Responsible for carrying out the necessary preparatory work in support of the application to enable the Environment Agency, as competent authority, to carry out its duties.
BAT	Best available techniques/technology, usually referring to the technique or process that will yield the greatest environmental benefit or cause the least environmental damage.
Biofouling	The accumulation of microorganisms, plants, algae or small animals where it is not wanted such as on marine

Term	Meaning
	infrastructure, where it can impede the structure's function.
Biota	In the context of our assessment, biota refers to animals (intact or otherwise) that have passed through the fish recovery and return System (ctenophores and jellyfish are excluded from our impingement mortality calculations).
Black wastewater	Wastewater contaminated with human faecal material.
Chemical exceedance	An area of water within which concentrations of chemicals are above background levels, as a result of a discharge activity.
Chemical plume	An area of water within which concentrations of chemicals are above background levels, as a result of a discharge activity.
Commissioning	The process by which a nuclear power station/reactor is inspected, checked and tested in order to allow it to begin operation.
Competent authority	Decision maker under the Habitats Regulations. For the WDA permit, it is the Environment Agency.
Decommissioning	The process by which a nuclear power station/reactor has its fuel removed, the plant and facilities taken down and the site restored to an agreed end-state.
EC50	Also known as the median effective concentration, the EC50 is the concentration of test substance which results in a 50% reduction in a measurable quality, such as algae growth, or algae growth rate.
Ecotoxicology	The nature, effects and interactions of substances that are harmful to the environment.
Empirical demand/decay formulation	Experiments to determine the initial demand and subsequent decay of TRO through the cooling water

Term	Meaning
	process and thereby the expected concentration of TRO in the effluent.
Enterococci	Bacteria; indicators of the presence of faecal material in water.
Entrainment	Small organisms passing through the various screens which filter seawater to prevent damage occurring within the cooling water system. Entrained organisms journey through the power plant with the cooling water before being discharged through the cooling water system outlet.
Entrapment	All organisms drawn into the cooling water system intakes, whether subsequently impinged on, or entrained through, screens.
Environmental quality standard (EQS)	The concentration and a corresponding statistic (for example, mean or 95^{th} percentile) below which a substance is not believed to be detrimental to aquatic life, based on the results of toxicity tests on organisms covering a range of levels within food chains. Each substance has its own EQS, which can differ depending on whether the receiving environment is fresh, transitional or coastal water.
Epifauna	Animals and aquatic plants living on the bed of the river/estuary/sea or attached to submerged rock/objects.
European site	Sites such as SPAs and SACs which are protected under European and UK law. Ramsar sites are also included in line with government policy.
Eutrophication	The increase in primary productivity and subsequent impacts on an ecosystem that arise as a result of inputs of nutrients (which can be human) raising ambient nutrient concentrations.

Term	Meaning
Fish recovery and return system	A system by which impinged fish and invertebrates will be washed off the rotating screens that protect the cooling water system and returned to sea through dedicated outlets.
Functional linkage	Refers to the role or 'function' that land or seas beyond the boundary of a European site might fulfil in terms of ecologically supporting the site's features.
Glass eel	A European eel (Anguilla anguilla) in its transparent, post-larval stage – prior to entering estuaries and becoming a pigmented elver.
Grey wastewater	Wastewater without human faecal contamination.
Habitats Regulations	The Conservation of Habitats and Species Regulations 2017 (as amended).
Haul-out site	A location on land that is used by seals for rest, to moult and to breed. The nature of these sites varies widely and can include rocky islets or shorelines, sandy beaches or sandbanks.
Hot functional testing	Part of the commissioning process which involves increasing the temperature of the reactor coolant system and carrying out comprehensive tests to ensure that coolant circuits and safety systems are operating as they should.
HRAS	The habitats regulations assessment system is a database used by the Environment Agency to generate HRA forms.
IFCA	Inshore Fisheries and Conservation Authorities.
Impingement	This describes organisms (fish and invertebrates) which are trapped on the various screens which filter seawater to prevent damage occurring within the cooling water system. Impinged organisms are returned to sea via the fish recovery and return system.

Term	Meaning
Infauna	Animals living within the river/estuary/seabed sediments.
Inter-quartile range	Within a range of values, 25% lie below the first quartile (Q1) and 75% lie below the third quartile (Q3). The inter-quartile range is the difference between the Q3 and Q1 values.
LC50	The lethal concentration 50 is the concentration of a chemical that will kill 50% of the sample population under scrutiny.
Loafing	A term used to describe a seabird that is resting on land or at sea, not foraging or flying.
Macroalgae	Seaweed.
Maximum potential area of organic exceedance	The area over which the annual FRR system discharge could theoretically be spread to achieve an even thickness that would uniformly release carbon at the proxy EQS rate of 100g organic carbon/m²/year.
Mean maximum	A mean maximum foraging range is the average (mean) of a number of maximum recorded foraging ranges.
Median	A unit of mass equal to one thousandth of a gram (1mg = 0.001g).
Microgram µg	A unit of mass equal to one thousandth of a milligram, and one millionth of a gram (1µg = 0.001mg).
Migratory routes	Pathways used by animals such as fish as they move from one area to another.
Milligram mg	A unit of mass equal to one thousandth of a milligram, and one millionth of a gram (1µg = 0.001mg).
Mixing zone	The mixing zone is the area around a discharge within which a quality standard is exceeded. The role of the regulator is to ensure that the size of the mixing zone is small enough so as to not impact on the function of the wider waterbody or habitat.

Term	Meaning
Moribund	Where an organism is at the point of death. In our mortality calculation, we have used the term moribund biota to mean biota passing through the FRR system that is dead and acts as a polluting matter.
Nanogram ng	A unit of mass equal to one thousandth of a microgram, and one billionth of a gram (1ng = 0.001µg).
Nutrient enrichment	The introduction of additional and/or new nutrients into a waterbody or other environment. This can cause disruption to the existing water quality regime and therefore impact on species and habitats.
Pheromones	Chemical substances produced by animals which serve as a stimulus to other individuals of the same species.
Phytoplankton	Freely floating organisms which are able to photosynthesise; often minute organisms that move with water currents, for example, single-celled algae.
Plankton blooms	High abundances of particular plankton types as a result of physical conditions and elevated nutrient levels.
Predicted no effect concentration (PNEC)	The concentration of a chemical which marks the limit below which no adverse effects of exposure in an ecosystem are measured. The PNEC is used for substances for which an EQS has not been set.
Qualifying features	The features for which the European site is designated and to be protected and managed for conservation.
Schedule 5 request	A formal instruction to the applicant to provide further information to provide clarification on points made in the permit application or to address gaps in that application.
Sedimentation	The process by which suspended particles may settle out over time onto the bed of the waterbody.
Shadow HRA	The applicant is required to provide the competent authority with the information it needs in order to carry out

Term	Meaning
	a habitats regulations assessment. This information may be provided in the format of an HRAR which would be referred to as the applicant's shadow HRA.
Siltation	Physical damage caused by the deposit of suspended solids.
Silver eel	A European eel (Anguilla anguilla) characterised by its silver colouration and developing into sexual maturity while undergoing physiological adaption for its marine spawning migration.
Source-receptor pathway	A framework for assessing the risk of a proposal on the environment. The source refers to the hazard – something that has the potential to cause harm. The receptor is something that could suffer harm from a hazard. The pathway is the way in which a hazard can come into contact with a receptor.
Special Area of Conservation	A protected area designated under the Conservation of Habitats and Species Regulations 2017 (as amended) in England and Wales, or the Conservation of Offshore Marine Habitats and Species Regulations 2017 (as amended) for UK offshore areas.
Special Protection Area	Special Protection Areas are protected areas for birds classified under the Wildlife & Countryside Act 1981 (as amended), the Conservation (Natural Habitats, & c.) Regulations 2010 (as amended) and the Conservation of Offshore Marine Habitats and Species Regulations 2017 (as amended).
Standard deviation	A statistical measure used to quantify the amount of variation or dispersion of a set of data values. The standard deviation describes, on average, how far each datum lies from the mean.
Synergistic effect	The impact of the interaction of a number of effects is greater than the sum of the individual effects.

Term	Meaning
Telemetry tagging study	Animals are equipped with electronic tags and information from the tag recorded remotely, for example, by radio receiver. This method can be used to determine the study animal’s location and its movements.
Thermal plume	The area of heated water caused by the discharges from a cooling water system.
Thermal regime	Refers to the existing temperature system of an area/waterbody.
Thermal uplift or thermal excess	The increase in temperature of a body of water as the result of a thermal input.
Tidal excursion	The horizontal distance that a particle moves during one tidal cycle of ebb and flood.
Turbidity	The amount of cloudiness in the water. High turbidity would result in low visibility due to the presence of suspended material such as mud, silt and sand, bacteria and chemical precipitates. Visibility would be greater in low turbidity conditions.
Volatilisation	The process of converting a chemical substance from a liquid or solid to a gas or vapour.

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Note for Referencing:

In support of its new nuclear build programme, British Energy/EDF Energy has used a management framework - BEEMS (British Energy Estuarine and Marine Studies) - to co-ordinate its research activities in estuarine and coastal waters. Resulting reports are often referred to as BEEMS technical reports or as being part of the BEEMS programme.

A BEEMS Expert Panel produced some of the reports. The reports are based on its members' own expertise, the scientific literature, the BEEMS Data Centre and inputs from named invited scientists with relevant specialist knowledge. An example of such a report is 'Thermal standards for cooling water from new build nuclear power stations', SAR008. In the case of SAR008, the panel included experts from academia, regulatory authorities and commercial consultants.

Other reports have been produced for EDF by commercial consultants without, to the best of our knowledge, reference to the Expert Panel.

Our reference list distinguishes between both types of reports. We reference only those reports known to have originated from the Expert Panel as having been authored by BEEMS, for example, SAR008 is cited as BEEMS (2019). All other technical reports submitted by the applicant as part of its application will be referenced with NNB GenCo as the corporate author.

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