HPC COMPANY DOCUMENT

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ENVIRONMENTAL PERMIT VARIATION APPLICATION: HINKLEY POINT C CONSTRUCTION WATER DISCHARGE ACTIVITY PERMIT – COLD COMMISSIONING EFFLUENT (ACTIVITY I)

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Revision 01

Company Document

CWDA – VARIATION 12 APPLICATION
NOT PROTECTIVELY MARKED

Approval: Environmental Permit Variation Application: Hinkley Point C Construction Water Discharge Activity

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NON-TECHNICAL SUMMARY

NNB Generation Company (HPC) Limited (NNB HPC) is building a new nuclear power station on the northern coast of Somerset.

As part of the project, the Construction Water Discharge Activity (CWDA) permit was obtained in February 2012 (EPR/JP3122GM) to support discharge activities, since then there have been 10 variations that have been obtained with variation 11 in determination with the Environment Agency at the time of writing. As part of the CWDA, 'Activity I' has been included to account for the discharge of trade effluent consisting of effluent from cold commissioning activities. This includes flushing, hydro-testing and demineralised water production.

During the cold commissioning stage of the project, demineralised water will be used to test systems. A demineralised water plant is to be constructed to generate the quantities of demineralised water required for the site using potable water.

During the detailed design of the demineralised water plant and the commissioning effluent treatment plant (CETP) that will treat effluent from cold commissioning it has become apparent that a further variation to the CWDA Permit is required. The requested changes are detailed below.

Copper:

Copper is present in the potable water supply to the demineralised water plant and will be concentrated during the process. It is also present as a catalyst for hydrazine destruction in the CETP, with the maximum concentration in the plant set at 10mg/l (10,000µg/l). The CETP has an ion exchange system to recover this catalyst and recycle it, reducing the copper concentration to below the Environmental Quality Standard (EQS). However, the ion exchange system may not always be running at full efficiency due to operational requirements. To address this, a limit of 102µg/l is proposed to be added to Activity I. It is noted that copper discharges are permitted under activities E2, F and H of the permit.

Zinc:

Zinc is present in the potable water supply to the demineralised water plant and will be concentrated during the demineralisation process to levels above the EQS. It would not be practical or environmentally beneficial to remove these low levels of zinc from the effluent from the demineralised water plant, therefore it is proposed to add zinc to Activity I. Based on analysis of the potable water and the results of the surface water pollution risk assessment a limit of 140µg/l is proposed (See Appendix B.). It is noted that zinc discharges are permitted under activities E2, F and H at significantly higher concentrations.

Free chlorine:

Chlorine is present in the potable water supply to the demineralised water plant and is also utilised in the treatment process at the CETP to oxidise ammonia. Chlorine is present in the potable water supply and could lead to a greater concentration at the outfall. Free chlorine rapidly reduces to chloride upon mixing with any oxidisable matter, which occurs upon discharge. Based on this analysis and the results of the surface water pollution risk assessment a limit of 1,200µg/l is proposed (See Appendix B.).

Treatment Chemicals:

A number of products are required to maintain the efficiency of the demineralised water plant including by "cleaning in place" and the prevention of biofouling. These substances contain constituent chemicals which will therefore be present in the effluent. These constituent chemicals were analysed in accordance with surface water pollution risk assessment guidance (See Appendix C). It is not proposed that numerical limits are implemented for these substances, with management controls being utilised to ensure that the assumptions underlying the assessment presented within this report are met. Therefore, there is anticipated to be no significant adverse effect on the receiving water.

NNB HPC is therefore seeking to vary the permit for Activity I to include additional discharges of copper, zinc and free chlorine.

Assessment in accordance with Environment Agency guidance has been undertaken and has demonstrated that the proposed changes will not have a significant adverse effect on the receiving water and will not impact upon Water Framework Directive compliance (Environment Agency, 2022). The effects of these discharges, in combination with those already permitted, have been considered.

CONTENTS

TABLES AND FIGURES

1 INTRODUCTION

NNB Generation Company (HPC) Limited (referred to as NNB HPC) is developing the first of a new generation of nuclear power stations on the north Somerset coast, approximately 13km northwest of Bridgwater. Under current construction arrangements, treated effluent from site is discharged into the Bristol Channel under the Construction Water Discharge Activity (CWDA) Permit. Activity I was added in March 2022 to allow for the discharge of treated effluent from the Cold Flush Testing Phase of Plant Commissioning (also referred to as Cold Functional Testing (CFT)) (See Appendix A for what is currently included under Activity I). During the detailed design of the demineralised water plant and the Commissioning Effluent Treatment Plant (CETP), further details of the effluent composition have emerged that have led to the need to vary the permit to account for the discharge of additional substances within the treated effluent to be discharged.

1.1 Purpose

The variation application, for which this report provides supporting information, seeks to amend the permit limits of copper, zinc and free chlorine for Activity I of environmental permit EPR/JP3122GM. It also seeks to authorise the discharge of other substances but without the setting of numerical limits as set out in Section 2.3.4.

1.2 Scope

This application relates only to the construction phase of the project and only seeks to vary limits set for Activity I – the discharge of trade effluent consisting of effluent from cold commissioning activities. There is no impact on any limits set under the Operational Water Discharge Activity (OWDA).

1.3 Summary description of the proposed variation

NNB HPC is requesting:

- The addition of a permitted limit for total Copper of 102µg/l;
- The addition of a permitted limit for Free Chlorine of 1,200µg/l; and
- The addition of a permitted limit for total Zinc of 140µg/l.
- Allowing the discharge of essential products needed for the demineralised water plant that have been assessed and do not present an unacceptable environmental risk.

1.4 Contents of this report

The report includes the following sections:

- Section 2 sets out the proposed variation, including the purpose and requested concentration changes for each substance.
- Section 3 shows the surface water pollution risk assessment which was carried out for each substance, along with justifications and treatment options; and
- Section 4 summarises the conclusions.

1.5 Definitions

Abbreviation	Definition
AA	Annual Average
CBP	Chlorination By-products
CEFAS	Centre for Ecology, Fisheries and Aquaculture Science
CETP	Commissioning Effluent Treatment Plant
CFT	Cold Functional Testing
CIP	Cleaning In Place
CWDA	Construction Water Discharge Activity (Permit)
ECHA	European Chemicals Agency
ECHA	European Chemicals Agency
EQS	Environmental Quality Standard
EVF	Effective Volume Flux
GETM	General Estuarine Transport Model
HPC	Hinkley Point C
MAC	Maximum Allowable Concentration
NNB HPC	NNB Generation Company (HPC) Limited
OWDA	Operational Water Discharge Activity (Permit)
PNEC	Predicted No Effect Concentration
TDS	Total dissolved solids
TRO	Total Residual Oxidant

2 PROPOSED VARIATION

2.1 Description of current operations

Activity I refers to the discharge of trade effluent consisting of effluent from cold commissioning activities via Outlet 12, as seen in figure 1 below. Cold functional testing refers to the flushing and hydrotesting of systems. This will be the first time the systems will be flushed; this will demonstrate the physical integrity of the infrastructure and the circuits. Current activities, discharges, and waste streams under Activity I can be reviewed in the current permit EPR/JP3122GM.

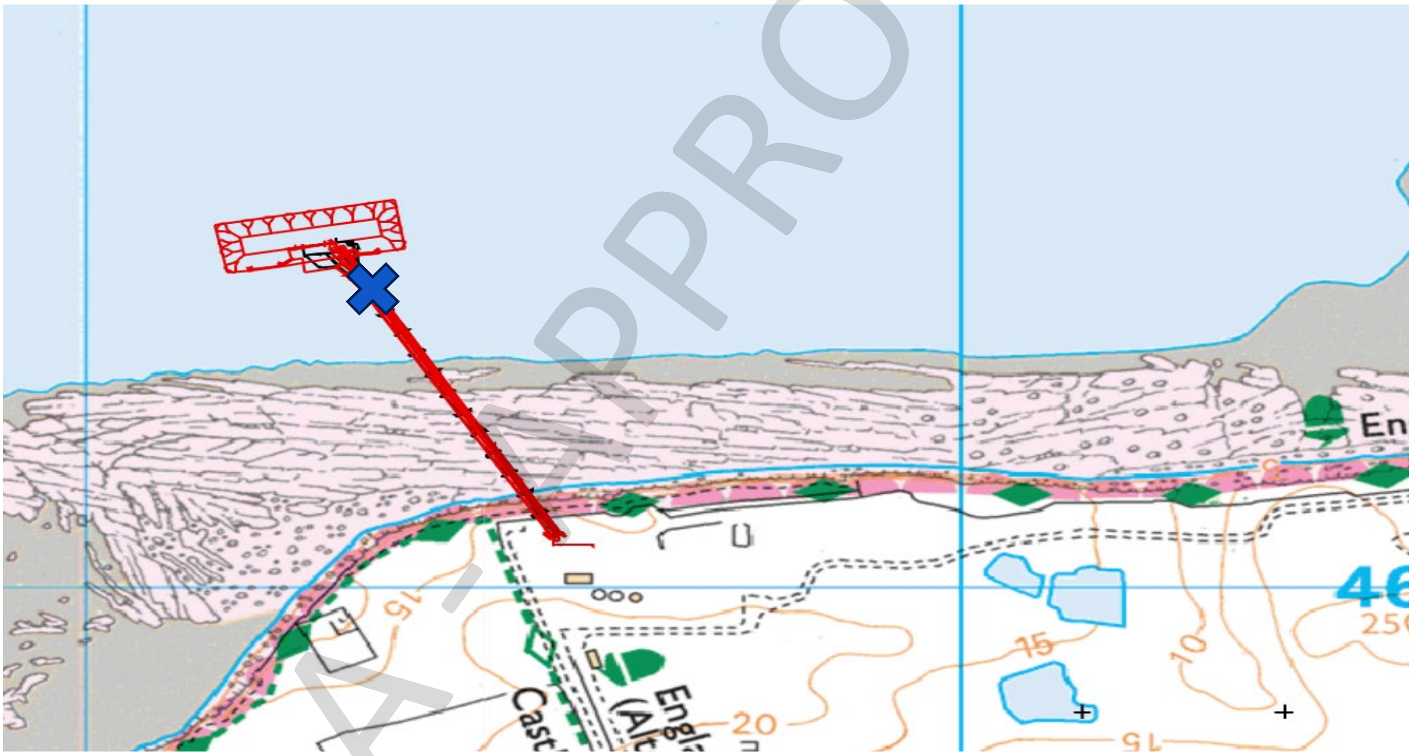

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Figure 1 Location of temporary jetty and Outlet 12. The blue X marks the approximate location of Outlet 12.

2.2 Effluent characterisation

Regular testing of the potable water supply to site has been undertaken for a range of parameters throughout 2023 (Appendix B). The demineralised water plant will produce c.700 litres of demineralised water for every 1000 litres of potable water. This means that any impurities in the potable water are concentrated 3.3 times in the effluent. This factor has been applied to the 95th percentile of the potable water quality to provide estimates of the effluent composition as detailed below.

The chemicals required to be used within the demineralised water plant have been assessed using details provided by the supplier of the plant, with regards to dosing rates and frequency of treatment.

Concentrations of copper and chlorine in the effluent from the CETP have been estimated by considering the dosing rate and the efficiency of the removal/recovery processes that are included within the CETP itself, along with consideration of the operational requirements.

2.3 Effluent development

2.3.1 Copper

Copper is present in the potable water supply to the demineralised water plant. The 95th percentile concentration of Total Copper from the demineralised water is predicted to be 102µg/l. In addition, copper sulfate is used as a catalyst for hydrazine destruction in the CETP, with the maximum copper concentration set at 10mg/l (10,000µg). The CETP has two ion exchange columns running in series to recover this catalyst and reuse it, reducing the copper concentration to below the Environmental Quality Standard (EQS). However, due to the operational needs of the CETP plant it will not always be possible to run both the ion exchange columns at all times (this would be during cleaning or backwashing of the system) and when only one column is in use, copper concentrations in the effluent could be above the EQS value (~100 µg/l, see Appendix B, Table 3). To address this, it is proposed to add a limit for copper of 102µg/l to Activity I. This value is below the limits currently in place for other effluents (activities) containing copper discharges within the permit.

2.3.2 Zinc

Zinc is present in the potable water supply to the demineralised water plant and will be concentrated during the demineralisation process to concentrations above the EQS. It would not be practicable or environmentally beneficial to treat to remove these low levels of zinc due to the large quantities of effluent that would be required to be treated and removed via tankers off site, and therefore it is proposed to add zinc to Activity I. Based on analysis of the potable water a limit of 140µg/l is proposed. It is noted that zinc discharges are permitted under activities E2, F and H at significantly higher levels.

2.3.3 Free Chlorine

Chlorine is present in the potable water supply and is also utilised in the treatment process of the CETP. It is intended that free chlorine will be removed from the potable supply in advance of demineralisation (through the use of sodium bisulphite), and also in the CETP through the granulated activated carbon filter. However, some breakthrough is still possible. Therefore, the potential effects of free chlorine on the receiving water have been assessed. Free chlorine has a high dispersion rate upon mixing and will rapidly react in the environment (ECHA, 2024q). Based on the quantities present in the potable water that has been analysed during the construction period of the project, a limit of 1,200µg/l is proposed. Potable water and CETP analysis can be found in Appendix B.

2.3.4 Demineralised water plant chemicals

Chemicals are used in the demineralisation process for “cleaning in place” and the prevention of biofouling. These chemicals will therefore be present in the effluent. No limit is being requested for these substances, but instead the permission to use and discharge of these substances at current estimated concentrations with control provided via operational and management controls. These controls will be focused around ensuring that no more that the amount assessed is being discharged. This is because, for the majority of the chemicals, accredited testing to the detection limits that would be required is not available. The concentrations assessed have been calculated based on the dosing rates provided by the plant supplier as detailed in Appendix C. The use of such substances can be reviewed in Table 1.

Table 1 Plant chemicals and their uses within the demineralisation plant

Substance	Plant Use
Antiscalant	An injection of antiscalant to limit salt precipitation on the reverse osmosis membrane [1]. It plays an important role in maintaining quality of the membrane
Biocide for reverse osmosis and prevention of biofouling	For Cleaning in Place (CIP) of the reverse osmosis membranes. CIP allows cleaning without disassembling the water treatment system. Additionally, A shock injection (once a week for one hour) of this biocide is used to prevent biofouling[2] in the reverse osmosis membranes.
Bisulphite	For the removal of the free chlorine before reverse osmosis
Basic Cleaning agent	For the Cleaning in Place (CIP) of the reverse osmosis membranes. CIP allows cleaning without disassembling the water treatment system.

Substance	Plant Use
Acid cleaning agent	For the Cleaning in Place (CIP) of the reverse osmosis membranes. CIP allows cleaning without disassembling the water treatment system.
Sulfuric Acid	Used in the demineralisation[3] process at two places: ion exchange resin regeneration and neutralization pit
Sodium hydroxide	Used in the demineralisation process at three places: pH regulation before the reverse osmosis 2nd pass, ion exchange resin regeneration and neutralization pit

[1] Reverse osmosis, separation technique in which pressure applied to a solution forces the solvent through a semipermeable membrane from a region of low concentration to one of high concentration, leaving behind the solutes.
[2] Biofouling is the fouling of underwater pipes and other surfaces by organisms such as bacteria and algae.
[3] Demineralization is the removal of dissolved mineral salts from water in this context

2.3.5 Buoyancy

The effluent from the potable water used in the demineralisation process was assessed as having an 95th percentile electrical conductivity of 549 µS/cm), giving it a Total Dissolved Solids (TDS) content of approximately 351 ppm. This was estimated by multiplying the electrical conductivity by a conversion factor of 0.64 (Rusydi, 2018). For reference, when considering major ions (calcium, magnesium, potassium, sodium, chloride, sulphate and alkalinity), the TDS of the Severn Estuary is >10,000mg/l, based on data available in TR428 (See Appendix E). This effluent makes up around 93% of the total effluent stream for this activity.

Therefore, most of the effluent from Activity I will be comprised of fresh water, which will be buoyant when discharged into a saline environment (Environment Agency, 2022). It is therefore expected that effluent from this discharge will be buoyant. As all other discharges via Outlet 12 have also been noted as buoyant, adding this effluent stream indicates that the combined effluent discharge will be buoyant.

It is recognised that the effluent discharged under Activity I will be comingled with groundwater (Activity E2), tunnel effluent (Activity F) and treated foul effluent (under a separate permit). Of these, tunnel effluent may at times be largely saline groundwater with a density close to that of seawater whilst the others are freshwater and therefore buoyant. The mixed effluent discharged from the jetty will therefore always be buoyant. The previous modelling (Cefas, 2021) upon which the assessment relies therefore remains valid.

3 ENVIRONMENTAL ASSESSMENT

3.1 Methodology

As this permit request includes discharging potentially hazardous chemicals, a surface water pollution risk assessment for estuaries and coastal waters was carried out in line with the Environment Agency's guidance (Environment Agency, 2022). Screening was carried out which involved identifying pollutants which will be discharged, gathering data on the pollutants such as the maximum estimated concentration of each chemical in the discharge, and then using this to carry out the screening tests.

These tests have 5 stages which are carried out in order;

- Test 1: Check if the discharge concentration is above 100% of the Environmental Quality Standard (EQS) or Predicted No Effect Concentration (PNEC) for each substance. If yes, Test 2 was carried out.

Test 2: Check if you are discharging to the low water channel (if the water does not flow across the estuary bed at any stage of the tide) in the upper parts of an estuary where the water is mainly fresh. This does not apply in this scenario, therefore all substances which failed Test 1 moved on to Test 3.

- Test 3: Check if the discharge is emitted into a location with restricted dilution or dispersion. This is not the case for discharges from HPC outlet 12 and Activity I. Therefore, the assessment moved onto Test 4.
- Test 4: Assess if the discharge location is less than 50m offshore from the seabed, or the seabed at discharge is less than 1m below chart datum. This does not apply in this scenario, so Test 5 was carried out for all substances which failed Test 1.

Test 5: The Effective Volume Flux (EVF) is calculated and compared to a maximum allowable EVF of 3 metres. The EVF for each substance required to conduct Test 5 was calculated using the following method:

Table 2 Test 5 process for H1 Assessment

Step 1	Multiply the effluent discharge rate (0.070 cubic metres per second) by the maximum discharge concentration of the chemical and element (in micrograms per litre).
Step 2	Subtract the average background concentration (assumed to be zero for most substances without sufficient data available) of the discharge location from the EQS/PNEC.
Step 3	Divide the result of step 1 by the result of step 2.

It is important to note that if the calculated EVF was below 3, the substance passed Test 5, and no further assessment is required. Substances which failed Test 5 are highlighted and justified below in Section 3.2.

3.2 Assessment - metals and chlorine

3.2.1 Results of the H1 assessment

Background water quality has been taken from previously agreed reports (CEFAS, 2021)

- Copper: 3.95 (µg/L)
- Zinc: 3.035 (µg/L)

It has been assumed that the background value for free chlorine is zero.

EQS values were taken from the Water Framework Directive Directions for England & Wales (2015).

Table 3 Copper, Zinc and Chlorine analysis summary (See Appendix B for data analysis)

Element	CAS No.	EQS (µg/L)	Max. discharge conc. (µg/L)	Test 1	Test 2	Test 3	Test 4	Test 5 (m^{3}s)	Required dilution factor
Copper	7440-50-8	4.76	102	Fail	N/A	N/A	N/A	Fail-8.81	121
Zinc	7440-66-6	6.8	140	Fail	N/A	N/A	N/A	Pass-2.6	
Free Chlorine	7782-50-5	10*	1200	Fail	N/A	N/A	N/A	Fail-8.4	121

* The EQS value for Chlorine was taken from the Water Framework Directive & c (2015) and refers to Total Residual Oxidant (TRO)

Free Chlorine:

Chlorine failed Test 5 with an EVF of 8.4. Detailed modelling has been previously undertaken to consider the impact of, inter alia, zinc contained within groundwater (CEFAS, 2021). This modelling demonstrated that even with an EVF of 20.37, concentrations within the receiving water were reduced to the relevant environmental quality standard within 5 metres on the seabed, and that the particular species of note within the vicinity are not impacted. Overall, the environmental impact of this discharge concentration is expected to be minimal.

The potential for chlorination byproducts (CBP) is recognised and is considered a particular issue when marine waters are chlorinated directly (CEFAS, 2011) due to the potential generation of brominated products which are more ecologically harmful than the chlorinated equivalent. The activities included in this permit do not involve the direct chlorination of such waters and there is considerable potential for mixing and for the rapid reduction of chlorine to chloride before entry to marine waters. Whilst this reduces the risk, as a conservative assumption, the available marine data (quoted in CEFAS, 2011) has been utilised. Data from coastal cooling water systems around Europe indicates an average bromoform concentration of 16.32µg/l based on chlorination rates between 0.3 and 1.5 mg/l. for the current discharge a maximum of 1.2mg/l has been considered but the data presented in Appendix B indicates that the majority of values are well below that. It should also be noted that the intention is to remove residual chlorine to a low level as part of the plants' operations and thus this assessment is "worst case". A maximum allowable concentration (MAC) of 5µg/l has been proposed (Taylor, 2006) and has been adopted in other assessments related to Hinkley Point C and Sizewell C and is adopted here. Using this value and the maximum permitted flow rate gives an EVF of 0.224. No further assessment is considered necessary.

Copper

Copper failed Test 5 with an EVF of 8.81. This is below the maximum EVF modelled in TR428 of 20.37 for Zinc, which assessed that for this EVF, there was no predicted exposure of designated bed features above the EQS at any time (Cefas, 2021). As the discharge is buoyant, exceedance at the bed was only expected within a very short distance (less than 5 m) of the discharge itself and that the particular species of note within the vicinity are not impacted. Overall, the environmental impact of this discharge concentration is expected to be minimal.

Zinc

Zinc passed Test 5 with an EVF of 2.6. Therefore, no modelling is required as no significant environmental impact is anticipated at the proposed discharge rate with a maximum concentration for Zinc of 140 µg/l.

3.2.2 In combination effects

Copper and Zinc are also discharged via Outlet 12 in activities E2, F and H. Therefore, an in-combination assessment was carried out to estimate the concentration of the combined effluent flows, using the following formula;

*Final mix = ((Concentration a * flow a) + (Concentration b * flow b) + (Concentration c * flow c)) / (flow a + flow b + flow c)*

The results can be seen in Table 4.

Table 4 In combination assessment for Copper and Zinc

Activity	Flow rates (l/s)	Copper Max concentration (µg/l)	Zinc Max Concentration (µg/l)
E2	20	221	1642.15
F	0.57	68	189
H	30	221	1642.15
I	70	102	140
Final mix	120.57	151.19	763.17

Activities E2, F, H and I will produce a combined maximum flow rate of 120.57 l/s. This will result in an estimated concentration of 152 µg/l of copper and 763 µg/l of Zinc in the combined flow. Therefore, the total concentration of Copper and Zinc in the effluent will actually be reduced with the addition of this flow through dilution. However, due to the increase in flow rate it is important to consider the impact this may have. A dilution factor for each substance was calculated using the following formula;

Dilution factor = Release concentration / (EQS-Background concentration)

Using this formula, it was calculated that a dilution factor of 186.65 and 202.70 are required to bring Copper and Zinc, respectively, down to their respective EVFs for this in-combination assessment. In previous modelling, it was established that in a worst-case scenario, a dilution factor for Zinc of ~436 (1642.15/3.765) would not pose a significant environmental risk (Cefas, 2021). Therefore, even though the flow rate is higher, the required dilution factor and combined concentration of copper and zinc are much lower than the modelled worst-case scenario (less than half). It is concluded that the environmental impact of adding this flow in combination with previously permitted flows will be negligible.

3.3 Assessment - Demin Plant Chemicals

3.3.1 Substances without a PNEC

PNECs have been taken from the European Chemicals Agency where available. Where PNECs were not available from that source, an attempt was made to derive one using data as shown in Table 5 below. This ecotoxicity data was used in line with ECHA guidelines on deriving a PNEC (ECHA, 2008). However, as seen in Table 5, insufficient data was available for the PO-EO Block Polymer substance, and no PNEC could be derived.

Table 5 Ecotoxicity data for substances without registered PNEC

Product	Substance	Fish	Invertebrates	Algae	Assessment Factor	PNEC (µg/l)	Source
Acid cleaning agent	PO-EO Block Polymer	>120 mg/l, (*Oncorhynchus mykiss*) LC50	>100 mg/l , (*Daphnia magna*), EC50	No data available	Insufficient data	N/A	(Sigma Aldrich, 2022)

Sulfuric Acid (H_2SO_4):

Sulfuric acid has no registered PNEC on the ECHA website. Acute effects from concentrated sulfuric acid may be expected due to pH change, however this will be controlled at the demineralisation plant through a "neutralisation pit" and all effluent will be discharged between pH 6-9 as previously discussed. This means that the substance will be discharged in the form of sulfate (SO_4^{2-}) and hydrogen ions (H^+) rather than sulfuric acid, with an estimated maximum discharge concentration for sulfate of 4,162µg/l.

The sulfate ions will be fully dissociated in the environment. The total dissociation of sulfuric acid at environmental pH implies that it will not, *per se*, adsorb onto particulates or accumulate in living tissues (ECHA, 2024o). It should be noted that background sulfate levels in the sea are already naturally high, at 1.8 g/l as per Appendix E (Cefas, 2021). This background level meant that the substance was screened out at Test 1 of the H1 assessment, as this discharge will be significantly below this value. Therefore, it is anticipated that the overall impact is likely to be negligible, and no further modelling is required.

Potassium hydroxide (KOH)

No PNEC for potassium hydroxide is provided on the ECHA website and it is noted therein that testing is not technically feasible. However, as a strong base potassium hydroxide will fully dissociate into potassium ions (K^+) and hydroxide ions (OH^-)(ECHA, 2024p). The pH of water discharged from the demineralised water plant will be managed through the neutralisation pit and thus will be maintained between 6 and 9. There will therefore be no impacts from the hydroxide ions. The estimated discharge concentration for potassium ions in this effluent is 60.81 µg/l. As with sulphate, potassium concentrations are naturally high within marine waters (255mg/l – Appendix E) and the concentration to be discharged is below this. Test 1 of the H1 assessment is therefore passed. Therefore, it is anticipated that the overall impact is likely to be negligible, and no further modelling is required.

Sodium salts

There are no registered PNECs for Sodium hydroxide, Sodium Carbonate and Sodium Chloride on the ECHA website, stating that testing is not technically feasible. However, Sodium concentrations are already high in the Severn Estuary at 6,990 mg/l (See Appendix E). This background concentration is significantly higher than any of the discharge concentrations expected from this effluent. Therefore, Test 1 is passed, and the environmental impact of these substances is likely to be minimal with no further modelling required.

3.3.2 Results of the H1 Assessment

Table 6 Surface water pollution risk assessment for biocide chemicals (See Appendix C)

Product	Component	CAS No.	AA EQS/PNEC (µg/l)	MAC EQS	Max discharge conc. (µg/L)	Test 1	Test 2	Test 3	Test 4	Test 5 (m^3/s)	Dilution factor
Antiscalant	ATMP acid	6419-19-8	40 (ECHA, 2024a)		218.19	Fail	N/A	N/A	N/A	Pass 0.38	
	HDTMPA Potassium Salt	38820-59-6	100 (ECHA, 2024b)		87.27	Pass	N/A	N/A	N/A	N/A	
	Potassium Hydroxide	1310-58-3	Screened out - See Section 3.3.1		60.81	Pass					
Biocide for reverse osmosis and prevention of biofouling	Reaction mass of 5-chloro-2-methyl-2H-isothiazol-3-one and 2-methyl-2H-isothiazol-3-one (3:1)	55965-84-9	3.39 (ECHA, 2024c)		77.1	Fail	N/A	N/A	N/A	Pass 1.59	
	Copper Nitrate	3251-23-8	5.2 (ECHA, 2024d)		2.57	Pass	N/A	N/A	N/A	N/A	
Bisulphite	Sodium hydrogensulphite (sodium bisulphite)	7631-90-5	110 (ThermoFisher, 2023)		2,629.08	Fail	N/A	N/A	N/A	Pass 1.67	
Basic cleaning agent	Tetrasodium ethylene diamine tetraacetate	64-02-8	283 (ECHA, 2024e)		3,001.05	Fail	N/A	N/A	N/A	Pass 0.74	
	Sodium Hydroxide	1310-73-2	Screened out See Section 3.3.1		2,000.70	Pass					
	Sodium Ethylhexyl Sulfate	126-92-1	13.57 (ECHA, 2024f)		600.21	Fail	N/A	N/A	N/A	Fail- 3.10	45.23
Acid cleaning agent	Citric Acid	77-92-9	44 (Carl Roth, 2024)		3,029.04	Fail	N/A	N/A	N/A	Fail- 4.82	69.84
	Sulphamic Acid	5329-14-6	180 (ECHA, 2024g)		2,019.36	Fail	N/A	N/A	N/A	Pass 0.2	
	PO-EO Block Polymer	9003-11-6	N/A- See Section 3.3.1		1,009.68						
Sulfuric Acid 96%	Sulfuric Acid (Discharged as Sulfate)	7664-93-9	Screened out- See Section 3.3.1		4,161.66	Pass					
	Ammoniacal Nitrogen	1336-21-6	23 (Water Framework Directive, 2015)		0.021	Pass	N/A	N/A	N/A	N/A	
	Iron	7439-89-6	1000 (Water Framework Directive, 2015)		0.17	Pass	N/A	N/A	N/A	N/A	
	Antimony	7440-36-0	11.3 (ECHA, 2024h)		0.0043	Pass	N/A	N/A	N/A	N/A	
	Arsenic	7440-38-2	25 (Water Framework Directive, 2015)		0.0043	Pass	N/A	N/A	N/A	N/A	
	Cadmium	7440-43-9	0.2 (Water Framework Directive, 2015)		0.00021	Pass	N/A	N/A	N/A	N/A	
	Lead	7439-92-1	1.3 (Water Framework Directive, 2015)	14 (Water Framework Directive, 2015)	0.022	Pass	N/A	N/A	N/A	N/A	
	Mercury	7439-97-6		0.07 (Water Framework Directive, 2015)	0.003	Pass	N/A	N/A	N/A	N/A	
	Selenium	7782-49-2	2 (ECHA, 2024i)		0.021	Pass	N/A	N/A	N/A	N/A	
Caustic Soda	Sodium Hydroxide	1310-73-2	Screened out-		5,887.61	Pass					

Product	Component	CAS No.	AA EQS/PNEC (µg/l)	MAC EQS	Max discharge conc. (µg/L)	Test 1	Test 2	Test 3	Test 4	Test 5 (m^3/s)	Dilution factor
	Sodium Carbonate	497-19-8	See Section 3.3.1		11.54	Pass					
	Sodium Chloride	7647-14-5			1.15	Pass					
	Sodium Sulfate	7757-82-6	1109 (ECHA, 2024j)		1.15	Pass	N/A	N/A	N/A	N/A	
	Sodium Chlorate	7775-09-9	240 (ECHA, 2024k)		0.69	Pass	N/A	N/A	N/A	N/A	
	Iron	7439-89-6	1000 (Water Framework Directive, 2015)		0.058	Pass	N/A	N/A	N/A	N/A	
	Mercury	7439-97-6		0.07 (Water Framework Directive, 2015)	0.00058	Pass	N/A	N/A	N/A	N/A	
	Nickel	7440-02-0	8.6 (ECHA, 2024l)	34 (Water Framework Directive, 2015)	0.012	Pass	N/A	N/A	N/A	N/A	
	Cadmium	7440-43-9	0.2 (Water Framework Directive, 2015)		0.0058	Pass	N/A	N/A	N/A	N/A	
	Arsenic	7440-38-2	25 (Water Framework Directive, 2015)		0.012	Pass	N/A	N/A	N/A	N/A	
	Chromium	7440-47-3	0.6 (ECHA, 2024m)	32 (Water Framework Directive, 2015)	0.0058	Pass	N/A	N/A	N/A	N/A	
	Lead	7439-92-1	1.3 (Water Framework Directive, 2015)	14 (Water Framework Directive, 2015)	0.0029	Pass	N/A	N/A	N/A	N/A	
	Antimony	7440-36-0	11.3 (ECHA, 2024h)		0.028	Pass	N/A	N/A	N/A	N/A	
	Selenium	7782-49-2	2 (ECHA, 2024i)		0.028	Pass	N/A	N/A	N/A	N/A	

3.3.3 Priority Hazardous Substances

Both sulfuric acid and caustic soda contain trace amounts of Cadmium and Mercury, which are classed as priority hazardous pollutants. These require additional screening under Environment Agency guidelines, which was carried out with the results detailed in Table 7 below:

Table 7 Priority Hazardous Pollutants Screening Calculations for Cadmium and Mercury

Element	Max. concentration (µg/l)	Total Daily Flow (l)	Daily discharge (µg)	Daily discharge (kg)	Annual discharge (kg)	Annual significant load limit (kg)	Above/Below annual significant load?
Cadmium	0.0060	1,260,000	7,543.30	7.54E-06	0.0028	5	Below
Mercury	0.0088	1,260,000	11,058.05	1.11E-05	0.0040	1	Below

The concentrations of these elements from each product were combined to give an estimated maximum concentration so that a worst-case scenario could be considered. The calculated annual discharge for both substances is below the annual significant load limit. As they both additionally passed Test 1 of the estuaries and coastal waters screening tests, they are therefore classed as insignificant and do not require any further modelling.

3.3.4 Justifications

All products to be used within the demineralised water plant which were analysed to be at concentrations above the EQS passed test 5 apart from Sodium Ethylexyl Sulfate and Citric Acid. Passing Test 5 indicates that they are below the required Effective Volume Flux (EVF) and would likely have no impact on the marine (saltwater) environment when discharged (this is based on discharge into a marine estuary environment, Bristol Channel). Justification for the use of the two products that did not pass test 5 can be found below.

Citric acid:

According to ECHA (2024n) citric acid is reported to be readily biodegradable. It is a weak acid and will ionise in aqueous solution at naturally occurring pH levels. All discharges will be within a pH of 6-9 when discharged and therefore this impact is neutralised, and the environmental impact will be minimal. Citric Acid failed Test 5 with an EVF of 4.82, which is significantly below the EVF of 20.37 which was assessed to be acceptable under GETM modelling (CEFAS, 2021). Therefore, the environmental impact of this substance being discharged at this concentration is anticipated to be negligible.

Sodium Ethylhexyl Sulfate:

According to ECHA (2024f) Sodium Ethylhexyl Sulfate is readily biodegradable. This assumption is based on three studies including a GLP (Good Laboratory Practice) test that was performed according to OECD guideline 301 B (Brunswik-Titze, 2003). Diefenbach (1995) and Daniel (2006) GLP studies, following the EU Method C.4-4 and ISO14593 respectively, indicated that Sodium Ethylexyl Sulfate is readily biodegradable. Whilst Sodium Ethylhexyl Sulfate failed test 5 with an EVF of 3.10, this is only slightly higher than the threshold of 3 utilised in Test 5 and is substantially below the EVF of 20.37 for Zinc which was assessed during GETM modelling. As already noted, sulphate levels in the sea are already naturally high and pH effects will be neutralised. Therefore, it is anticipated that the overall impact is negligible, and no further modelling is required.

3.4 Treatment Approach

All effluent will be neutralised to ensure a pH of between 6-9 prior to its discharge. It is important to note that there are limited options for further treatment of the substances/metals in the effluent. Any potential treatment options would require the use of further resources and would likely generate wastes requiring off-site disposal.

Offsite disposal/treatment via tankers would also be grossly disproportionate to the environmental impact of the effluent being discharged into the environment; this is due to the quantity of effluent being produced, 70 litres a second, which would require an excessive amount of transportation. This would be roughly one tanker an hour 24 hours a day for several months, which would not be a sustainable option.

The aqueous wastes from the maintenance of the demineralised water plant are routed to a sealed “neutralisation pit” for treatment to ensure that the pH of the discharge effluent is acceptable. This will be an automatic process utilising a pH probe to control the dosing of sulfuric acid and sodium hydroxide to lower and raise the pH as required. Dosing rates and the “set points” for acceptable concentrations will be confirmed during the commissioning of the plant but will be such as to provide confidence that effluent discharged from this process has a pH between 6 and 9 as required under the permit.

The commissioning effluent treatment plant uses a multistep process to achieve the requisite destruction of hydrazine and ammonia as well as the removal of suspended solids to meet the permit requirements. The operation of this plant, and the controls in place to provide environmental protection will be detailed in an Operating Techniques Report for agreement by the Environment Agency. However, in summary the plant will have the flowing steps:

- Flocculation (with ferric chloride) and dissolved air filtration to remove suspended solids;
- Sand filtration

- Hydrazine destruction (oxidation using hydrogen peroxide and a copper catalyst)
- Ammonia destruction (oxidation using sodium hypochlorite)
- Filtration through granulated activate carbon (polishing and removal of excess hypochlorite)
- Ion exchange (to recover copper catalyst for reuse)
- Online monitoring, likely to include pH, total suspended solids and ammonia

pH will be corrected at various points through the process as required to optimise the reactions and then to ensure compliance with the permit pH limits. Effluents produced within the plant (e.g. form the regeneration of the ion exchange columns) will be recirculated though the plant.

4 CONCLUSIONS

Previous modelling and recent analysis, using the Environment Agency's (2022) risk assessment methodology, of data has been used to assess the environmental impact of the proposed discharges. Previous modelling indicates that there would be no significant environmental impacts of the proposed discharges to the designated bed features within the Natura 2000 site. The proposed variations for Activity I are therefore as follows:

- An addition of a permitted limit for total Copper of 102µg/l;
- An addition of a permitted limit for Free Chlorine of 1,200µg/l
- An addition of a permitted limit for total Zinc of 140µg/l.
- Allowing the discharge of essential biofouling products that have been analysed.

The data used within this assessment has been verified by NNB HPC against publicly available sources such as the European Chemicals Agency (ECHA) and is considered representative.

The assessment has demonstrated that there would be no likely significant effect on the conservation status of the protected areas and would not impact on the Water Framework Directive status of the receiving waters.

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APPENDIX A: PERMITTED ACTIVITIES, DISCHARGES AND WASTE STREAMS UNDER ACTIVITY I

Variation EPR/JP3122GM/V009 amends the permit to include an additional water discharge activity (WDA), Activity I for the discharge of trade effluent consisting of effluent from cold commissioning activities, including hydro-testing and demineralised water production. Descriptive and numerical limits have been included in the permit to regulate this activity. These include:

i. Maximum daily discharge volume – 1500 cubic metres per day

ii. Maximum rate of discharge – 70 litres per second

iii. Maximum suspended solids (measured after drying at 105°C) – 675 milligrams per litre and 264 milligrams per litre annual average.

iv. Maximum and minimum pH range – 6 to 9

v. No significant trace present so far as is reasonably practicable of visible oil or grease

vi. Maximum concentration of Hydrazine – 15 micrograms per litre

vii. Maximum concentration of Ammoniacal nitrogen (expressed as N) – 271 milligrams per litre

Variation EPR/JP3122GM/V010 amends the ammonia limits for activities E2 and H. This amendment is to reflect the updated water quality modelling provided with the application.

The modelling used the 95th percentile concentration of ammonium, converted to ammoniacal nitrogen from borehole sampling as the source input from both these activities. The results of this ammoniacal nitrogen modelling was then converted to unionised ammonia concentrations using a standard algorithm (which considers salinity, pH and temperature, which are the key parameters in the conversion). Therefore a single ammoniacal nitrogen limit as follows is appropriate to regulate both ammoniacal nitrogen and un-ionised ammonia on both of these activities:

i. Maximum concentration of Ammoniacal nitrogen (expressed as N) – 9.5 milligrams per litre

The Environment Agency has also amended the title of Activity F to “Cementitious wash water” and adjusted the suspended solids limit on all activities discharged via Outlet 12. This replaces the standard (250 mg/l) limit with more site specific limits which represent the background levels in the receiving environment:

i. Maximum suspended solids (measured after drying at 105°C) – 675 milligrams per litre.

ii. Maximum annual average (12 month rolling period) - 264 milligrams per litre.

Several monitoring and reporting conditions have also been removed as the discharge scenarios that required this monitoring are no longer occurring on site. These include:

i. Monitoring and reporting the muck bay drainage volume separately, as all effluent volumes discharged under Activity H will now be monitored as a combined effluent and compliance measured against original Maximum daily discharge volume of 2592 m^3/day and maximum rate of discharge limit of 30 litres per second.

ii. Reporting the combined total daily volume of Activity E2 and Activity H as flow balancing between these two activities is no longer required on site, and has been removed as a potential operating technique from the OT10 -Construction Water Discharge Activity Permit: Dewatering Operating Techniques Report and the OT12 - Construction Water Discharge Activity Permit: Tunnelling Operating Techniques Report.

We consider in reaching that decision we have taken into account all relevant considerations and legal requirements and that the permit will ensure that the appropriate level of environmental protection is provided.

APPENDIX B COPPER, ZINC AND CHLORINE DATA AND CALCULATIONS

Table B 1: Potable water samples and analysis

Date	Sampling site	Free chlorine	Copper	Zinc
		mg/l	mg/l	mg/l
15/02/2023	HPC Fire Hydrant 1	0.25	0.02	0.01
15/02/2023	HPC Fire Hydrant 2	0.22	0.01	0.01
15/02/2023	HPC Fire Hydrant 1	0.26	0.01	0.01
15/02/2023	HPC Fire Hydrant 3	0.3	0.01	0.01
15/02/2023	HPC Fire Hydrant 6	0.54	0.01	0.01
15/02/2023	HPC Fire Hydrant 9	0.26	0.01	0.01
20/02/2023	HPC K14 Demand.S	0.24	0.01	0.01
20/02/2023	HPC K14 Tidy.Cam	0.25	0.01	0.01
20/02/2023	HPC K14 Unites.Ye	0.25	0.01	0.01
20/02/2023	HPC K14 Soap.Stru	0.27	0.01	0.01
21/02/2023	HPC K14B Pre tens		0.01	0.01
03/03/2023	PM KBJV R2X		0.01	0.01
03/03/2023	KBJV 63mm Road 2		0.01	0.01
09/03/2023	HPC Toilet Block 8	0.15	0.01	0.01
09/03/2023	HPC Toilet Block 8	0.18	0.01	0.01
13/03/2023	HPC Inside Toilet B	0.06	0.01	0.01
24/03/2023	HPC FH 18 HAN	0.33	0.05	0.03
24/03/2023	HPC FH 37	0.3	0.07	0.03
24/03/2023	HPC FH 96	0.2	0.01	0.01
24/03/2023	HPC FH 45	0.37	0.07	0.04

Date	Sampling site	Free chlorine	Copper	Zinc
24/03/2023	HPC FH 32	0.32	0.04	0.02
24/03/2023	HPC FH 11	0.3	0.01	0.01
27/03/2023	HPC NOA 63mm fe	0.35	0.01	0.01
27/03/2023	HPC HAN Parent M	0.33	0.01	0.01
31/03/2023	K8B DE-MIN LINE		0.01	0.01
31/03/2023	K19 KBJV Parent M		0.01	0.01
06/04/2023	HPC K19B FH77 -	0.33	0.01	0.01
11/04/2023	K8B DE-MIN LINE	0.06	0.01	0.01
11/04/2023	K19 PARENT MAI	0.35	0.01	0.01
13/04/2023	HPC Site HOM Bal	0.06	0.01	0.01
13/04/2023	HPC Site Hydrant N	0.33	0.01	0.01
13/04/2023	HPC Site Hydrant N	0.33	0.01	0.01
13/04/2023	HPC Site Hydrant N	0.08	0.01	0.01
13/04/2023	HPC Site Hydrant N	0.3	0.01	0.01
14/04/2023	K14B WCC Supply	0.36	0.01	0.01
14/04/2023	K14B WCC Welfar	0.35	0.01	0.01
09/05/2023	HPC FH84 K23B	0.13	0.01	0.01
09/05/2023	HPC Linxon NFM P	0.21	0.01	0.01
09/05/2023	HPC Linxon NFM 2	0.16	0.01	0.01
09/05/2023	HPC FH41 K14	0.22	0.01	0.01
09/05/2023	HPC FH31 HAN	0.06	0.01	0.01
09/05/2023	HPC FH10 EOA	0.26	0.01	0.01

Date	Sampling site	Free chlorine	Copper	Zinc
09/05/2023	HPC FH2 K5 Behin	0.25	0.01	0.01
09/05/2023	HPC FH42 K6	0.06	0.01	0.01
12/05/2023	HPC W/O Bylor Of	0.24	0.01	0.01
12/05/2023	HPC W/O Bylor Of	0.27	0.01	0.01
17/05/2023 10:23	KBJV K28 LAB CANTEEN	0.06	0.01	0.04
17/05/2023 10:45	KBJV K28 LAB SINK	0.06	0.01	0.09
17/05/2023 11:01	KBJV K28 OUTSIDE SUPPLY	0.06	0.01	0.12
18/05/2023 09:30	HPC SITE F3.1 CANTEEN	0.25	0.01	0.02
18/05/2023 11:00	HPC WCC WELFARE CABIN	0.31	0.01	0.01
23/05/2023 10:30	HPC Bottle station 6 K118	0.27	0.01	0.01
23/05/2023 09:00	HPC T.C.R Feed K11J	0.23	0.01	0.01
23/05/2023 09:15	HPC T.C.R Parent K11J	0.23	0.01	0.01
25/05/2023 08:45	HPC Toilet block 2/k10 Parent	0.19	0.01	0.01
25/05/2023 08:50	HPC Toilet block 2/k10 Feed	0.19	0.01	0.01
25/05/2023 08:55	HPC Toilet block 2/k10 inside block	0.19	0.01	0.01
28/06/2023 08:45	K28 Lab Supply KBJV	0.13	0.01	0.01
29/06/2023 06:43	K19 Parent Mian KBJV - ///circling.gobblers.lectures	0.27	0.03	0.03
29/06/2023 07:05	K8B DE-MIN LINE KBJV - ///suffer.juggled.offhand	0.25	0.01	0.01
30/06/2023 09:30	HPC/KIIW/ Hydrant 24 Parent	0.06	0.01	0.01
30/06/2023 09:40	HPC/KIIW/ Hydrant 24	0.06	0.01	0.01
30/06/2023 10:00	HPC/KIIW/ Hydrant 11	0.1	0.01	0.01
07/07/2023 09:00	HPC K19A PM	0.13	0.01	0.01

Date	Sampling site	Free chlorine	Copper	Zinc
07/07/2023 09:10	HPC K19A Cabin	0.13	0.01	0.01
13/07/2023 11:00	HPC FH11 Parent	0.08	0.02	0.01
13/07/2023 11:10	HPC FH11 No 1	0.06	0.01	0.01
13/07/2023 11:20	HPC Lay Flat Hose 2	0.06	0.01	0.05
13/07/2023 11:30	HPC Lay Flat Hose 3	0.06	0.01	0.04
13/07/2023 11:40	HPC Lay Flat Hose 4	0.06	0.01	0.04
14/07/2023 08:15	HPC U2 HDAB building Parent K8D W47B	0.13	0.01	0.01
14/07/2023 08:20	HPC U2 HDAB building K8D W47B	0.11	0.01	0.01
14/07/2023 09:00	HPC emergency shower K14b	0.06	0.01	0.01
17/07/2023 08:37	KBJV LAB WELFARE TAP	0.07	0.01	0.01
17/07/2023 08:10	HPC Parent Main Connection K28/K28B	0.06	0.01	0.01
17/07/2023 08:20	HPC Jacobs Kitchenette K28/K28B	0.06	0.01	0.01
19/07/2023 08:30	HPC FH 36 K28	0.06	0.01	0.01
19/07/2023 09:00	HPC FH 60 K11	0.06	0.01	0.01
19/07/2023 09:30	HPC FH 77 K10	0.14	0.01	0.01
19/07/2023 10:00	HPC FH 66 K11	0.1	0.01	0.01
19/07/2023 10:30	HPC FH 22 K11	0.1	0.02	0.01
19/07/2023 11:00	HPC FH 114 K19	0.15	0.01	0.01
01/08/2023 08:40	HPC Jacobs Toilet block internal	0.06	0.01	0.01
04/08/2023 08:00	HPC K5A Parent Main	0.1	0.01	0.01
04/08/2023 08:15	HPC K5A New Filling Point	0.11	0.01	0.01
08/08/2023 11:00	HPC, W45 Bylor, Toilet 9	0.13	0.01	0.01

Date	Sampling site	Free chlorine	Copper	Zinc
08/08/2023 11:15	HPC, W45 Parent	0.12	0.01	0.01
10/08/2023 09:00	HPC K12 Parent	0.09	0.01	0.01
10/08/2023 09:15	HPC K12 Bilfinger	0.14	0.01	0.01
21/08/2023 07:45	HPC FH23 K12	0.06	0.01	0.01
21/08/2023 08:15	HPC FH18 K11J	0.11	0.01	0.01
21/08/2023 09:00	HPC FH2 K5C	0.08	0.03	0.02
21/08/2023 09:45	HPC FH3 K11B	0.06	0.01	0.01
21/08/2023 10:45	HPC FH85 K18A	0.06	0.19	0.09
21/08/2023 08:30	HPC FH 97 K4	0.12	0.01	0.01
22/08/2023 09:05	Decisions Workroom SPEEDS Parent main	0.08	0.01	0.01
22/08/2023 09:20	Hardback. Landlady. Large 25mm Service	0.11	0.01	0.01
25/08/2023 09:00	K15B Bylor North Toilet	0.13	0.01	0.01
29/08/2023 16:00	HPC W15B HS2 Parent - Jabs, Drill, Flickers	0.06	0.01	0.01
29/08/2023 16:20	HPC W15B HS2 Toilet Block - Skater, Crossword, Clay	0.06	0.01	0.01
	Potable Water Mean	0.17	0.014	0.015
	Potable water 95th percentile	0.35	0.031	0.04
	Effluent (mean)	0.58	0.048	0.051
	Effluent (95th percentile)	1.17	0.102	0.13

Table B 2: Test 5 for Copper, Zinc and Chlorine

Element	Copper	Zinc	Chlorine
Water Depth (m)	3	3	3
Discharge flow rate (m3)	0.07	0.07	0.07
Release conc. (µg/l)	102	140	1200
Discharge flow rate*Release conc (A)	7.14	9.8	84
Background conc. (µg/l)	3.95	3.035	0
EQS	4.76	6.8	10
EQS - Background conc. (B)	0.81	3.765	10
EVF (A/B)	8.81	2.6	8.4
EVF <3?	NO	YES	NO

Table B 3: Test 5 calculations for CETP Copper and Chlorine

	Copper	**Chlorine**
Concentration in effluent - pre IX (µg/l)	10000	500
Concentration after 1 IX column (99% removal) (µg/l)	100	5
Concentration after 2 IX columns (99% removal) (µg/l)	1	0.05
flow rate (l/s)	70	70
Flow rate (m^3)	0.07	0.07
Release conc. (µg/l)	100	5
Discharge vol.*Release conc. **(A)**	7	0.35
Background conc. (µg/l)	3.95	0
EQS (µg/l)	4.76	10
EQS - Background conc. **(B)**	0.81	10
EVF (A/B)	8.64	0.035
EVF <3?	NO	YES

APPENDIX C CHEMICALS FOR USE IN DEMINERALISATION PLANT DATA AND CALCULATIONS

Table C 1: Annual consumption of substance and percentage of total effluent

Substance	Average Annual Consumption (l)	% of total effluent
Antiscalant	145	0.0873
Biocide for CIP and biofouling	427	0.257
Bisulfite	1092	0.657
Basic Cleaning Agent	3324	2.001
Acid Cleaning Agent	3355	2.019
Caustic Soda	1918	1.154
Sulfuric Acid	713	0.429

Total effluent per annum = 166,142 litres

% of total effluent = (Average annual consumption/Total effluent per annum) x 100

µg/l in effluent = ((% of total effluent/100) x %mass) x 10000

Table C 2: Substance chemical composition analysis for maximum discharge concentration

Substance	Component	CAS No.	%Mass (max)	µg/L (max)	%effluent (max)	µg/l in effluent (max)
Antiscalant	ATMP acid	6419-19-8	25	250000	0.021819	218.19
	HDTMPA Potassium Salt	38820-59-6	10	100000	0.008727	87.27
	Potassium Hydroxide	1310-58-3	10	100000	0.008727	87.27
	Water	7732-18-5	79			
Biocide for CIP and biofouling	Reaction mass of 5-chloro-2-methyl-2H-isothiazol-3-one and 2-methyl-2H-isothiazol-3-one (3:1)	55965-84-9	3	30000	0.007710	77.10
	Copper Nitrate	3251-23-8	0.1	1000	0.000257	2.57
	Water	7732-18-5	98.9			
Bisulfite	sodium hydrogen-sulphite	7631-90-5	40	400000	0.262908	2629.08
	Water	7732-18-5	65			
Basic cleaning agent	Tetrasodium ethylene diamine tetraacetate	64-02-8	15	150000	0.300105	3001.05
	Sodium Hydroxide	1310-73-2	10	100000	0.200070	2000.70
	Sodium Ethylhexyl Sulfate	126-92-1	3	30000	0.060021	600.21
	Water	7732-18-5	91			
Acid cleaning agent	Citric Acid	77-92-9	15	150000	0.302904	3029.04
	Sulphamic Acid	5329-14-6	10	100000	0.201936	2019.36
	PO-EO Block Polymer	9003-11-6	5	50000	0.100968	1009.68

Substance	Component	CAS No.	%Mass (max)	µg/L (max)	%effluent (max)	µg/l in effluent (max)
	Water	7732-18-5	91			
Sulfuric Acid	Sulfuric Acid (Dischared as sulfate)	7664-93-9	99	990000	0.424859	4248.59
	Residue on ignition		0.05	500	0.000215	2.15
	Free Sulpher Dioxide	7446-09-5	0.01	100	4.3E-05	0.43
	Total Chloride (HCl)	7647-01-0	0.0025	25	1.1E-05	0.11
	Oxides of Nitrogen	7697-37-2	0.0015	15	6.4E-06	0.064
	Ammoniacal Nitrogen	1336-21-6	0.0005	5	2.2E-06	0.021
	Iron (Fe)	7439-89-6	0.004	40	1.7E-05	0.17
	Antimony (Sb)	7440-36-0	0.0001	1	4.3E-07	0.0043
	Arsenic (As)	7440-38-2	0.0001	1	4.3E-07	0.0043
	Cadmium (Cd)	7440-43-9	0.000005	0.05	2.2E-08	0.00021
	Lead (Pb)	7439-92-1	0.0005	5	2.2E-06	0.021
	Mercury (Hg)	7439-97-6	0.00007	0.7	3E-07	0.003
	Selenium (Se)	7782-49-2	0.0005	5	2.2E-06	0.021
Caustic Soda	Sodium Hydroxide	1310-73-2	51	510000	0.588761	5887.61
	Sodium Carbonate	497-19-8	0.1	1000	0.001154	11.54
	Sodium Chloride	7647-14-5	0.01	100	0.000115	1.15
	Sodium Sulfate	7757-82-6	0.01	100	0.000115	1.15
	Sodium Chlorate	7775-09-9	0.006	60	6.9E-05	0.69
	Iron	7439-89-6	0.0005	5	5.8E-06	0.058
	Mercury	7439-97-6	0.000005	0.05	5.8E-08	0.00058
	Nickel	7440-02-0	0.0001	1	1.2E-06	0.012
	Cadmium	7440-43-9	0.00005	0.5	5.8E-07	0.0058

Substance	Component	CAS No.	%Mass (max)	µg/L (max)	%effluent (max)	µg/l in effluent (max)
	Arsenic	7440-38-2	0.0001	1	1.2E-06	0.012
	Chromium	7440-47-3	0.00005	0.5	5.8E-07	0.0058
	Lead	7439-92-1	0.000025	0.25	2.9E-07	0.0029
	Antimony	7440-36-0	0.00024	2.4	2.8E-06	0.028
	Selenium	7782-49-2	0.00024	2.4	2.8E-06	0.028

Table C 3: Test 5 for substance with a maximum discharge concentration above their PNEC

Substance	ATMP Acid	(Reaction mass of 5-chloro-2-methyl-2H-isothiazol-3-one and 2-methyl-2H-isothiazol-3-one	sodium hydrogen-sulphite	Tetrasodium ethylene diamine tetraacetate	Sodium Ethylhexyl Sulfate	Citric Acid	Sulphamic Acid
Water Depth (m)	3	3	3	3	3	3	3
Discharge rate (m^3)	0.07	0.07	0.07	0.07	0.07	0.07	0.07
Release conc. (µg/l)	218.19	77.10	2629	3001	600.21	3029	605.81
Discharge rate x Release conc. (A)	15.27	5.40	184.04	210.07	42.01	212.03	42.41
Background conc.	0	0	0	0	0	0	0
EQS/PNEC	40	3.39	110	283	13.57	44	180
EQS - Background conc. (B)	40	3.39	110	283	13.57	44	180

Substance	**ATMP Acid**	**(Reaction mass of 5-chloro-2-methyl-2H-isothiazol-3-one and 2-methyl-2H-isothiazol-3-one**	**sodium hydrogen-sulphite**	**Tetrasodium ethylene diamine tetraacetate**	**Sodium Ethylhexyl Sulfate**	**Citric Acid**	**Sulphamic Acid**
EVF (A/B)	0.382	1.592	1.673	0.742	3.096	4.819	0.236
< 3?	YES	YES	YES	YES	NO	NO	YES

APPENDIX D: RESPONSES TO PRE-APPLICATION COMMENTS

EA comment	Section(s)	Page(s)	EA review priority (H / M / L)	EA review comments	Further EA notes/comments	HPC response to EA comments
1	Non-technical summary	3 and 4	H	Need an in combination assessment for copper and zinc where substances have limits in other activities on the permit.	Copper and zinc discharges are permitted under activities E2, F and H (current permit EPR/JP3122GM)	In combination aftects have been assessed using the previously assessed values in previous permit applications. Overall concentration of Copper and Zinc in the discharge will actually be reduced through dilution when this effluent stream is added. See Section 3.2.2
2	Non-technical summary	4	M	Need to consider the breakdown of chemicals, especially chlorine, and how they will react in the marine environment.	Note that total residual oxidant (TRO) and chlorination by-products (CBPs) are discussed and assessed within the HPC operational permit's decision document (e.g., paragraphs 139, 150, 153, 290 to 295, 325 to 326, 360, and 422 to 423). Do any of the Chlorination by-products (CBPs) need to be considered in the risk assessment? For the operational SZC WDA permit, the following assessment standards were utilised; for TRO (MAC EQS (95%ile) of 10µg/l) and Bromoform (at SZC a PNEC of 5.0µg/l (95%ile) was used for the assessment of bromoform)	Text added to the body of the report to address this.
3	Non-technical summary	4	M	Query what analysis was done for zinc and free chlorine to reach the limits stated.	Based on analysis of the potable water a limit of 140µg/l is proposed. - Zinc "Based on this analysis a limit of 1,200µg/l is proposed." - Chlorine	The permit limits requested have been derived from the site's collection of potable water quality data. This data was collected from several locations around the site as part of the site's validation of the "wholesomeness" of the drinking water supply. The data is provided in Appendix B of the application report.
4	Non-technical summary	4	M	It is stated *"A number of products are required to maintain the efficiency of the demineralised water plant including by "cleaning in place" and the prevention of biofouling".* Need to reflect that these products contain constituent chemicals/substances for which there may be EQSs/PNECs that need to be considered and risk assessed. We will need to review and confirm any proposed PNECs with our ETAS team as part of the determination process (for use in our determination and HRA, CROW Act assessments etc)		The assessment of these constituent chemicals has been completed and is set out in Section 3.3 of the application report. PNECs have been taken, where possible, from the European Chemicals Agency database.

5	List of tables and figures, and 2.1	6 and 9	L	The legend for figure 1 on page 6 states that Corallina features will be marked by number. However, no features are marked on map provided in figure 1 on page 9. Please provide clarity on this, and indicate if this is included within an additional figure, revised version of figure 1, or if the updated version of TR550 includes this detail. Additionally, please also confirm the location of Outlet 12 with an appropriately marked label. (as there may be interested parties who are unfamiliar with the existing discharge locations associated with the jetty).		The figure has been replaced with a simpler one just showing the discharge location. Ecological details are presented in CEFAS reports TR428 and TR550 and therefore it is not repeated in the application report.
6	1.3	7	L	It is stated *"An increase in the permitted concentration of Copper from 0µg/l to 102µg/l;"* . Should this be amended to state "An increase in the permitted concentration of total Copper from 0µg/l to 102µg/l"?		Reworded for clarity - See Section 1.3
7	1.3	7	M	It is stated on three of the bullet points that HPC are requesting an "increase" in the permitted concentration of copper, free chlorine and total zinc. However, Activity I does not currently permit the discharge of any concentrations of copper, zinc and free chlorine (and the residual chemical substances from products used in the process). The proposal is therefore a request for the "addition" of these substances within the Activity I discharge, rather than for increases (as you have previously described in your non technical summary (page 4, paragraph 4)).		Reworded for clarity - See Section 1.3
8	1.3	7	L	It is stated "*Allowing the discharge of essential products needed for the demineralised water plant that have been assessed and do not present an unacceptable risk* ". This should be amended to state "Allowing the discharge of essential products needed for the demineralised water plant that have been assessed and do not present an unacceptable environmental risk"		Reworded for clarity - See Section 1.3
9	1.5	8	L	For the abbreviation of TRO, the definition states "Total Residual Oxygen". This should instead state "Total Residual Oxidant".		Corrected - See Section 1.5
10	2.2	10	M	Effluent characteristics - Will this discharge still be buoyant? What is its density?	Page 14 says "As the discharge is buoyant, exceedance at the bed was only expected within a very short distance (less than 5 m) of the discharge itself." However, high amounts of potassium salts are added in addition to the already saline groundwater	An estimate of the total dissolved solids within the potable water supply has been made utilising the electrical conductivity data collected; this total dissolved solids value was then utilised to estimate the total dissolved solids concentration in the waste from the demin plant; the effluent is still low TDS and therefore buoyant relative to sea water. This water is 93% of the total volume discharged from the demin plant and thus we are confident that the overall discharge is buoyant. See section 2.3.5

11	2.3.1	10	L	It is stated *"Wastewater from the demineralised water plant may contain a maximum of 102 µg/l of copper "*. Please update this to clarify if this maximum applies to total or dissolved copper.		Clarification is still being sought on thisfrom the laboratory.
12	2.3.1 and 2.3.3	10 and 11	M	It is stated on page 10: *"However, due to the operational needs of the CETP plant it will not always be possible to run both the ion exchange columns at all times (this would be during cleaning or backwashing of the system) and when only one column is in use copper concentrations in the effluent could be above the EQS value (~100 µg/l, see Appendix B, Table 3). "* It is stated on page 11: *"Whilst it is intended that free chlorine will be removed from the potable supply in advance of demineralisation (through the use of sodium bisulphite), and also in the CETP through the granulated activated carbon filter . However, some breakthrough is still possible."* The operation of the CETP/ion exchange columns is likely to require an operating technique(s) within any granted permit due to its linkage with the proposed discharge activity and concentrations of copper/chlorine etc. An initial draft/description of the general process (i.e. for any worst case discharge concentration) will be required for determination of the permit (could result in a Schedule 5 info request during determination if not provided with the application), with the potential for aspects to be covered via pre-operational conditions (for submission by HPC to the EA for review and written approval within an agreed timescale at a later date) if the exact process/operating methodology for the CETP has not yet been finalised.		There is already a requirement for an Operating Techniques Report for Activity I (PO10 becoming OT13 when approved) which will provide these details. It should be noted that the plant's treatment solution has not substantially changed since Activity I was added to the permit under Variation 009/010. If deemed necessary NNB HPC would not object to a similar condition being imposed for the demineralisation plant effluent.
13	2.3.1	10	M	Copper concentrations stated as being above EQS value during cleaning or backwashing of the system. How often would this occur and what would be the duration of the batched discharges?		The periodicity of backwashing will depend on the volumes as effluent being treated and upon verification and optimisation testing to be completed during commissioning. It is therefore not possible to provide a fixed number but it will only be undertaken when the treatment demand is high. during less demanding periods the effluent treatment will be suspended during backwashing so that both columns can be regenerated as this will recover more copper and therefore save money. It should also be noted that when this waste stream with slightly elevated copper is discharged, it is not a new effluent stream - it is the treated effluent just with more of the copper catalyst leaving site.
14	2.3.2	11	M	It is stated "It is noted that zinc discharges are permitted under activities E2, F and H at significantly higher levels". Please clarify by replacing "levels" with "concentrations".		Fixed- See Section 2.3.2

15	2.3.4	11	M	It is stated *"No limit is being requested for these substances".* Please be aware that although no limits are requested by the applicant, compliance limits and/or effluent monitoring may potentially be required and therefore be included within any granted permit for some or all of the proposed discharge substances (as will be confirmed by the EA and communicated to HPC during the determination of the WDA permit application).		NNB HPC recognises this but notes that for many of the substances it is unlikely that accredited analysis to the limits that are likely to be needed is possible in commercial laboratories in real-world effluents with potential interference effects.
16	2.3.4 (table 1)	11 to 12	M	The material safety data sheets (MSDSs) for the proposed dosing/cleaning products are likely to be required to support the determination of the permit variation.		The Safety Data Sheets for the products to be used have been reviewed by NNB HPC. In many cases they do not provide full details only the minimum information required by law. To enable the detailed assessment presented in the Application Report to be undertaken full composition was obtained under an Non-Disclosure Agreement. Provision of the SDSs would enable third parties like the composition information the branded product in breach of this agreement.
17	3.1	12 to 13	H	The proposed methodology does not appear to account for the annual significant load test for any priority hazardous substances (PHSs) identified in the proposed discharge (or within the constituent chemicals of the proposed chemical products identified within table 4). From a quick scan it appears this test would need to be completed by HPC for the proposed discharges of cadmium and mercury.		Calcs completed, both substances passed PHS screening test along with Test 1 of H1 assessment - See Section 3.3.3
18	3.1 and 3.3.1 (tables 3 and 4)	11, 12 and 15 to 19	H	Please clarify how you have considered annual average (AA) and maximum allowable concentration (MAC) EQSs values, as well as long and short term (aka chronic and acute) PNECs for the proposed substances/chemicals in your proposed H1 risk assessment methodology.		AA and MAC have now both been included in the assessment where relevant (See Table 6). PNEC's are calculated from available chronic and acute data and are always based on the lowest observed toxicity value over all species tested. Therefore, any PNEC used will consider the worse-case scenario toxicity and should be acceptable as a standalone metric for both long and short term toxicity when carrying out the assessment.
19	3.1	12	L	It is stated "*• Test 1: Check if the discharge concentration is above the Environmental Quality Standard (EQS) or Predicted No Effect Concentration (PNEC) for each substance. If yes, Test 2 was carried out".* Please clarify in the revised version of the document that test 1 applies to 100% of the EQS *(e.g. "Check if the discharge concentration is above 100% of the Environmental Quality Standard" (EQS)).*		Fixed- See Section 3.1
20	3.2.1 and Appendix B	13 and 35	M	Need to clarify DOC to work out correct copper EQS: 4.76, rather than 3.76?	If 3.76 is correct, this is lower than the quoted background?	A DOC value of 1.75mg/l has been used based on the 2009 baseline (Amec report), and a review of recent data from the EA's monitoring suggests this remains conservative. Fixed based on justification- See Section 3.2.1
21	3.2.1	14	L	Need to clarify that TR428 didn't model EVF.		Fixed

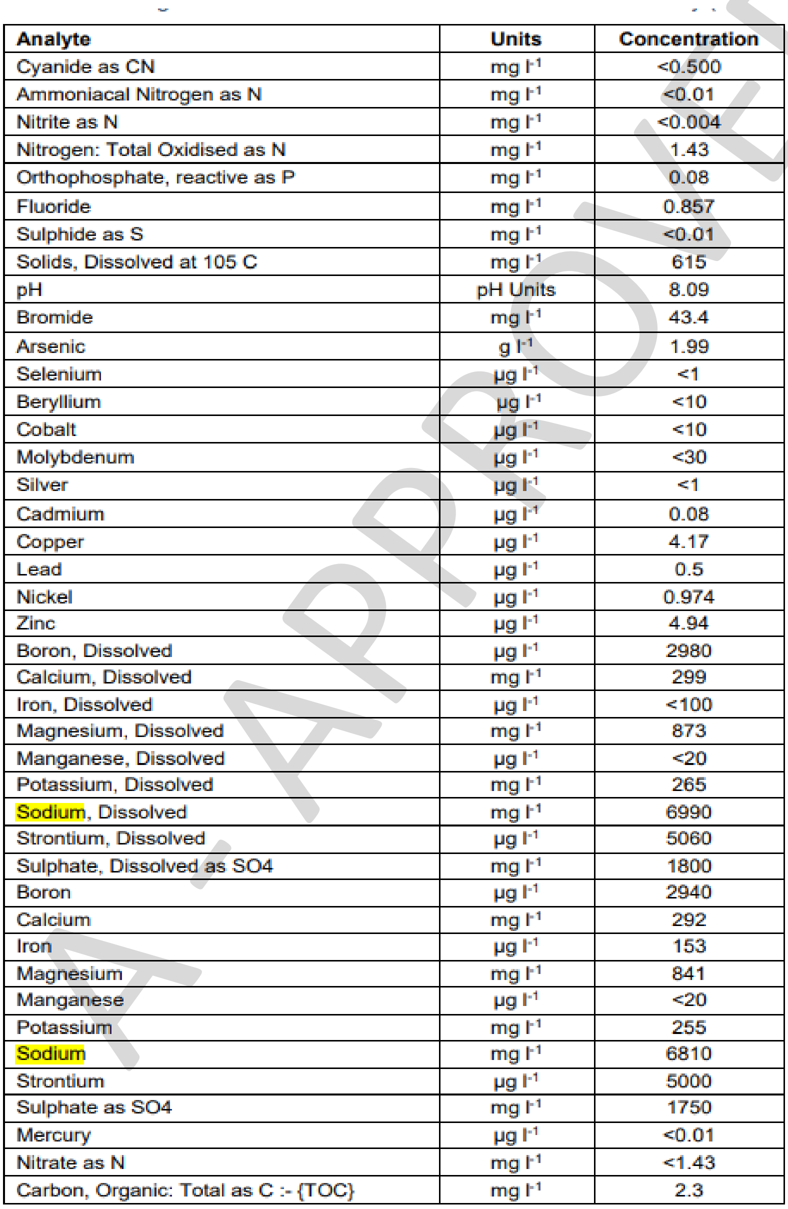
22	3.3.1	15 to 19	For awareness only	Table 3- we will need our chemicals assessment team (ETAS) to check and agree the suggested PNECs.	This is an EA action but we want to be sure that HPC is aware that we will be consulting our ETAS (Ecotoxicology advisory service) internally on these during the determination of the variation, and may need to revise the assessment of some of the proposed discharge substances/chemicals.	Noted.
23	3.3.1	17 (table 4)	H	Citric acid - quoted EQS/PNEC at 44µg/l, but lower quantities found i.e. marine PNEC of 36µg/l (via Ref 3). Additionally, our ETAS team have previously advised (in 2013) of chronic and acute PNECs of 16ug/l (Long term/Chronic) and 160ug/l (Short term/Acute) for Citric Acid which should be incorporated into your assessment.		The references provided by the Environment Agency appears to be for a salt of nickel and citrate and therefore not applicable to the citrate that will be used at HPC. In the absence of a source we can references for the 2013 values the report retains the publicly available values (See table 6).
24	3.3.1	16	H	Cadmium - quoted EQS/PNEC at 1.14µg/l, but lower quantities found in government guidance at 0.2µg/l (Ref 4). Cadmium has a TRAC EQS (AA) of 0.2µg/l which must be used for any environmental assessment. Please ensure the appropriate EQS is considered in your assessment.	Cadmium is also a PHS (priority hazardous substance) and so the risk assessment will also need to incorporate the annual significant load test (aka 'part B screening'), which is required regardless of if a PHS screens out as environmentally insignificant via tests 1 to 5 (aka 'part A screening). This requirement is stipulated on GOV.uk and within our guidance for the permitting of hazardous substances to surface waters (LIT13134, section 2.4.2)).	Fixed- Passed PHS screening. See Section 3.3.3
25	3.3.1	16	M	Lead - quoted EQS/PNEC at 3.3µg/l, but lower quantities found in government guidance annual EQS at 1.3µg/l, but max EQS is 14µg/l (Ref 4).	Lead has an AA TRAC EQS of 1.3µg/l and a MAC TRAC EQS of 14µg/l. These values will need to be considered in the assessment of Lead.	Fixed- See Table 6
26	3.3.1	16	H	Mercury - possible units error, but quoted EQS/PNEC at 67.2µg/l, but lower quantities found in government guidance (as mercury has a MAC EQS of 0.07µg/l (Ref 4). Please ensure the relevant EQS is applied to your assessment.	Mercury is also a PHS (priority hazardous substance) and so the risk assessment will also need to incorporate the annual significant load test (aka 'part B screening'), which is required regardless of if a PHS screens out as environmentally insignificant via tests 1 to 5 (aka 'part A screening). This requirement is stipulated on GOV.uk and within our guidance for the permitting of hazardous substances to surface waters (LIT13134, section 2.4.2)).	Fixed- Passed PHS screening. See 3.3.3
27	3.3.1	16 to 19	M	Please ensure clarification is provided regarding total and dissolved metals (e.g. for iron and mercury), as well as the type of chromium (e.g. is total/dissolved, and trivalent or hexavalent being referenced). This clarification will also ensure there is no confusion with readers during the application's publication and consultation phase.		Report has been updated where this information is available.

28	3.3.1 and Appendix C	16 and 38	M	Variation in copper nitrate: 0.303µg/L for max discharge in table 4 (page 16) but max in wastewater is 2.752µg/L in Table C (page 38) - clarify the difference?		Fixed- See Table 6 and table C2
29	3.3.1	17	H	Sulfuric acid has a dilution factor of 18,197 but it then completely discounted and it is concluded there will be no impact. Please provide clarification and supporting evidence why this large proposed volume of sulfuric acid is environmentally acceptable?	At the pre-app meeting, we were told that HPC would not be discharging this high concentration of sulfuric acid, but the report needs to be updated to explain the processes it will undergo and what will be discharged.	Sulfuric acid will (as a strong acid) dissociate into hydrogen ions and sulphate ions so in chemical terms there will be no such thing as sulfuric acid present. pH will be controlled at the demin plant through a "neutralisation pit" so that the pH is always within the permitted range. the sulfate concentration is well below the naturally occurring background (1.8 grams/litre as per TR428). The "neutralisation pit" will monitor the pH in real time and add acid or alkali as required to bring the pH to within the permitted range and this effluent will be only be discharged when compliant.
30	3.3.1	18	H	Although the correct TRAC EQS (AA) for Nickel (8.6µg/l) has been referenced for the assessment, it also has a MAC EQS (34µg/l) that must also be considered in the assessment too. Please ensure AA and MAC EQSs are considered in the assessment.		Fixed- See Table 6
31	3.3.1	18	H	Assumed the AA TRAC EQS for hexavalent chromium has been applied in table 4 (0.6µg/l). It also has a MAC TRAC EQS of 32µg/l that needs to be assessed too.		Fixed- See Table 6
32	3.3.1	18 and 19	H	Arsenic is included within table 4 twice (for Sulphuric Acid and Caustic Soda) with a PNEC stated as 4.7µg/l. However, Arsenic has a TRAC EQS (AA) of 25µg/l which should be used for any H1 environmental risk assessment. Please confirm why 4.7µg/l is proposed and update the risk assessment accordingly.		Fixed- See Table 6. Statutory value is adopted.
33	3.3.1 and Appendix C	18 and 39	L	Table 4 vs Table C doesn't consistently use the same decimal places / rounding. Please ensure consistency is provided.	I.e. Sodium hydroxide 6300 / 6304	Fixed- All to 2 d.p now
34	3.3.2	20	H	Citric acid and sulphuric acid, are both quoted as "minimal effect". However, as per the EA references 1 and 2 (via tab 2), these substances/acids are potentially "very toxic to aquatic life"	Please provide further explanation of how citric acid and sulphuric acid will be neutralised and will be of low environmental risk as part of the proposed discharge	Information for both acids is taken from the ECHA REACH page for the relevant substance. These are referenced in the References Section. As now detailed in the Application Report, the pH of effluent discharged from the demineralisation plant will be automatically adjusted to between 6 and 9 such that sulfate and citrate will be present rather that the associated acids. The sulfate concentration will be below the naturally-occuring concentrations in the estuary and citrate, as a naturally-occurring short-chain organic acid is highly biodegradable
35	3.3.2 and 3.4	20 and 21	M	pH 6-9 is a very wide range, please provide clarification to confirm how this will be managed	Question of could it effect sensitive species like Corallina and Sabellaria?	These are the limit values that have been included for each activity permitted under the HPC CWDA permit, and indeed the Operational WDA permit. These limit values are also widely used outside of HPC. Additional explanation around how pH will be managed has been provided within the Application Report (Section 3.4).

36	3.4	21	M	Please provide additional information regarding the potential effluent treatment options and associated costs (i.e. of any treatment options and tankering offsite for appropriate treatment and disposal). As this justification will be required to support the determination.		The volume of effluent produced by the demineralised water plant maximum production is ~30m3/hr i.e. more than one articulated tanker per hour; it is not considered practicable or desirable to transport this volume of dilute effluent from off-site disposal. It is also noted that any potential authorised receiving site would not be explicitly treating for the substances of concern and thus there would be no real environmental benefit form this.
37	4	22	M	The proposals (as discussed by HPC in the bullet points) are not increases of existing discharges, they for additional concentrations of substances not currently included within the permit for activity I. Please ensure clarification is included on this point within the revised supporting information report (as this will help ensure consistency and reduce the potential for confusion of any interested parties reviewing the documents during the publication and consultation stage).		Fixed- See Section 4
38	Appendix B	28 to 33	L	Appendix B has Fire Hydrant sampling sites? Clarity would be beneficial.		Fire hydrants use the same potable water that will be taken in by the demineralisation plant, and so were used as sample sites.
39	Appendix B	34	M	Table B has different background values for copper and zinc compared to TR428 page 87 from Amec 2009. Please provide clarification regarding this differences.		TR428 REV 14 includes the correct copper and zinc values and was included in this report. TR428 rev14 was sent to the EA following pre app discussions.
40	General	General	H	Please note, a shadow/supporting HRA and CROW Act report will need to be submitted with the permit application (ideally it would be shared as part of the pre-app process. This should provide supporting information as per the minimum requirements previously shared in our NNB Habitats Regulations Assessment checklist (as shared with HPC via e-mail (from Alex Evans to Chris Fayers, James Holbrook and Ross Pettigrew on 13/10/2023)	This could be provided as a running update to the latest version of TR550.	An updated TR550 (Shadow HRA) is included in the application pack.
41	General	General	H	Add references to statements when describing processes and environmental effects.	As requested during pre-app meeting held on 07/03/2024, we need to be able to review any cited references as part of our determination process.	Fixed
42	General	General	L	Please confirm there will be no nitrogen in any breakdown products via the proposals for CWDA12?	Otherwise this will need in combination assessment with HPC variation 11 (CWDA11). HPC suggested during the pre-app call held on 07/03/2024 that there will be no nitrogen.	No substances that yield dissolved inorganic nitrogen are being used in the processes given rise to the effluents assessed in this variation application.

APPENDIX E: BACKGROUND VALUES FOR CONTAMINANTS IN THE SEVERN ESTUARY INCLUDED IN TR428 (CEFAS,2021)

Table E 1 Background contaminants in the Severn Estuary



Analyte	Units	Concentration
Cyanide as CN	mg l^{-1}	<0.500
Ammoniacal Nitrogen as N	mg l^{-1}	<0.01
Nitrite as N	mg l^{-1}	<0.004
Nitrogen: Total Oxidised as N	mg l^{-1}	1.43
Orthophosphate, reactive as P	mg l^{-1}	0.08
Fluoride	mg l^{-1}	0.857
Sulphide as S	mg l^{-1}	<0.01
Solids, Dissolved at 105 C	mg l^{-1}	615
pH	pH Units	8.09
Bromide	mg l^{-1}	43.4
Arsenic	g l^{-1}	1.99
Selenium	µg l^{-1}	<1
Beryllium	µg l^{-1}	<10
Cobalt	µg l^{-1}	<10
Molybdenum	µg l^{-1}	<30
Silver	µg l^{-1}	<1
Cadmium	µg l^{-1}	0.08
Copper	µg l^{-1}	4.17
Lead	µg l^{-1}	0.5
Nickel	µg l^{-1}	0.974
Zinc	µg l^{-1}	4.94
Boron, Dissolved	µg l^{-1}	2980
Calcium, Dissolved	mg l^{-1}	299
Iron, Dissolved	µg l^{-1}	<100
Magnesium, Dissolved	mg l^{-1}	873
Manganese, Dissolved	µg l^{-1}	<20
Potassium, Dissolved	mg l^{-1}	265
Sodium, Dissolved	mg l^{-1}	6990
Strontium, Dissolved	µg l^{-1}	5060
Sulphate, Dissolved as SO4	mg l^{-1}	1800
Boron	µg l^{-1}	2940
Calcium	mg l^{-1}	292
Iron	µg l^{-1}	153
Magnesium	mg l^{-1}	841
Manganese	µg l^{-1}	<20
Potassium	mg l^{-1}	255
Sodium	mg l^{-1}	6810
Strontium	µg l^{-1}	5000
Sulphate as SO4	mg l^{-1}	1750
Mercury	µg l^{-1}	<0.01
Nitrate as N	mg l^{-1}	<1.43
Carbon, Organic: Total as C :- {TOC}	mg l^{-1}	2.3

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CWDA – VARIATION 12 APPLICATION

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APPENDIX F: CEFAS BEEMS TECHNICAL REPORT TR428; HINKLEY POINT C CONSTRUCTION DISCHARGE MODELLING ASSESSMENT AT THE TEMPORARY JETTY LOCATION

Cefas BEEMS Technical Report TR428; Hinkley Point C construction discharge modelling assessment at the temporary jetty location

NOT PROTECTIVELY MARKED

DOCUMENT TITLE	Cefas BEEMS Technical Report TR428; Hinkley Point C construction discharge modelling assessment at the temporary jetty location.

ISSUE REASON	P6 - For Construction

CONTRACTOR DETAILS

CONTRACTOR NAME	Cefas		
CONTRACTOR DOCUMENT NUMBER	BEEMS Technical Report TR428	**CONTRACTOR REVISION**	14

ECS CODES

REVISION HISTORY

REVISION	REVISION DATE	PREPARED BY	POSITION/TITLE	CHECKED BY	POSITION/TITLE	APPROVED BY	POSITION/TITLE
01	14/08/2017	Liam Fernand	Principal Physical Oceanographer	Dave Sheahan	Principal Scientist	Dean Foden	Hinkley Point lead
02	13/09/2017	Liam Fernand	Principal Physical Oceanographer	Dave Sheahan	Principal Scientist	Brain Robinson	Programme director
03	15/09/2017	Liam Fernand	Principal Physical Oceanographer	Dave Sheahan	Principal Scientist	Dean Foden	Hinkley Point Lead
04	19/10/2017	Dave Sheahan	Principal Scientist	Liam Fernand	Principal Physical Oceanographer	Liam Fernand	Principal Physical Oceanographer
05	25/10/2017	Dave Sheahan	Principal Scientist	Liam Fernand	Principal Physical Oceanographer	Brian Robinson	Programme Director
06	09/04/2018	Liam Fernand	Principal Physical Oceanographer	Dave Sheahan	Principal Scientist	Dean Foden	Hinkley Point Lead
07	20/04/2018	Dean Foden	Hinkley Point Lead	Dave Sheahan	Principal Scientist	Dave Sheahan	Principal Scientist
08	08/06/2018	Liam Fernand	Principal Physical Oceanographer	Dave Sheahan	Principal Scientist	Dean Foden	Hinkley Point Lead
09	26/01/2021	Liam Fernand	Principal Physical Oceanographer	Dave Sheahan	Principal Scientist	Dean Foden	Hinkley Point Lead
10	23/03/2021	Dave Sheahan	Principal Scientist	David Haverson	Modelling Lead	Dean Foden	Hinkley Point Lead
11	24/03/2021	Dave Sheahan	Principal Scientist	David Haverson	Modelling Lead	Dean Foden	Hinkley Point Lead
12	10/06/2021	Dave Sheahan	Principal Scientist	David Haverson	Modelling Lead	Dean Foden	Hinkley Point Lead
13	25/06/2021	Dave Sheahan	Principal Scientist	David Haverson	Modelling Lead	Andrew Griffith	Principle Investigator
14	24/11/2021	Dave Sheahan	Principal Scientist	David Haverson	Modelling Lead	Andrew Griffith	Principle Investigator

REVISION STATUS/SUMMARY OF CHANGES

Revision	Purpose	Amendment	By	Date
01	Initial release		LF	14/08/2017
02	Update	Revision following client comments	LF	13/09/2017
03	Update	Revised TBM chemicals source terms	LF	15/09/2017
04	Update	Revision following client comments	DS	19/10/2017
05	Update	Revision following regulator comments	DS	25/10/2017
06	Update	Revision following addition of sections on sewage discharge and coliforms	LF	9/04/2018
07	Update	Minor update in response to EDFE comments	DF	20/04/2018
08	Update	Update in response to comments from the Environment Agency	LF	08/06/2018
09	Update	Update to include cold commissioning	LF	26/01/2021
10	Update	Revision following client comments	DS	23/03/2021
11	Update	Revision following client comments	DS	24/03/2021
12	Update	Revision following EA and client comment	DS	10/06/2021
13	Update	Revision following EA and client comment	DS	25/06/2021
13	Update	Table correction following EA and client comment	DS	24/11/2021

Hinkley Point C construction discharge modelling assessment at the location of the temporary jetty Revision 14

Hinkley Point C construction discharge modelling assessment at the location of the temporary jetty Revision 14

Dave Sheahan, Liam Fernand, Amelia Araujo, Tiago Silva, Berrit Bredemeier, Lenka Fronkova, Jonathon Beecham, Mark Breckels, Gemma Kiff, Richard Harrod.

Version and Quality Control

	Version	Author	Date
Draft with source terms updated from Edition 1 and the inclusion of tunnel boring and sewage discharges	0.01	Liam Fernand	09/08/2016
Executive QC	0.02	Dean Foden	10/08/2017
Revision	0.03	Liam Fernand & Dave Sheahan	11/08/2017
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Revised TBM chemicals source terms	2.01	Liam Fernand	12/09/2017
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Revision following client comments	4.01	Liam Fernand	14/09/2017
Executive QC & Final Draft	4.02	Dean Foden	15/09/2017
Revision following regulator comments	4.03	Liam Fernand	16/10/2017
Executive QC & Final Draft	4.04	Brian Robinson	18/10/2017
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Correction in response to client comment	13.01	David Sheahan	23/11/2021
Executive QC & Final Draft	13.02	Andrew Griffith	24/11/2021
Submission to EDFE as Revision 12	14.00		24/11/2021

Table of contents

List of Tables and Figures

Tables

Figures

Abbreviations and Glossary

Abbreviation / Term	Definition
AEVF	Allowable Effective Volume Flux
BOD	Biological oxygen demand
CETP	Commissioning Effluent Treatment Plant
CPM	Combined Phytoplankton and Macroalgal Model
CWDA	Construction Water Discharge Activity
CWW	Cementitious Washwater Water
DIN	Dissolved inorganic nitrogen
EQS	Environmental Quality Standard
EVF	Effective Volume Flux
CWW	Cementitious wastewater
GETM	General Estuarine Transport Model
HXA	KER, TER, SEK Tanks
KER	Liquid Radwaste Monitoring and Discharge System
MAC	Maximum Allowable Concentration
MSFD	Marine Strategy Framework Directive
NTU	Nephelometric Turbidity Units
PNEC	Predicted No Effect Concentration
PSU	Principal Salinity Units
SCL	Spray Concrete Lined
SEK	Conventional Island Liquid Waste Discharge System Tanks
TBM	Tunnel Boring Machine
TER	Additional holding tanks for return to liquid waste treatment
TraC	Transitional and Coastal
UV	Ultraviolet
WDA	Water Discharge Activity
WFD	Water Framework Directive

Executive summary

Cefas has been commissioned by NNB Generation Company (HPC) Ltd (NNB GenCo) to assess the priority substances and specific pollutants present in various discharges, to be made under a proposed Construction Water Discharge Activity (CWDA) permit application, at the location of the temporary jetty at Hinkley Point C (HPC). Dilution and dispersion of the substances in the marine environment have been investigated using a validated GETM (General Estuarine Transport Model) model of Hinkley Point (see BEEMS Technical Report TR267 Edition 2).

The contaminants of concern at the jetty discharge are:

1. Groundwater from the dewatering system which contains metals and dissolved inorganic nitrogen (DIN) and ammoniacal nitrogen.
2. Treated sewage discharge which contains DIN and ammoniacal nitrogen from three permanent treatment units.
3. Effluent from tunnel excavations containing small amounts of Tunnel Boring Machine (TBM) soil conditioning chemicals and variable quantities of groundwater containing metals and DIN and ammoniacal nitrogen.
4. Addition of nutrients, ammoniacal nitrogen and other process chemicals resulting from cold commissioning of the turbines and associated pipework.
5. Cementitious washwater (CWW)
6. Commissioning discharge of hydrazine.
7. Commissioning discharge considering hydrazine, ethanolamine contribution to ammoniacal nitrogen,
8. Commissioning discharge considering hydrazine, ethanolamine contribution to nitrogen and trisodium phosphate contribution to phosphorus.

Version History

In Edition 2, analysis of the treated sewage discharge and the discharge from the tunnelling operations was added. Of all the groundwater chemicals released, zinc is released in the highest concentrations compared to the Environmental Quality Standard (EQS). Edition 2 used values for background concentrations supplied by the Environment Agency (EA) which are statistically more robust than previously used concentrations, and which were also lower than in Edition 1 of this report. As modelling was performed above the background concentration of the contaminant of interest, the difference between the EQS for zinc and the background concentration increased from 1.8 µg l^{-1} (used in Edition 1) to 4.18 µg l^{-1}.

In Edition 3, the source terms for the TBM soil conditioning chemicals (obtained from NNB GenCo's tunnel boring contractor) were revised.

In Edition 4, Figure 1 was updated to show muck bay drainage. Calculation of various discharge elements were provided in a new Appendix E. In Table 3, some values corrected: the ammonia background value was corrected to represent mean conditions.

In Edition 5, the mean background zinc concentration was corrected to 3.03 µg l^{-1} (previously a 50th percentile value of 2.62 µg l^{-1} was used) producing a new value for the adjusted EQS threshold of 3.77 µg l^{-1}. Minor change / correction to DIN values was carried out. None of these corrections influenced screening pass/fail decisions. In Table 6 Effective Volume Flux (EVF) calculations were corrected, but this did not change any assessments.

The discharge profile was complicated and varies with time during the construction of HPC and so several different cases were considered. The two worst-case discharge profiles were:

i. Case C (April to June 2019 on the August 2017 programme) which included discharges of 20 l s^{-1} of groundwater, 13.3 l s^{-1} of treated sewage and 30 l s^{-1} tunnelling discharge (which consists mostly of groundwater with soil conditioning chemicals from 1 TBM). This discharge had the maximum heavy metal discharge. The DIN discharge was at the predicted maximum loading and was the same as for Case D.

ii. Case D (June 2019 onwards) which includes up to 25 l s^{-1} of groundwater, 13.3 l s^{-1} of sewage and 6 - 7 l s^{-1} of tunnelling discharge from 2 TBMs). This discharge had the maximum concentration of TBM soil conditioning chemicals.

TBMs will be used to excavate the two cooling water intake tunnels and the cooling water discharge tunnel. The largest component of the discharge produced during tunnelling was groundwater.

Ground conditioning chemicals are used at the cutter head to optimise TBM efficiency and include anti-clogging agents, anti-wear components and soil-conditioning compounds. The exact chemical constituents of the ground conditioning chemicals will depend upon the ground conditions encountered on site, and therefore cannot be precisely specified in advance of drilling trials by the tunnelling contractor in 2018. To enable the discharge to be assessed, several potential drilling compounds were reviewed for toxicity and percentage concentration in the drilling fluids; representative products that would represent a worst-case discharge were then selected for assessment.

Changes made in Edition 6

i. Section 4.5 of this report contains revised estimates of the maximum concentration of ammoniacal nitrogen associated with the discharge from the sewage. Edition 5 included estimates of the sewage as a 95th percentile of 5 mg l^{-1}, however the EA wish to permit a maximum concentration and therefore 20 mg l^{-1} has been being used as the maximum concentration. It should be noted that it is the same treatment plant that is proposed in Edition 5 and Edition 6 of this report.

ii. Consideration of coliforms has also been included in sections 4.9 and 5.2.1, including consideration of the potential impact to shell fisheries in section 4.9.

iii. It has also been decided that there will no longer be a sewage discharge across the intertidal at Outlet 1. This has therefore been removed from in combination assessments considered in section 5.

iv. This edition also contains updates to the GETM modelling outputs. There had been concern about concentration spikes that were associated with a particular wind event. These were caused by a mis-match in the handling of the layers of the model (sigma co-ordinates) when it reached low water depths and the way the discharge chemical was being treated: a numerical solver was used to interpolate which produced some model instabilities resulting in erroneously high values. These model instabilities also resulted in some overall underestimation of mean concentrations. Updated modelling has been carried out using 15 layers, providing greater stability than the 20 layers previously modelled. The updated discharge time series has a much clearer tidal signal, and lower peak values, higher mean and higher 95th percentile values, but much lower maximum values than previously, as the erroneous spike no longer occurs. The updated GETM modelling approach is described in section 3 and model outputs are shown in section 4.

Changes made in Edition 7

This edition includes estimates of the effect of the additional nutrients and ammoniacal nitrogen due to the discharge of the breakdown products of hydrazine and other commissioning chemicals during the cold commissioning phase, during which drainage is expected from one or two HXA tanks per day. This has been included as a separate section (4.10). The methodology has three parts;

i) To include the discharge in the GETM model so that the dilution and spreading of the ammonia plume and the potential for impact upon designated features can be considered.

ii) Use of the CPM model to predict the impact upon phytoplankton production and macroalgae production in the wider estuary.

iii) To consider the jetty discharges in the context of a Water Framework and habitats assessment.

Changes made in Revision 10

Following client feedback, the text was edited in several sections to clarify where changes have been made to introduce the commissioning discharge assessment. A section of abbreviations/glossary has also been added at the beginning this report.

Changes made in Revision 11

Minor sections of text were updated following client comments and some edits were made to clarify the keys in several Figures.

Changes made in Revision 12

Following feedback from the Environment Agency additional details have been added to the report to explain the different wastewater streams more fully for the cold commissioning phase and to include reference to the cementitious wastewater discharge. The different discharge scenarios were updated in Table 1 to include new wastewater streams. Data in Table 3 have also been updated to show calculations made by the Environment Agency in the stage 1 Habitats Regulations Assessment. The different discharge rates modelled for hydrazine and commissioning chemical discharges are explained in the context of the use of a hydrazine treatment plant and post treatment storage prior to discharge. Explanation is provided that a separate report BEEMS technical report TR550 provides a more comprehensive assessment of biological quality elements and designated features.

Changes made in Revision 13

Following feedback from the Environment Agency additional details have been added to the report: Corrections and clarification have been made to Table 1 and it is highlighted that Case D discharges during the construction period are those that most represent the situation now and including the period when CWW and commissioning discharges would also take place. Recalculations by the Environment Agency made to groundwater datasets resulted in reductions in nitrogen loading figures and these are shown where applicable. Some small increases in metals discharges also resulted and are indicated but these do not change the assessment. Some further detail was added to explain that the in-combination effects of the small discharge of CWW are unlikely to result in significant changes to the assessment made for in combination inputs from Case D construction activity and from commissioning wastewater.

Changes made in Revision 14

Following further feedback from the Environment Agency (23/11/21) additional details have been added to the report: Corrections and clarification have been made to Table 25 the heading and table values have been edited so that it now shows H1 tests for the combined construction wastewater and the commissioning wastewater discharges for total ammonia and unionised ammonia.

Conclusions

Early versions of this report provided an assessment of the construction discharge only. From version 7 the commissioning inputs of un-ionised ammonia, phosphorus, and nitrogen in combination with the construction inputs of these chemicals are also considered. In the summary below the most precautionary assessment scenario is described. For heavy metals, tunnelling chemicals, and for coliforms and BOD associated with treated sewage, the most precautionary scenario occurred during the construction period. For those assessments that have been updated to incorporate combined commissioning inputs i.e. for DIN, phosphorus and ammoniacal nitrogen, the inputs from combined construction and commissioning are considered. The level of suspended solids concentrations in commissioning wastewater will vary but will be treated to meet agreed permit conditions.

Heavy metals

For Case D, both copper and zinc fail the Environment Agency screening tests. During peak ground water load (Case C) chromium also fails this test, although only marginally and for a period of approximately eight weeks when the flow is predicted to be at a maximum. If the annual average was used, then only zinc would be of potential concern as the copper Effective Volume Flux (EVF) is substantially below the threshold. As zinc was the substance of greatest exceedance this discharge was considered further by detailed modelling. The areas of exceedance for zinc at the surface were 0.3 Ha and 0.125 Ha for Cases C and D respectively. As the discharge is buoyant, exceedance at the bed was only expected within a very short distance (less than 5 m) of the discharge itself. Some small additional metals inputs occur via the CWW discharge, but the discharge rate and concentrations are so low that this is not expected to change the present in combination assessment for Case D construction activity inputs and those from commissioning.

There is no predicted exposure of designated bed features above the EQS at any time.

TBM soil conditioning chemicals

Chemical constituents of TBM ground conditioning products BASF Rheosoil 143 and Condat CLB F5/M failed the initial EQS screening and were investigated further using modelling approaches. With the worst-case chemical constituent (i.e. with the most toxic chemical group) there was no exceedance of the PNEC at the bed and the areas of exceedance at the surface were very small (0.19 ha for Rheosoil 143 and 1 ha for Condat CLB F5/M). This assessment used examples of typical soil conditioning chemicals (primarily different types of surfactants) with particularly low (i.e. the most conservative) PNEC values. Providing the chemical components of any other products selected for soil conditioning have an Effective Volume Flux value at or below 58.7, then areas of exceedance will be the same or less than those shown here for CLB F5 mono-alkyl sodium sulphate.

DIN (construction and commissioning)

Dissolved inorganic nitrogen (DIN) will be released from the jetty discharge point into the estuary during the construction period. Under the Water Framework Directive Standards, the Bridgwater Bay waterbody has 'Moderate' status for DIN. The jetty discharges result in a very localised elevation in DIN in the receiving waterbody and the initial screening test was passed (Table 3).

The average annual uplift from the jetty discharge during year 1 (from construction inputs only) was estimated at 0.36 $\mu mol\ l^{-1}$ relative to a mean annual concentration of 75 $\mu mol\ l^{-1}$ within Bridgwater Bay, and 'Moderate' status was unaffected. Due to high turbidity, productivity in the Severn is light-limited (Underwood, 2010) and the effects of minor additional DIN loading on the designated Severn Estuary features are deemed insignificant and not assessed further. In-combination effects of discharges from HPB are considered in Section 5 and it was concluded that there was no direct intersection between the HPB discharge and the jetty discharge. Based on the results of a Combined Phytoplankton and Macroalgae (CPM) model, this assessment would also apply during the period when the breakdown products of cold commissioning discharge chemical inputs make additional contributions to the construction discharges of nitrogen and phosphorus. Some small additional nitrogen inputs occur via the CWW discharge, but the discharge rate and concentrations are so low that this is not expected to change the present in combination assessment for Case D construction activity inputs and those from commissioning.

Ammoniacal nitrogen (construction and commissioning)

Using the EA calculator to determine the proportion of un-ionised ammonia in construction discharges containing ammoniacal nitrogen, the EQS for un-ionised ammonia (21 µg l^{-1}) was exceeded in Case C_{max} and D_{max}, but only in the immediate vicinity of the discharge (within less than 10 m). Rapid dilution rates mean that the EQS was only exceeded when groundwater discharges and sewage discharges were at their maximum. The total area of EQS exceedance was 0.005 ha and, even during maximum discharges, the initial screening test was passed (Table 3). When combined construction and cold commissioning inputs of un-ionised ammonia are considered, the area above the 21 ug l^{-1} threshold, when using the 95th percentile of ammoniacal nitrogen, is small (maximum 0.2 hectares). For the actual EQS when using the annual average there are no areas of exceedance and for the un-ionised ammonia concentrations associated with *Corallina* and *Sabellaria* features, short term values are less than 25% of the EQS. An additional assessment of the in-combination effects of concurrent sewage discharges from the temporary jetty and HPB are considered below.

For total ammonia concentrations, the modelling shows that at the 25m resolution of the model for the construction and commissioning phase there is no exceedance of values in relation to habitats standards for estuaries (WQTAG086) for ammonium for either the mean (1100 ug l^{-1} (as N)) or of the MAC (8000 ug l^{-1}(as N)). Some small additional ammoniacal nitrogen inputs occur via the CWW discharge, but the discharge rate and concentrations are so low that this is not expected to change the present in combination assessment for Case D construction activity inputs and those from commissioning.

Biological oxygen demand

The sewage treatment works is expected to achieve a maximum concentration of Biological Oxygen Demand (BOD) of 40 mg l^{-1} (i.e. draw down over 5 days) and the indicative Maximum Allowable Concentration (MAC) to be applied in the permit is therefore 40 mg l^{-1}. Using the 13.3 l s^{-1} discharge and a BOD of 40 mg l^{-1}, a daily BOD of 46 kg was calculated. This amount of oxygen would be transferred across 14364 m^2 l of the water surface in a day. The tidal excursion (how far a particle is advected) at Hinkley Point, even on the weakest (neap) tides, is many kilometres, thus there is ample resupply of oxygen from the atmosphere so that no change in oxygen concentration would be observed. No change to this assessment is expected for the additional cold commissioning inputs.

Suspended solids

The background suspended solids concentration in the receiving water is relatively high (with a mean of 264 mg l^{-1} and a minimum of 33 mg l^{-1}). Commissioning activities such as hydrostatic testing and flushing will result in variable suspended solids loadings within resultant effluents. The Commissioning Effluent Treatment Plant (CETP) will incorporate methods to reduce suspended solids to permitted levels prior to discharge.

Coliforms – bathing water standards and shellfish

The discharge point is not in designated bathing waters. Model predictions (which do not consider wave-driven mixing) indicate that treatment from the plant is sufficient to ensure that microbial concentrations in discharged waters comply with bathing water standards within a maximum of 2.8 km from the discharge point (without UV treatment) and within 10 m (with UV treatment). The nearest designated bathing waters are 12 km distant from the jetty discharge and the closest shell fishery is 32 km distant and so no effects on these features are predicted. No change to this assessment is expected for the additional cold commissioning inputs.

Potential in-combination effects with the HPB discharge

This report has considered the potential interaction of the jetty discharges and the sewage discharge from HPB (2.4 km distant). There is no overlap of the plume mixing zone and the HPB discharge, and no interaction occurs because of the physical separation of the discharge locations and the small discharge volume from the jetty.

During the main construction period the total annual loading of DIN has been considered for the two impacted Water Framework Directive designated waterbodies (Bridgwater Bay and River Parrett). The combined effect of HPC (construction discharge at the jetty) plus HPB is to uplift the DIN concentration in the Bridgwater Bay water body by 0.58 μmol l^{-1} and the Parrett waterbody by 2.52 μmol l^{-1}. There would therefore be no change of status: the present mean is 75 μmol l^{-1} and the 99th percentile concentration for Good status in turbid waters is 180 μmol l^{-1}. When considering the additional cold commissioning inputs, the use of a CPM model confirmed that there was no influence of combined inputs of nutrients on phytoplankton production in the estuary.

It is not known what the actual discharge concentration of DIN is from Hinkley Point B, however assuming the same standard of secondary treatment as Hinkley Point C would imply an extent of exceedance of approximately 1.8km. This theoretical exceedance could only occur in very calm conditions. Under such calm conditions the plume would be long and thin and would not interact with the temporary jetty discharge, as the tidal stream lines are physically separate. In practice for most of the time, wave mixing will rapidly dilute the discharged plume so that no interaction could occur.

If UV treatment is applied at HPC then no microbial interaction with HPB is likely.

The thermal plume discharge from HPB has been considered and is expected to raise the mean background sea temperature at the jetty discharge location (where exceedance of the EQS's occurs) by approximately 1°C, this small temperature rise compared to the annual seasonal variation is considered unlikely to have any effect on the toxicity of any of the chemicals or metals considered.

Consideration of the effects of combined discharges from construction and cold commissioning on Water Framework Directive waterbodies and habitats

Due to the high turbidity environment, productivity in the Severn Estuary is light-limited (Underwood, 2010) and the effects of a DIN loading from combined construction and cold commissioning discharges on phytoplankton in the Severn Estuary are considered insignificant. To test this understanding, modelling was undertaken to assess the effects of additional nutrients on phytoplankton production using a Combined Phytoplankton and Macroalgae (CPM) model (Appendix F). Low phytoplankton production was predicted but the addition of nutrients from construction and cold commissioning, including inputs from the HPB, had no effect on production, due to the light limitation. The additional inputs from cold commissioning therefore cause no deterioration in the water body status under the WFD for phytoplankton and have no significant influence on the Marine Strategy Framework Directive (MSFD) area Celtic Sea.

Test for inclusion of habitats in WFD assessment

The tests for inclusion of habitats in a WFD assessment are based on the extent of the footprint of an activity. In this case for combined construction and cold commissioning discharge, the tests are whether habitats contravene any of the following criteria:

i. 0.5km² or larger
ii. 1% or more of the water body's area
iii. within 500m of any higher sensitivity habitat
iv. 1% or more of any lower sensitivity habitat

For tests i., ii. and iv. these criteria are not met. For test iii, the jetty discharge is within 500 metres of *Sabellaria* and *Corallina* habitat and therefore requires further assessment.

Potential effects on higher and lower sensitivity WFD habitats

During the construction period the predicted plume discharge from the jetty is a fresh water source, and is buoyant, therefore the highest concentrations are associated with surface waters. The highest areas of exceedance of standards for all parameters of relevance to a WFD assessment was for one of the tunnelling chemicals, Condat CLB F5/M, for which an area of 1 ha at the surface exceeds the relevant EQS. At the bed, the relevant concentration was predicted to be below EQS within 5 metres of the discharge. Neither mean bed concentrations nor 95th percentile concentrations exceed the EQS, and benthic features should therefore remain unaffected.

Ammoniacal nitrogen discharge is at its maximum during the construction period when cold commissioning wastewater discharges occur. Assessment of combined discharges showed no areas of exceedance for either total ammonia concentrations or the mean un-ionised ammonia EQS at the surface or the bed. An area of only 0.2 ha at the surface was predicted to exceed the EQS for un-ionised ammonia as a 95th percentile. More detailed time series analysis, considering more extreme summer temperatures when the proportion of un-ionised ammonia is likely to be maximal, confirmed that concentrations were less than 25% of the EQS at the locations closest to *Corallina* and *Sabellaria* features. The same assessment would apply to lower sensitivity habitat close to the jetty discharge.

A habitats assessment provided in BEEMS TR443 established that there was either no pathway for effects or no likely significant effects arising from jetty discharges of construction chemical inputs during Case C and Case D, which are considered the most significant inputs during the construction period.

The predicted discharge concentrations of hydrazine used in cold commissioning were evaluated for toxicological effects in BEEM TR445. A discharge concentration of 15 μg l^{-1} was sufficiently precautionary that the acute PNEC was never exceeded at the *Corallina* features and only at *Sabellaria* stations D and E. Furthermore, the plume was very short lived (1-2 hours) and concentrations were well below the acute PNEC (4 ng l^{-1} as a 95th percentile) at all features.

1 Background

Cefas has been commissioned by NNB Generation Company (HPC) Ltd (NNB GenCo) to assess the priority substances and specific pollutants present in various discharges, to be made under a proposed construction Water Discharge Activity (CWDA) permit application, at the location of the temporary jetty at Hinkley Point C (HPC) (to be known as Outlet 12). Dilution and dispersion of the substances in the marine environment have been investigated using a validated GETM (General Estuarine Transport Model) model of Hinkley Point (see BEEMS Technical Report TR267 Edition 2).

The flow rates used for the modelling construction and commissioning discharges are shown in Table 1. The contaminants of concern are:

1. Groundwater from the dewatering system which contains metals and dissolved inorganic nitrogen (DIN) and ammoniacal nitrogen.
2. Treated sewage discharge which contains DIN and ammoniacal nitrogen from three permanent treatment units.
3. Effluent from tunnel excavations containing small amounts of Tunnel Boring Machine (TBM) soil conditioning chemicals and variable quantities of groundwater containing metals and DIN. Input of tunnelling effluent is scheduled to stop in January 2022.
4. Cementitious wastewater discharge (CWW).
5. Commissioning discharge of hydrazine.
6. Commissioning discharge considering hydrazine, ethanolamine contribution to ammoniacal nitrogen,
7. Commissioning discharge considering hydrazine, ethanolamine contribution to nitrogen and trisodium phosphate contribution to phosphorus.

Dewatering of deep excavations is required during the construction of HPC. In this process, groundwater is pumped from a network of deep boreholes and discharged sub-tidally at a location near the seaward end of the HPC temporary jetty.

NNB GenCo has reviewed the data from the boreholes that will form the longer-term network (those along the northern, western, and eastern sides of the deep excavation), as well as wider data sets that are reflective of current conditions, including temporary boreholes installed to enhance the efficacy of local dewatering. In each case, the 95th percentile for each of the substances of concern has been considered as this excludes anomalously high values while still providing a robust assessment. To enable a robust assessment of the potential impacts of the proposed discharge on the marine environment and interest features to be completed, reasonable worst-case values have been selected from these datasets and from the March 2017 data upon which Edition 1 of this report was based. This report contains the results of modelling these updated worst-case values.

The output from the permanent sewage treatment plants is discharged via the HPC temporary jetty.

The main bulk of the tunnelling material (with associated soil conditioning chemicals) is returned with the spoil to the muck bay. The tunnelling spoil will be re-used on-site in accordance with the site materials management plan. Sources of water from the tunnelling operations will include groundwater entrained within the tunnelling spoil, groundwater from the shaft dewatering, very minor seepages of groundwater into the tunnel, water used for cleaning equipment and dust suppression, surface run-off from the muck bay and groundwater seepage into the launch pits and Spray Concrete Lined (SCL) tunnels.

One of the issues when considering all three discharge streams is to consider the timescale of the likely discharges and potential maximum discharges and loads. This report considers when loads of a contaminant are at maximum levels or are likely to persist as discharges for a reasonable period.

1.1 Indicative construction discharge schedule

In August 2017 based on the best knowledge of the likely sequencing of different phases of the construction period, a series of discharge scenarios was developed taking account of the highest likely wastewater inputs from different construction sources. These Cases A to D were used to assess the maximal inputs of different contaminants of concern. Case E is omitted here but essentially covers the latter period of construction when tunnelling inputs are completed. This schedule is included to enable the plausible worst-case volume and contaminant concentrations to be considered for permitting. The schedule will inevitably change, but the summary of the worst-case conditions should cover the likely changes. The indicative sequence, duration and start point for different activities as envisaged in August 2017 is provided in Table 1 and Figure 1. For the assessment of the contaminant inputs from the cementitious waste water (CWW) and commissioning discharges the construction activities and discharges that are occurring in combination are best represented by those described for Case D. No seasonal dependence of the schedule has been considered therefore changes to the start or end times do not affect conclusions in the assessment: the assessment of impact is not dependent on the seasonality of the operations. The main seasonal factors affecting the discharge are wind variations and wave mixing. The modelling undertaken does not include wave mixing and so is conservative. Seasonal increases in wave height will increase mixing and reduce the areas of intersection (if any exist) between features and discharged waters above EQS concentrations. Even in the worst-case modelling condition no such intersection exists, and therefore we conclude that the areas of intersection will not be changed because of seasonal influences.

Table 1. Indicative sequencing of the relevant discharges based upon August 2017 construction plans. (Recent data on the actual flow rates for groundwater and tunnel effluent indicate that the values used here provide precautionary assumed overlaps between different activities and contaminant source contributions.)

Main site Groundwater	Sewage	Week	Tunnelling wastes (and associated) discharges	Case
De-watering discharge at Jetty, 20 l s^{-}		1	NA	Case A 20 l s^{-1} (jetty)
20 l s^{-1}		17	Approximately 7 l s^{-1}	N/A
20 l s^{-1}	sewage treatment plant discharge (jetty) 13.3 l s^{-1}	25	12 l s^{-1} ramping up to 22 l s^{-1} as SCL works ramp up. Tunnelling for intake 1 continues.	Case B 55 l s^{-1} (jetty)
20 l s^{-1}	13.3 l s^{-1}	49	30 l s^{-1} (ca. 26.7 l s^{-1} groundwater also including ca.,3 l s^{-1} soil conditioning chemicals from the use of 1 TBM).	**Case C** Peak Ca.,63 l s^{-1} (jetty)
20 l s^{-1}	30 l s$^{-1.}$ Rare but potentially maximum discharge.	49	30 l s^{-1} (ca. 26.7 l s^{-1} groundwater also including ca.3 l s^{-1} soil conditioning chemicals from the use of 1 TBM).	**Case C1max** Peak Ca., 80 l s^{-1}
20 l s^{-1}	13.3 l s^{-1}	81	SCL works complete. Tunnelling continues HPC Intake 1, Outfall, and Intake 2. Maximum use of TBM soil conditioning chemicals corresponds to the output from 2 TBMs working simultaneously. 6 l s^{-1}	**Case D** 40 l s^{-1} (original tunnelling assessment)[2] 38.3 l s^{-1} assessed for combined commissioning input at jetty[3]
(20 l s^{-1})[4]	(13.3 l s^{-1})[4]	NA[5]	Cementitious wastewater (CWW) plus other Case D inputs	**Case F** (0.6 l s^{-1} CWW)[6]
(20 l s^{-1})[4]	(13.3 l s^{-1})[4]	NA[5]	Commissioning discharge – this input contributes nitrogen and ammoniacal nitrogen from addition of ammonia and breakdown of hydrazine, ethanolamine, and phosphorus from trisodium phosphate see section 3.5 and 4.10 plus other Case D inputs	**Case J**[7] (70 l s^{-1} commissioning discharge)

[1] There has been no treated sewage discharge from the jetty as of 1st June 2021 but discharges are scheduled to start in the next few months; [2] For the original 2017 assessment of tunnelling chemicals a minimal groundwater dilution flow (20 l s^{-1}) was assumed during Case D. This effectively produced a most conservative scenario for tunnelling chemicals as it minimises dilution (assuming 20 l s^{-1} groundwater + 13.3 l s^{-1} treated sewage + 6 l s^{-1} tunnelling chemical which was rounded up to 40 l s^{-1} discharge);

[3] The total volume for assessment of DIN during Case D 38.3 l s^{-1} includes 13.3 l s^{-1} sewage contribution + 20 l s^{-1} general groundwater input + 5 l s^{-1} groundwater from tunnelling. The additional 6 l s^{-1} tunnelling chemical make-up water will not add DIN but will dilute the overall concentration so to provide the most conservative assessment this was not included in the flow rates for the DIN calculation.

[4] The total volume of groundwater (including 5 l s^{-1} from tunnelling) and sewage contributions of chemicals of concern during Case D are considered in combination with additions of the same contaminants from CWW or commissioning inputs.

[5] NA - not applicable as start timing not identified in 2017 scheduling

[6] During Case F cementitious wastewater input contributions are evaluated in combination with those for Case D

[7] During Case J the construction discharge for DIN and ammoniacal nitrogen uses the Case D example at 25 l s^{-1} groundwater with additional contributions from commissioning inputs.

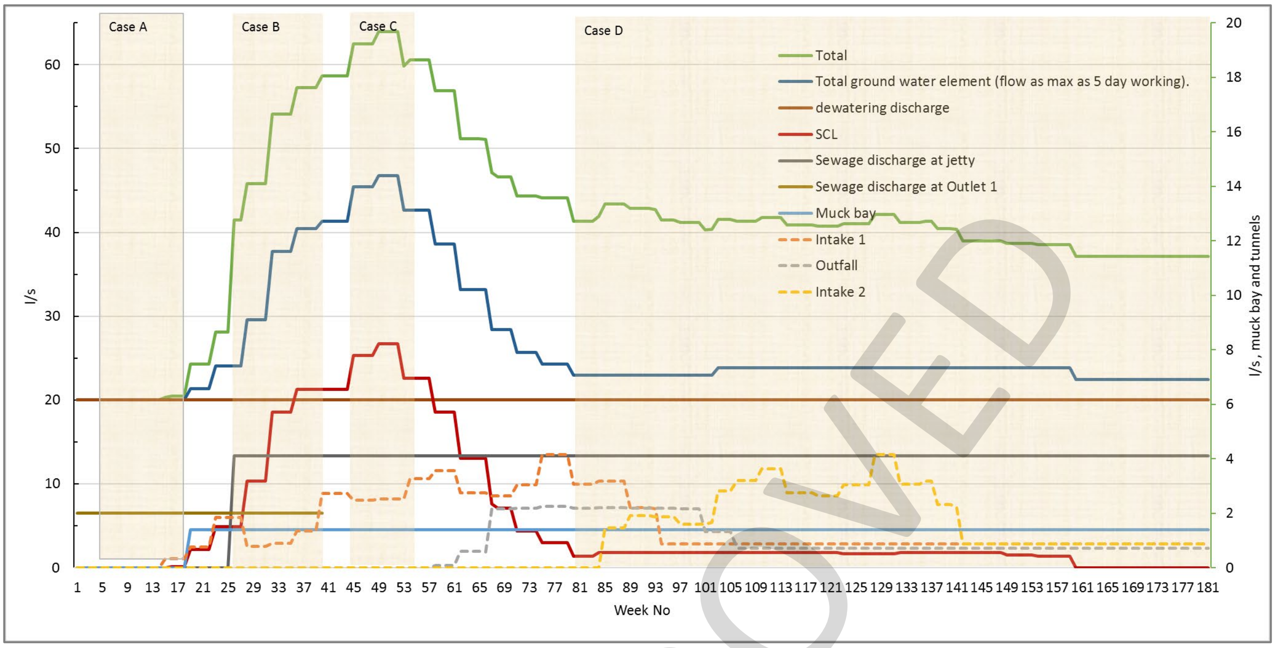

Figure 1. Likely flow volumes discharged at the jetty location from the start of tunnelling. Discharge volumes from 'Muck Bay' and TBM tunnelling for HPC intake 1, outfall and intake 2 are shown on the right hand axis. Timing is according to August 2017 scheduling and selected scenarios for assessment represent the most conservative based on the assumed overlap of activities contributing to various contaminant sources.

Groundwater comprises the main dewatering flow (which remains constant at 20 l s^{-1} through the period considered) plus the contributions of groundwater resulting from the tunnelling and associated operations. Figure 1 shows that the groundwater discharge starts at 20 l s^{-1} from dewatering (Case A) and then, at around week 17, is added to by the discharge from the SCL (spray concrete-lined) works for approximately 50 weeks, reaching a maximum of around 46 l s^{-1} groundwater (Case C). Thereafter, the groundwater element of the discharge reverts to levels of around 25 l s^{-1} (Case D). For the EVF calculation of groundwater derived substances, only the volume of groundwater has been used, with no assumption of additional dilution from the sewage discharge. During Case J groundwater flow rate is set at 25 l s^{-1} (as for the original Case D construction assessment of DIN and ammoniacal nitrogen) but additional commissioning inputs of these substances are also included (see section 3.5 and 4.10).

Figure 1 shows that the maximum discharges of flows that contain metals and DIN will occur during Case C (between weeks 45 and 53 when the groundwater element reaches 46 l s^{-1}). Case C is relatively transitory. Case C1, which includes an extreme case of sewage discharge, is also likely to be highly transitory. Once the SCL works are complete (Case D) the total groundwater discharge falls to approximately 25 l s^{-1}. The waste from the TBM soil conditioning chemicals contains its highest concentration during Case D. The total discharge during Case D is 38.3 l s^{-1} (40 l s^{-1} was used for the tunnelling chemicals assessment as this includes minimum groundwater flow 20 l s^{-1}, 13.3 l s^{-1} sewage and tunnelling chemicals) and this value has been used in the calculation of conditioning chemical discharge concentration and EVF.

As part of a surface water risk assessment (Environment Agency and Department for Environment Food and Rural Affairs, 2016) the concentration of substances present in the discharge must be assessed against a list of specific pollutants and their Environmental Quality Standards (EQS). Initial screening tests (historically referred to as H1 tests) were conducted to determine if the concentrations of priority substances and specific pollutants in the discharge exceeded their respective EQS. For any substances that breach the EQS in the initial screening tests (Test 1 (above the EQS) and Test 5 (EVF > water depth), see section 2) it is necessary to conduct further detailed modelling to determine the extent and magnitude of the predicted exceedance of the EQS in the receiving waterbody.

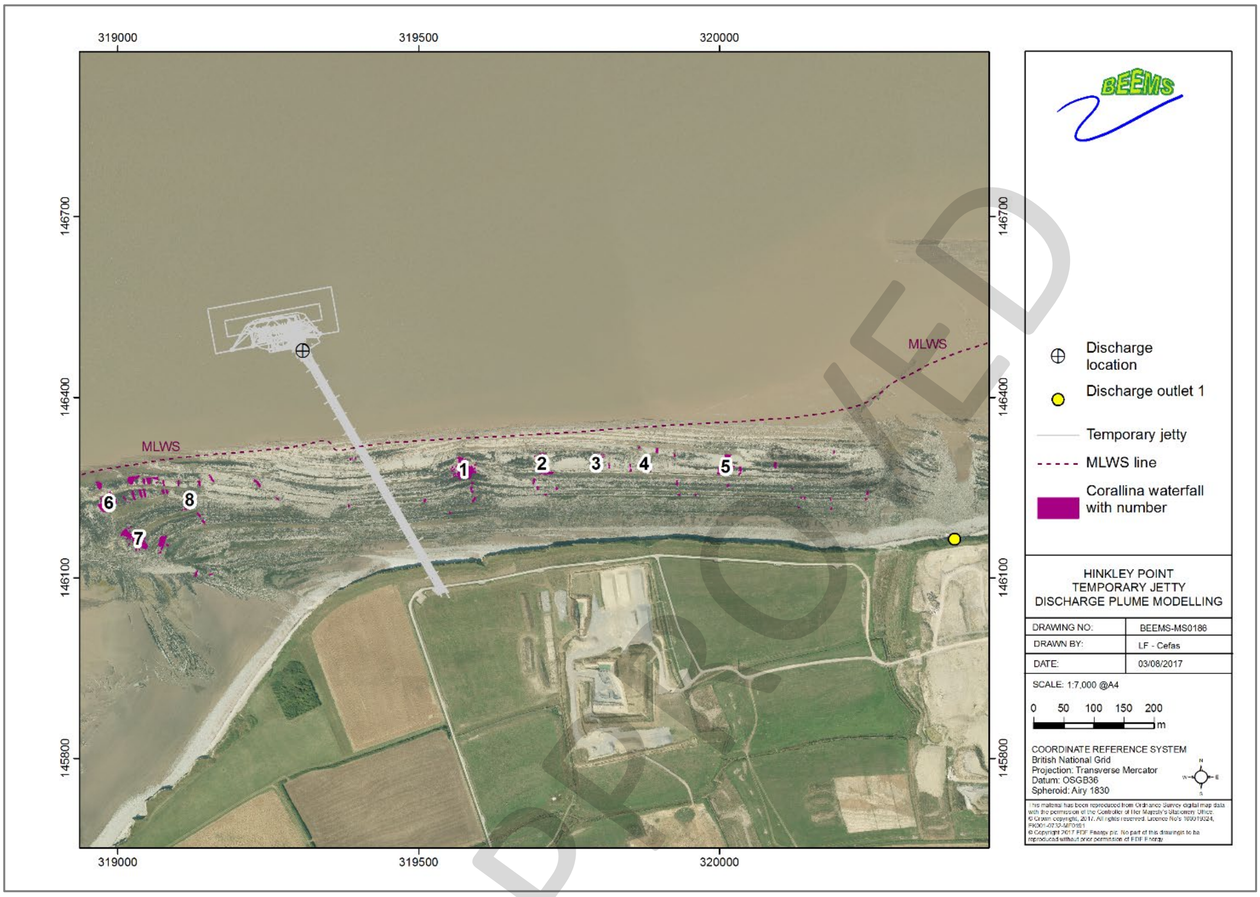

Figure 2. Location of the temporary jetty and proposed discharge point (shown by a cross within a circle). The main *Corallina* features of interest shown in purple and numbered for future reference in this report. The existing cross shore discharge point (Outlet 1) is shown by a yellow circle.

2 Application of Environment Agency guidance for the assessment of the subtidal discharge.

The EA screening approach applies to the discharge from the jetty because the discharge is to the subtidal environment and beyond 50m from mean low water spring (MLWS) tidal level. The proposed construction discharge is a low volume of groundwater, sewage treatment effluent and tunnelling waste (see Table 1) with concentrations of some contaminants exceeding EQS levels. The properties of the proposed discharge are shown in Table 2. The commissioning discharge and cementitious water discharges are discussed in the construction and cold commissioning section 3.5.

Table 2. Proposed jetty discharge characteristics. The discharge location is shown in Figure 2.

Discharge Characteristics	Value
Location OSBG	319315E 146475N
Location WGS84	51° 12.7056' N 003° 9.3894' W (51.21176 N 3.15649 W)
Charted water depth (surface to bed) at discharge location	At least 3.0 m
Discharge flow	Varies with Case.
Discharge salinity	1 PSU

Groundwater priority and specific contaminant data

When calculating summary statistics for all substances, any values below the method detection limit were adjusted to a value of half the detection limit. For metals, modelling tests use both total and dissolved concentrations to assess potential deterioration of surface water quality (Environment Agency, 2014). The total concentration of substances was used in the initial screen and in subsequent modelling to take account of uncertainty regarding the partitioning of substances into the dissolved phase as the groundwater mixes with the seawater. For several neutral hydrophobic chemicals and some metals, however, solubility would be expected to decrease under saline conditions (Turner, 2003). The assessment includes the screening of the source terms against the saltwater EQS values presented in the Water Framework Directive (Standards and Classification) Directions (England and Wales) (WFD, 2015). NNB GenCo has reviewed the data from the boreholes that will form the longer-term network (those along the northern, western, and eastern sides of the deep excavation) as well as wider data sets that are reflective of current arrangements, including temporary boreholes installed to enhance the efficacy of local dewatering. In each case, the 95th percentile for each of the substances of concern has been considered as this excludes anomalously high values while still providing a robust assessment. To enable a robust assessment of the potential impacts of the proposed discharge on the water environment and on the interest features to be made, the worst-case values have been selected from these datasets and from the March 2017 data. Summary statistics for the concentrations of substances measured in the site groundwater carried forward to the modelling assessment are shown in Table 3.

The updated guidance for surface water pollution (Environment Agency, 2016) recommends the application of an initial test (Test 1) for discharges to Transitional and Coastal (TraC) waters in which the discharge concentration is compared to the relevant quality standard or equivalent for that substance. Where the discharge concentration exceeds the standard concentration, further assessment is required. As this construction discharge will be subtidal a further test ("Test 5") is recommended, comparing the discharge specific Effective Volume Flux (EVF) with the location specific Allowable Effective Volume Flux (AEVF). If the EVF is not greater than the AEVF, then the discharge is considered insignificant and is screened out.

Relative to chart datum the discharge depth for construction related effluents will be at least 3.0 metres therefore a maximum AEVF value of 3.0 is used for comparison in Table 3.

The grey shaded discharge concentrations in Table 3 are those used in the EVF calculation. Theoretically, the mean values could be used in the EVF calculation with the annual average EQS, however, this assumes that the mean discharge is an annual average. As the discharge concentration is determined by the dewatering process it is not appropriate to assume a random process contributing to the discharge concentration, and the discharge is intended to occur over several years. There could, for instance, be many months when values above the mean are present in the chemical discharge. As a precautionary approach, the 95th percentile discharge concentrations have been used for calculating the EVF values.

The Environment Agency considered the datasets submitted for the assessment of construction discharges in December 2017. They confirmed that most of the values used within the screening were conservative, however a few (shown in bold and underlined Table 3) had slightly higher values. This was not considered to be an issue as zinc was still the substance which had the highest EQS exceedance, and therefore was still the ‘contaminant of concern’ which was most relevant to be carried forward to the modelling stages. The slight discrepancies between the Zinc 95th percentile values were also not considered to be an issue because it was not expected that this slight increase (1.37%) to the input data would vary the outcome results of the modelling assessments.

As the suspended sediment concentration at a given location directly affects light penetration and the potential for increased phytoplankton growth, the reference concentration of dissolved inorganic nitrogen (DIN) for TraC waters for the Good/Moderate boundary also references the suspended sediment concentration. The average turbidity concentration measured at Hinkley Point (Amec, 2009) was 214 NTU. This defines Hinkley as turbid with associated 99th percentile winter DIN values for transitional and coastal waters of 2520 µg l^{-1} and 3780 µg l^{-1} thresholds for Good and Moderate respectively (Water Framework Directive Standards and Classification Directions, 2015, Appendix B). It should be noted that a portion of the DIN in groundwater is nitrate/nitrite which may not all readily convert to ammonia, but total conversion to ammonia was assumed to ensure that the assessment made was conservative.

Table 3. Groundwater contaminants and concentrations likely to be present in the construction dewatering discharge and comparison to EQS for three cases. AA refers annual average concentration and MAC refers to the maximum allowable concentration. EVF ($m^3 s^{-1}$) has been derived using 95th percentile discharge concentrations and the AA EQS (except for mercury where the MAC EQS has been used). The shaded values indicate those used in the screening test assessment. These data are based on Environment Agency calculation from NNB GenCo data sources. Underlined updated values had non-significant increases relative to original Cefas calculations.

Contaminant	**Assessed discharged concentration µg l^{-1}**		**Saltwater AA EQS µg l^{-1}**	**Saltwater MAC EQS (as 95%ile) (µg l^{-1})**	**Back-ground conc-entration (µg l^{-1})**	**(EVF) Case A and Case D**	**EVF Case C**	**TraC Water test 5 EVF< 3.0 Pass/Fail**
	Mean	**95%ile (used in EA Screening test)**						
Un-ionised ammonia (N)	258.75	123.5	21	-	**4.6**	**0.15**	**0.352**	**Pass**
DIN groundwater	1860.92	4073	2520[1]		1050	0.06	0.129	Pass
Cyanide	0.025	50	1	-	0	1.00	2.34	Pass
Total cadmium	0.09	0.460	0.2	-	**0**	**0.05**	**0.12**	**Pass**
Total chromium	4.58	24	0.6[2]	32	0.02	0.83	1.93	Pass
Total lead	0.85	3	1.3	14	0.02	0.05	0.11	Pass
Total copper	31.7	221	4.76	-	3.95	**5.46**	**12.17**	**Fail**
Total zinc	427.2	1642.15	6.8	-	3.035	**8.72**	**20.37**	**Fail**
Total mercury	0.2	0.49	-	0.07[3]	0.02	0.2	0.46	Pass
DIN Sewage sources		20,000[4]	2520		1050	0.19	0.41	Pass

[1] 99th percentile (180 µmol) standard for period 1st November – 28th February for dissolved inorganic nitrogen for Good status, Appendix B, Table 17.

[2] The EQS in seawater is set for dissolved hexavalent chromium only but this is dissolved total chromium (all species).

[3] The EQS for mercury is only set as a 95th percentile.

[4] A max value not 95th percentile, ammoniacal nitrogen as a proxy for total nitrogen from sewage treatment (µg l^{-1}) as other contributions e.g. NO_2, NO_3 are expected to be small.

The Effective Volume Flux of the discharge (EVF) is defined as:

$EVF = (EFR \times RC) / (EQS - BC)\ m^3\ s^{-1}$

Where:

EFR = the effluent discharge rate ($m^3\ s^{-1}$)

RC = release concentration of the priority substance of concern (µg l^{-1})

EQS = EQS (AA) of the substance of concern (µg l^{-1})

BC = mean background concentration at the discharge location (µg l^{-1})

For Case A and Case D, which together represent most of the total tunnelling time, both copper and zinc fail the screening tests. During peak ground water load (Case C) chromium also fails this test, although only marginally and for a period of only approximately 8 weeks when the flow is predicted to be at a maximum. If the annual average is used, only zinc would be of potential concern (the copper EVF is substantially below the threshold). As zinc is the substance of greatest exceedance then this report considers this discharge further, with detailed modelling in a real-world simulation described in section 3. Calculation of EVF values as shown in Table 3 are provided in more detail in Appendix C, Table 22..

2.1 Total loads for Cadmium and Mercury.

There are specific requirements for annual loads of cadmium and mercury compounds. Figure 3 shows that the criteria not to exceed 5kg and 1kg (respectively) are met, for both cadmium and mercury respectively.

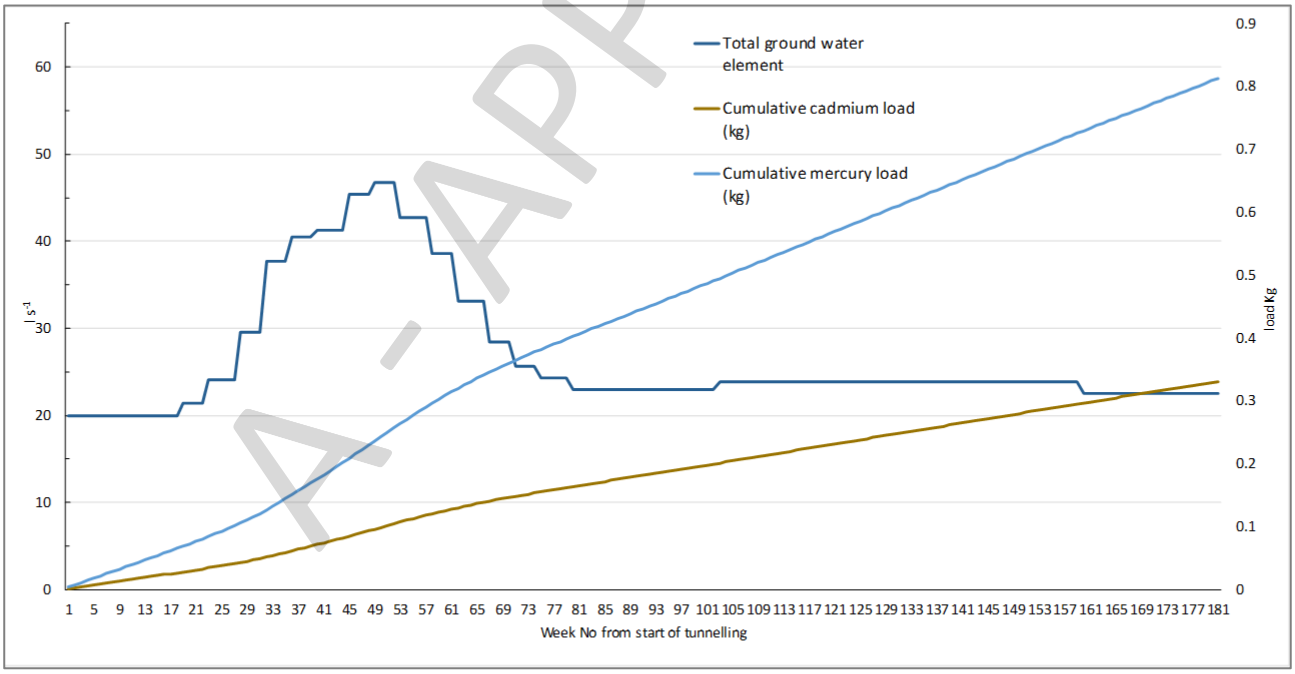

Figure 3. Three-year timeline of groundwater discharge (l s^{-1} left axis) and resulting cumulative metal load for Mercury and Cadmium (kg right axis).

3 Discharge Assessment Methodology

3.1 Modelling approach.

The release and mixing of zinc in the construction discharge was modelled using the validated Hinkley Point 25 m resolution GETM model. This is a 3D hydrodynamic model with an inbuilt passive tracer to represent zinc. As a worst case, it was assumed that there was no loss of dissolved zinc due to sediment absorption or biological uptake. Using these assumptions allowed concentrations to be scaled, as the modelled concentration was simply a function of dilution. The model setup, calibration and validation are described in British Energy Estuarine & Marine Studies (BEEMS) Technical Report TR267 Edition 2. As with the 100m resolution Hinkley Point GETM model (BEEMS Technical Report TR177) the surface is forced with reanalysed data from a meteorological model (ERA40 interim from ECMWF). The boundary conditions were forced by a broader 3D GETM domain, described in BEEMS Technical Report TR177.

The construction discharge characteristics are shown in Table 2. The discharge outfall is attached to a jetty pile and located approximately 1 m above the seabed (approximately 2 m below lowest astronomical tide (LAT)). CORMIX modelling (shown in Appendix D of this report) indicates that the plume will be buoyant and form a surface pool (or pond) at slack water which will become increasingly elongated as the tidal flow increases, forming a long thin streak at peak tidal flow. CORMIX is unable to replicate many of the features simulated by the GETM model, and GETM is therefore a better model to use away from the near field (further than 10s of metres from the outfall). Specifically, GETM can replicate wind driven behaviour and has precise bathymetry so that interactions with the tidal flow (e.g. eddies) are well replicated. Neither the CORMIX nor the GETM model includes the effects of waves which enhance vertical mixing and increase dilution. The modelling predictions of plume areas above the EQS are therefore conservative: the actual discharge will be subject to more mixing and dilution (caused by wave action) than the models are able to replicate and so the actual concentrations in the environment will be lower than those predicted.

The mean background concentration of zinc in the environment is 3.03 µg l^{-1} (See Appendix A**)** whilst the EQS is 6.8 µg l^{-1}. When comparing the model results against the EQS, an adjusted value of 3.77 μg l^{-1} was used as a threshold to account for the background concentration of zinc, calculated by simply subtracting the background concentration from the EQS concentration.

3.2 Discussion of initial mixing conditions

The greatest challenge in modelling a small volume, buoyant flow is to sufficiently replicate the initial mixing whilst retaining the ability to simulate real wind and bathymetric features.

In this study, the GETM model domain used a discrete grid with dimensions of 25 m by 25 m and 15 vertical layers in a sigma co-ordinate system in which the layer thickness changed with water depth. The discharge flow for Case D (25 l s^{-1}) was small compared with the total volume in the model grid cell, so to avoid excessive initial dilution, the discharge was made into the model surface layer, which is consistent with the results of the near field CORMIX modelling of a buoyant plume.

It should be noted that in a buoyant plume with a discharge in an offshore location, unless mixing occurs, there will be no impact on seabed features. Consideration of the tidal cycle is useful in understanding the likely modes of impact. When the flood tide is at its strongest (with flow to the east), the discharge plume will initially be buoyant, and will then be advected in a narrow surface streak and mixed down. As mixing occurs the concentration within the streak will rapidly drop. At high water, around slack tide, a pool of the discharged water will form at the surface which will be advected westwards as the ebb tide increases. As the tidal range is large in the Severn Estuary, this surface layer of water will be separated vertically from the bed, and the discharged water will not meet sensitive features such as *Sabellaria* or *Corallina* patches. As the tidal flow velocity increases, the strong tidal flows and rough topography of the Severn Estuary generate strong vertical mixing which ensures a large reduction in the concentrations of contaminants in the discharged water.

The period around low water slack tide is the time of greatest *potential* concern. It would be expected that the slack water period at low tide would also result in ponding, and that this ponded water would then be advected as the flood tide increases. As the water depth at this time is low, it has the *potential* for interaction with the bed and to be advected onto the sensitive areas of the rock platform. As the flow increases after low water slack tide, the water depth increases and the potential for interaction with the bed at concentrations of concern decreases. It is therefore the period around low water slack tide that needs the best simulation from the model. The CORMIX model system was used to understand the initial mixing condition (Appendix D). It indicated that at 25m distance from the discharge the dilution was approximately 22-fold. CORMIX modelling also showed that the plume rapidly comes to the surface (because of its buoyancy) so that only a very small footprint of exposure (radius of up to 5 m or 78 m^2) occurs at the bed.

The discharge varies with time. During Case A and Case D it is small compared to the model grid size (approximately 20 – 25 l s^{-1} when considering groundwater alone) and therefore initial dilution due to mixing in the model is potentially overestimated. This was overcome by simulating discharge into the upper grid cell of the model only, successfully replicating the near-field mixing suggested by the CORMIX simulation. At low water slack tide, the vertical cell size at the surface in the GETM model at the outfall location is 0.2 m and the total volume in the upper grid cell approximately 125 m^3. During Case B and Case C conditions the initial mixing condition is less of a concern where volumes of discharge peak at 63 l s^{-1}.

As the Cormix modelling suggested that initial dilution was 22-fold at a distance of 25 m from the discharge (i.e. the same size as a single grid cell) then the discharge volume of 20 l s^{-1} met this dilution criterion within 284 seconds or approximately 5 minutes. For the larger Case C discharge, 22-fold dilution was achieved in 95 seconds.

The period of near slack water (but not zero velocity) in the model is typically around 30 minutes, much longer than the worst case 5 minutes given above, thus the GETM model will correctly represent the concentrations of zinc around low water and thus replicate the low water ponding situation well. The ponded water is then advected by the tides. The model is therefore able to replicate the period of concern (low water slack tide) accurately. The advection of the ponded water is shown in Appendix E.

The maximum concentration at the point of discharge (within 25 m) may be underestimated, but away from that grid cell (25 m by 25 m) the concentrations are well represented.

While the tide advects water along the coast, with a small cross-shore component, it is the wind direction that gives the greatest variability in the cross-shore component and possible impact on to the shore and sensitive habitat.

3.3 Analysis of wind scenarios.

The tide will move the plume along the coast, but it is expected that the winds from the northern quadrant will have the greatest potential to push the plume onto the intertidal areas where *Corallina officinallis* and *Sabellaria* sp. are found. The year 2008 has been used as the representative year for all the Hinkley Point C thermal and chemical modelling (BEEMS Technical Report TR177) and hydrodynamic data collected in that year was used to validate the models. To maintain consistency with previous modelling work, 2008 was, therefore used as the modelling year in this study. Analysis of the wind speed and direction for the year 2008 (see Figure 4) shows that the month of November exhibited both the highest percentage of days with northerly winds and highest percentage of days with average wind speed in the 5 -15 m s^{-1} range from N and NW directions. Choosing the month of November to perform the simulation ensures the worst-case scenario for impact and a realistic variability in weather forcing.

The current operational Hinkley Point B discharge was included in the simulation (equivalent to Run A in BEEMS Technical Report TR267 Ed.2) for the period of 21/10/2008 to 30/10/2008 to spin up the temperature and salinity across the domain and with the discharge simulation run from 1/11/2008 to 20/11/2008. However, it was not expected that the absence of the HPB plume (such as during an HPB outage) would affect the results as there would be little interaction between the discharge at the jetty and the HPB thermal plume. On the flood tide, the jetty discharge does not reach the HPB outfall at significant concentrations and, on the ebb tide, the thermal plume from HPB mostly passes to the north of the jetty.

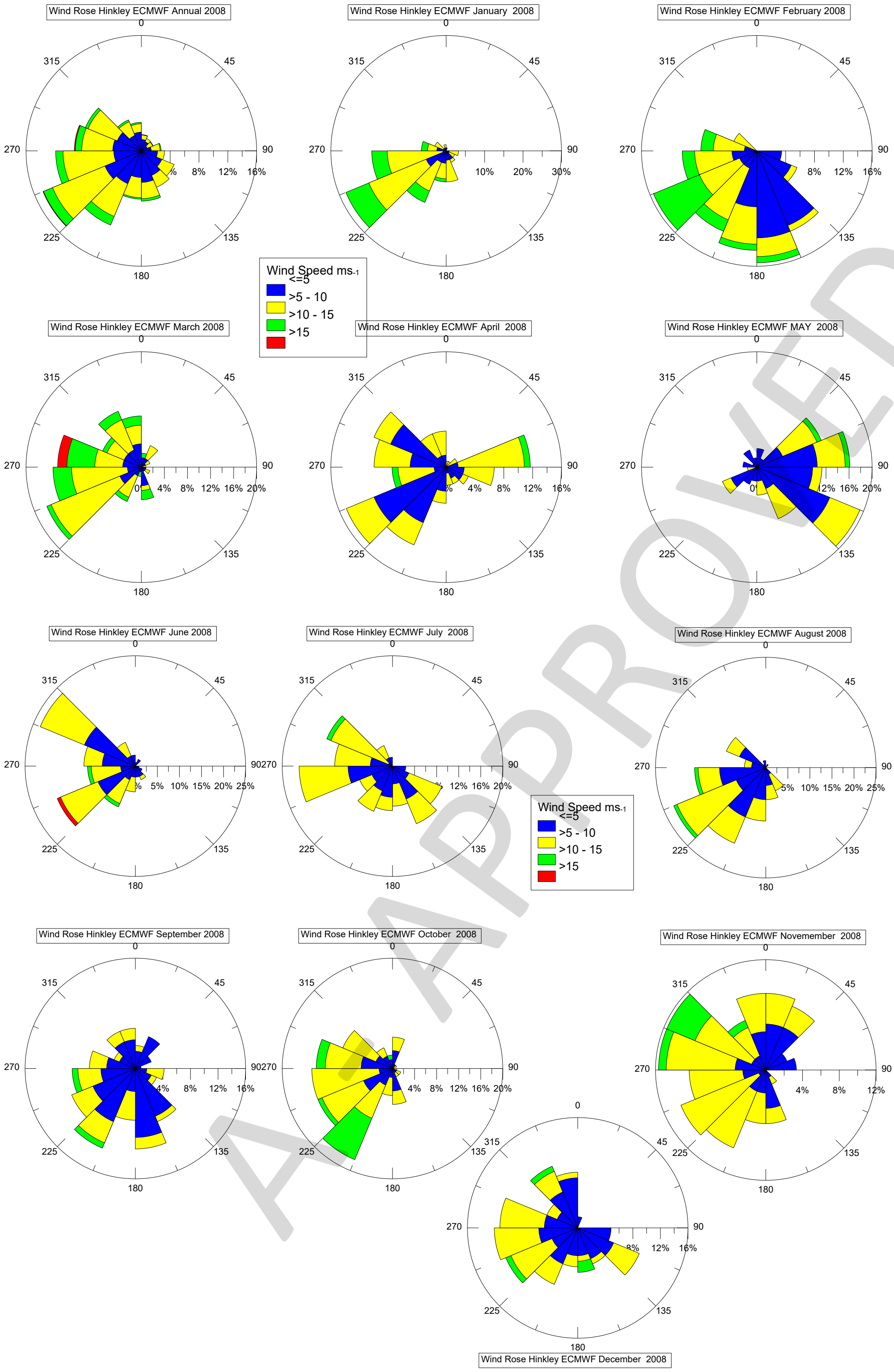

Figure 4. Wind rose for 2008 showing annual and monthly rows. November has the strongest component of winds from the North and was therefore selected as a worst case for the modelling.

3.4 Tunnelling materials and chemicals.

Tunnel boring machines (TBMs) will be used to excavate two tunnels required for the cooling water intakes and one for the cooling water discharge. Tunnels will be constructed in sections or rings. One ring is equivalent to 1.5 metres of tunnel length and an estimated maximum of 24 rings per intake tunnel per day and 16 rings for the outfall tunnel per day will be completed.

By far the largest volume of wastewater produced by tunnelling operations comprises groundwater from the deepest excavations completed during early stages of the SCL works. This groundwater discharge is considered alongside the main dewatering discharge, as it will be of similar composition and therefore could also contain levels of zinc of potential concern. There are also much smaller quantities of water which contain chemicals from the tunnelling operations, and those chemicals are considered here.

To obtain optimum performance with TBMs, ground-conditioning chemicals are used at the cutter head. These chemicals improve ground properties for cutting and for the initial removal using a screw conveyor. During the subsequent transport of removed materials from the cutting face on a conveyor belt, some residual fluids associated with the conditioned ground material will leach out and be captured in the pit at the bottom of the tunnel. These fluids, along with small amounts of natural groundwater from the cutting face, will then be pumped out and discharged at the jetty location.

Chemical use in tunnelling is associated with three broad functions which are:

(i) Fuelling and lubrication of the TBM

(ii) TBM protection greases / sealants

(iii) Ground conditioning

Table 4 provides a description of these main chemical applications in tunnelling, the most likely chemical types and their properties and indicates the fate of residual wastes.

Table 4. General chemical use, treatment and disposal associated with tunnelling operations

Chemical function	Chemical type	Description of use	Disposal route
Fuelling and lubrication	Hydraulic oils	Various uses on TBM	Spills when filling or seal leaks treated with absorbent granules, granules disposed of by licenced waste disposal
	Other oils	Various uses on TBM	As above
	Diesel	Backup generators	As above
Sealant	Grease	Approx. 2.5 kg per ring used in positive loss protection	Returned to muck bay as contained within excavated spoil. Remainder in barrel returned to surface, washed and waste disposed of by licenced waste disposal
	Tail skin grease	1.5 kg m^2 left on tunnel wall lining	In tunnel encased on outer surface of ring. Remainder in barrel returned to surface, washed and waste disposed of by licenced waste disposal
Ground conditioning	Various	circa 50l per ring if system running at 100 %	Spoil returned to muck bay, residual fluids lost to pit bottom are recovered and pumped to jetty

Fuelling and lubrication of the TBM will be managed to minimise the possibility of any oil/chemical spills but any potential losses will be contained by appropriate treatment and disposal. The sealant greases are formulated to be impervious to water and preferentially associate with the ground materials. All sealant used will therefore either remain associated with the tunnel walls or retained within the spoil. During ground conditioning, different chemicals may be used as anti-clogging agents, as anti-wear components and for soil conditioning. The exact conditioning products are likely to be specific to the TBM chosen and to the substrate encountered which will not be known until trial boring commences. To enable the discharge to be assessed, several potential drilling compounds were reviewed for toxicity and percentage concentration in the drilling fluids, and products that would represent a worst-case discharge were selected for assessment. Chemical constituents of TBM ground conditioning products BASF Rheosoil 143 and CLB F5 M failed the initial EQS screening and were investigated further using modelling approaches for these products based on the proportion of specific active substances and their PNECs (described in Table 5). The main chemical groups included are surfactants and 2-methyl-2,4 pentanediol (also known as hexylene glycol). These chemicals are very soluble and those that have not bonded to particles would run to the pit bottom and subsequently be discharged at the jetty.

It is expected that 48 litres of ground conditioning product will be used per ring for the intake tunnels and 64 litres for the outfall tunnel. For each product, the discharge assessment assumes the use of the highest hazard chemical based on quantity and toxicity that is present (highest effective volume flux). Based on a relative maximum product density of 1.05 and assuming maximum percentage composition for a component active substance, the total quantity of each substance used per ring and for 40 rings per day (see section 3.4.1) was calculated (Table 5 and Appendix C, Table 23). Note that the total quantity estimates for each chemical are considered conservative / worst cases as in practice more than 1 product (including some with lower toxicity) may be used at the same time.

Table 5. Example products for use in ground conditioning, their properties and percentage of key component substances and associated Predicted No Effect Concentrations for each substance or surrogate value for a group of similar substances. Details of calculations in Appendix C, Table 23.

Chemical function	**Product**	**Main active substance(s)**	**Active mass (kg) per day assuming 100% use for 1 intake tunnel and 1 outfall tunnel.**	**Predicted no effect concentration (PNEC) for aquatic environment (µg l^{-1})**
Anti-clogging agent	BASF Rheosoil 143	Sodium lauryl ether sulfate (<30%)	68.5 kg[1] (based on 40 rings per day)	40[2]
Soil conditioning-additive	CLB F5 M	2,4-Pentanediol, 2-methyl- (≤10%)	22.8kg[1] total (based on 40 rings per day).	4300[3]
		Alcohols, C10-16, ethoxylated, sulfates, sodium salts – (≤10%)		35[2]
		Mono-C10-16-alkyl, Sodium sulfate (≤10%)		4.5[4]

[1] This value takes account of substance density (1.05), % active substance, and assumes 90% associated to spoil (see later discussion); [2]see Table 15 HERA 2004; [3]see SIDS, 2001, [4]see Table 13 HERA, 2002

The PNEC values shown in Table 5 for each active substance are either taken directly from relevant risk assessment reports i.e. for 2-methyl-2-4 pentanediol (SIDS initial assessment report, 2001), or use the lowest PNEC from a substance group assessment i.e. PNEC values calculated for other alcohol ethoxylate sulphates are derived for representative carbon chain length substance or worst case if not known (Table 15 in HERA, 2004,) and for mono-C10-16-alkyl sodium sulphate (Table 13 HERA 2002). In the case of mono-C10-16-alkyl sodium sulphate we assessed the C14 toxicity (as this generated the most conservative PNEC) whereas the substance will be composed of a range of carbon chain lengths.

3.4.1 Screening methodology assessment.

Theoretically, a maximum of 24 rings could be installed per intake tunnel per day and 16 rings for the outfall tunnel. There is overlap in time of construction between the HPC cooling water Intake 1 and the cooling water outfall and between the outfall and Intake 2. The current drilling programme (Figure 1) shows a short overlap between the drilling of all 3 tunnels. However, for operational reasons including power availability, all three TBMs will not be operating at full capacity simultaneously. Using a realistic total construction estimate of 40 rings per day gives a total mass of 68.5 kg per day for BASF Rheosoil (Table 5). This assumes that overall, 10% of the active substance of the product used leaches out of the soil and is then discharged via the jetty. This is considered a conservative estimate of the level of adsorption to the mineral material removed from the tunnel for each ring.

Various literature sources show that at surfactant solution concentrations of several hundred mg l^{-1} there is adsorption of between 3 – 19 mg of anionic surfactants per gram of mineral (i.e. kaolinite) associated with the solution (Lv *et al*., 2011, Yekeen *et al*., 2017). Based on the predicted surfactant concentration in the conditioning fluids and the large quantity of mineral material removed per ring it is likely that all but a few percent of surfactant will be adsorbed to the mineral waste but a conservative 90% is assumed here. Case D is the most likely time when peak ring installation rates (and hence peak usage of soil conditioning chemicals) will occur.

Table 6. Environment Agency screening assessment of surfactant components of products. Example chemicals for use in ground conditioning, their properties and fate (for details of calculations see Appendix C, Table 24).

Conditioning product	Estimated Discharge concentration mg l^{-1} of active substance. Case D	Saltwater AA EQS[1] µg l^{-1}	Background concentration µg l^{-1}	Effective volume flux (Case D) Total flow 40 l/s (m^3 s^{-1})	TraC Water test 5 EVF< 3.0 (Pass/Fail)
BASF Rheosoil 143	19.8	40	0	19.80	Fail
CLB F5 M Ethoxylated sulphates	6.6	35	0	7.54	Fail
CLB F5 M Mono- alkyl sodium sulphate	6.6	4.5	0	58.67	Fail

[1] these EQS values derived from HERA 2004 for both BASF Rheosoil 143 (sodium lauryl ether sulfate) and for CLB 5M (Alcohols, C10-16, ethoxylated, sulfates, sodium salts –(≤10%) Mono-C10-16-alkyl, Sodium sulfate (≤10%)

As these chemicals fail the TRAC 5 screening test they are considered further in the next section.

3.5 Assessment of construction and cold commissioning inputs.

Edition 6 of this report considered the construction discharge inputs. During the latter phase of the construction period (best represented by Case D construction discharge inputs) cold commissioning of the reactors and associated pipework will take place. During this process, a range of tests will be conducted, and conditioning will be undertaken with demineralised water (potable water may be used in some cases) and various chemical additives. The discharge of commissioning wastewater will contribute to intermittent discharges of commissioning chemicals and their breakdown products. During cold commissioning there is no available cooling water system therefore discharge is planned via the jetty. The commissioning discharge has been assessed for inputs of hydrazine using a discharge rate of 83.3 l s^{-1} and this assessment is described in BEEMs technical report TR445. Here the breakdown products of that hydrazine and other commissioning chemicals are assessed in combination with construction inputs for Case D (see Table 1).

Testing of the primary and secondary circuits requires them to be filled and flushed several times each with demineralised water and treatment chemicals. As a precautionary assessment the maximum daily discharge volume is taken to be 1500 m^3d^{-1}, equivalent to the contents of the two 750 m^3 HXA tanks that serve this waste stream. The discharge rate is expected to be 37 l s^{-1} per tank or 70 l s^{-1} for discharge of both. The discharge is expected to last for a period of 5.63 hours. The modelled discharge rate is lower than that modelled for the hydrazine discharge modelling which used a rate of 83.3 l s^{-1} over a 5 hour period (BEEMS TR445). The higher discharge rate was based on information available at the time of modelling and the lower discharge rate is considered more accurate for the HXA tanks. In terms of the hydrazine modelling for commissioning, as the discharge concentration would be the same for either discharge rate, the higher rate of 83.3 l s^{-1} is considered to provide a slightly more conservative assessment. However, for the hydrazine and other commissioning chemical breakdown products modelling the 70 l s^{-1} has been used.

Following work on the commissioning effluent treatment plant (CETP) it was identified that this development will create an intermediate stage before discharge of the HXA wastewater. The CETP would have a much lower predicted discharge rate of 11 l s^{-1} but there may also be further storage just post treatment to provide a means of monitoring effluent quality and to allow for batch discharge via the jetty. A further wastewater stream will be derived from the demineralised water plant with an indicative discharge rate of 17 l s^{-1}. This discharge may also be routed to a storage tank prior to discharge from the jetty.

The discharge modelling conducted for hydrazine in TR445 and for the hydrazine breakdown products in this report (TR428) provide a conservative assessment as it assumes maximal discharge rates from the jetty (70 – 83 l s^{-1}) with this waste stream made up entirely of either commissioning chemical breakdown products or of hydrazine at one of several treatment levels. However, it is likely that with dilution by other waste streams either hydrazine or the commissioning chemical breakdown products will represent a smaller fraction of the total discharge modelled.

Previous assessments (83 l/s) are considered conservative as the lower mass flow rate and further dilution (of the 11 l/s discharge) will mean a smaller initial discharge concentration than previously assessed (which showed no impact of the features considered). Furthermore, while the total mass of hydrazine released is the same, it is released over 24 hours rather than 5 hours, so that decay becomes more relevant, and will further reduce the concentrations below levels previously modelled. Previously modelling showed no impact of designated features above PNEC, and the reduction in mass flux of hydrazine will reduce potential exposure even further.

Although the discharge rates modelled are considered representative of total discharge rates from the jetty the hydrazine concentration discharged would be lower and so discharges may occur over a longer period than modelled, although based on operational practice this is unlikely to exceed 8 hours a day.

The chemicals present during commissioning are expected to be hydrazine, an oxygen scavenging chemical, ammonia for pH adjustment, ethanolamine, and trisodium phosphate. An initial screening of the discharge of these chemicals (Appendix C Table 25) confirms that hydrazine and un-ionised ammonia would not pass, and both require more detailed assessment. Hydrazine has been assessed in detail in BEEMS TR445. Ammonia input from commissioning is contributed both directly and potentially from the breakdown of hydrazine and ethanolamine. Ammonia contributions from construction inputs during Case D and from commissioning inputs are shown in Appendix C Table 26 and Table 27 and are assessed in section 4.10. Phosphorus inputs are derived based on the conservative assumption that the total mass PO_4-P present in the trisodium phosphate used in commissioning will be discharged and is available for plant growth. The nitrogen and phosphorus inputs present during cold commissioning and the potential contribution to plant growth in the estuary are assessed in the following sections.

3.5.1 Nutrient input assessment.

As phosphate is not normally the limiting nutrient in marine systems in near coastal water of the UK, the assessment of construction nutrient inputs in Edition 6 of this report focussed on nitrogen only. The influence of the nitrogen loadings upon waterbody nutrient status is discussed in section 4.5.2. but more detailed modelling was not considered necessary. When taking account of the additional nutrient inputs during the cold commissioning, an updated assessment was made in this report version (Ed7) using a combined phytoplankton macroalgal model (CPM) (Aldridge et al., 2008). This model includes the combined construction and cold commissioning inputs of nitrogen and phosphorus which are all discharged at the construction outfall at the jetty location just before the jetty head.

3.5.2 Other chemical input assessments.

Assessment of the construction inputs of ammoniacal nitrogen in Edition 6 of this report focussed on the proportion of un-ionised ammonia in the construction discharge as influenced by local seawater physicochemical parameters. The CORMIX model is used to determine the point at which the discharge is sufficiently mixed such that the proportion of un-ionised ammonia falls below its annual average EQS of 21 $\mu g\ l^{-1}$ (NH_3-N).

In this Edition 7 an assessment of the combined cold commissioning and construction inputs of ammoniacal nitrogen is made. For the combined assessment reference is made to the un-ionised ammonia EQS and to the total ammonia concentration as referenced in ammonia standards for estuaries (WQTAG086, 2005).

3.5.3 Cementitious washwater

The Hinkley Point C project continues to use concrete and cementitious grout for a number of applications. Cement and grout equipment and containers require washing out, for example at the end of each shift, which creates a cementitious wash water. Although there is the potential to reuse some wash water in the mix, in many circumstances reuse is not possible due to quality specifications. Currently excess CWW is being removed from site by tanker for off-site treatment leading to increased vehicle movements and fuel use, and social and economic impacts. NNB HPC would like to be able to discharge CWW via Activity F to reach a more sustainable approach, however, to do this a variation to the currently agreed activity is seen as the most appropriate way forward.

NNB HPC propose to vary the permit to:

- change the discharge location for CWW to Outlet 12; and
- increase the permitted flow rate to 50m^3/day which is considered sufficient for all CWW discharged through to the completion of the project.

It is recognised that the current permitted discharge location (Outlet 1) which discharges to the sensitive foreshore has higher potential to impact the environment due to the potential for direct contact with receptors such as Sabellaria spp. and Corallina spp. Changing the discharge to Outlet 12 located at the HPC jetty would reduce the potential for impact to the environment as it is a subtidal location where there is greater opportunity for dilution and dispersion to occur. Detailed modelling was also produced for the previous CWDA variation which enabled discharge of tunnelling effluent and groundwater from this location.

A review of the likely volumes of CWW that cannot be re-used to make new concrete or grout has indicated that 10m^3/day as allowed under the existing permit is insufficient. It is considered that marine works may produce up to 20m^3/day and the main civils works may produce up to 30m^3/day giving a total of 50m^3/day although it is unlikely that both sources will be producing CWW at maximum capacity at the same time.

NNB HPC will provide a cementitious wash water characterisation report as per permit condition PO2 when the required information becomes available. NNB HPC recognise that no discharge can commence under Activity F until a submission under PO2 is approved by the EA.

Treatment to remove suspended solids and to adjust pH will be required to facilitate discharge. The precise treatment system is yet to be determined but is likely to comprise a lamella settlement step, likely enhanced with coagulant and flocculent and a pH correction step which will utilise carbon dioxide to neutralise the excess alkalinity. All the treatment chemicals to be used have previously been approved for use by the Environment Agency in connection with treatment of surface water which is discharged via the same outfall. A cement water characterisation report is in preparation. The ground, granulated blast furnace slag (GGBS) and the cement are commonly used and well understood ingredients within cementitious products; the principal substances that could conceivably give rise to environmental effects are metals, anions, and elevated pH. The wash water will be treated to reduce the pH to between 6 and 9 as required under the CWDA permit (Environment Agency, 2018). Therefore, this risk will be removed and does not require further consideration. Given the receiving water is saline, anions are not considered a risk and will be disregarded. This is because of the high chloride and sulphate concentrations naturally present in saline waters. Based on a preliminary characterisation the potential for in combination effects of the concrete wash water with other construction and commissioning discharges is considered in section 4.10.4.

4 Results

4.1 Modelling of the discharge for Zinc in relation to *Corallina*

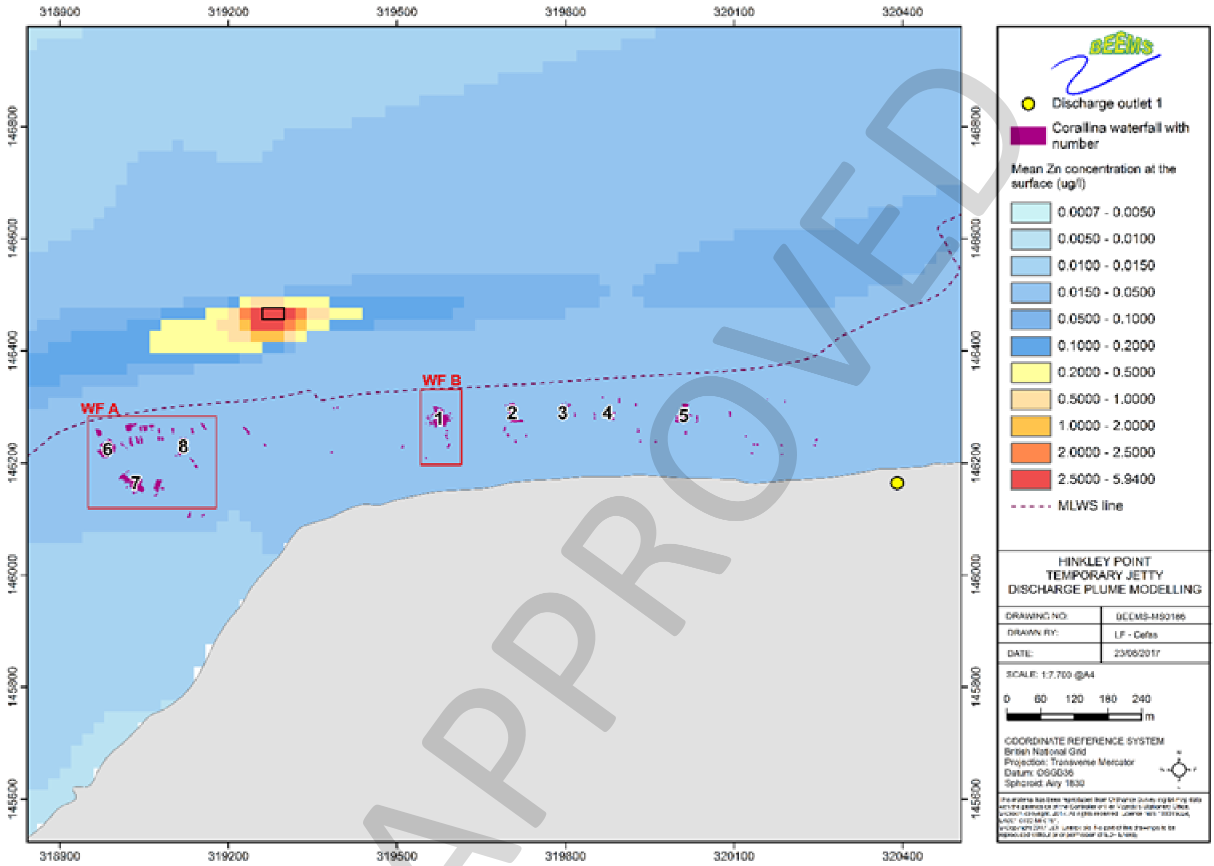

Figure 5. Distribution of average (monthly mean) surface concentrations of zinc for Case D in relation to the *Corallina* features. The EQS is exceeded for the small area by the discharge itself. Features labelled WF are the *Corallina* waterfalls referred to in the HPC jetty monitoring reports (BEEMS TR256). The comparative EQS is 3.77 µg l^{-1}.

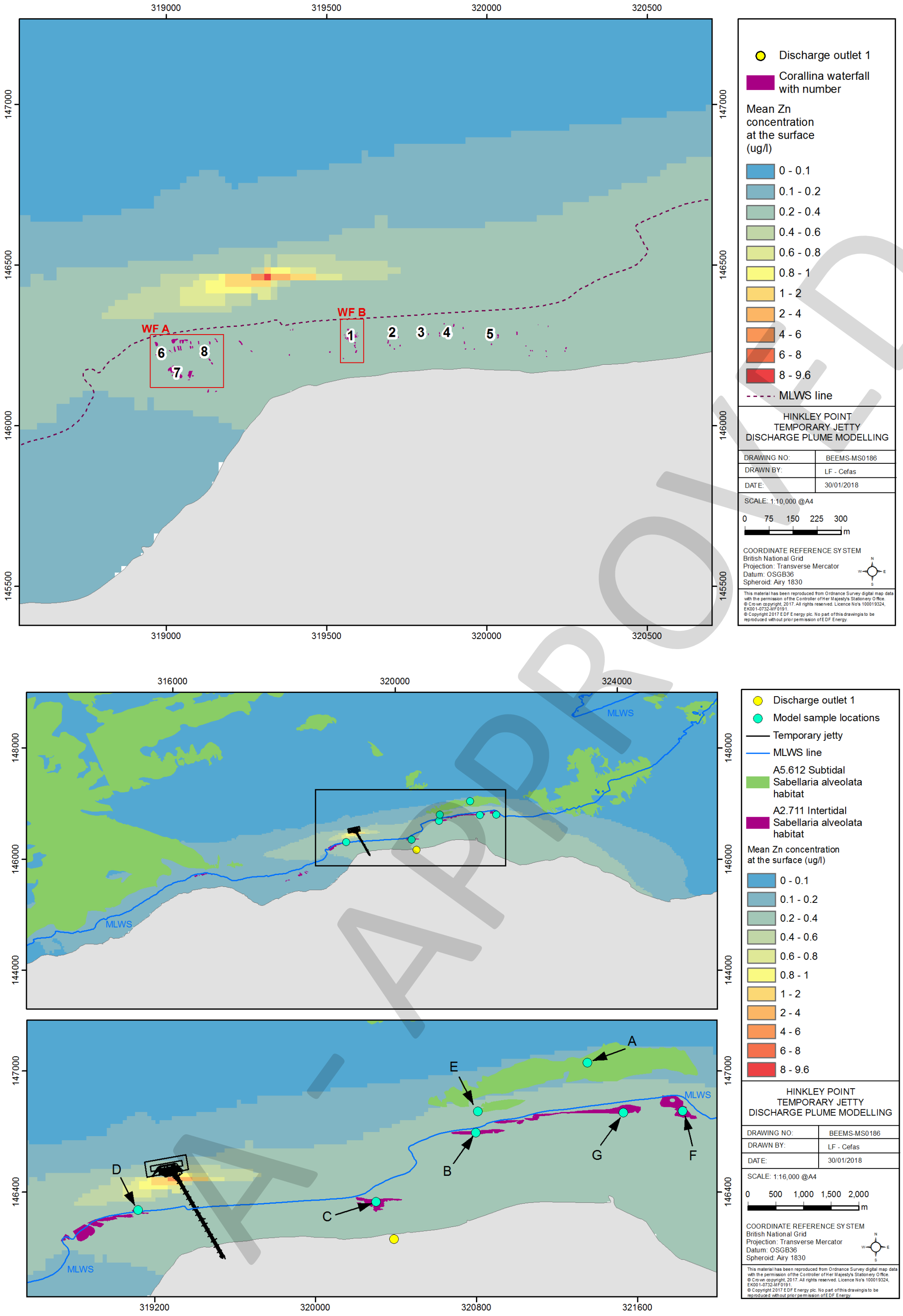

Figure 6. Distribution of average (monthly mean) surface concentrations of zinc for Case C in relation to the *Corallina* features. The EQS is exceed for the small area by the discharge itself. Features labelled WF are the *Corallina* waterfalls referred to in the HPC jetty monitoring report (BEEMS TR256). The comparative EQS is 3.77 µg l^{-1}.

The predicted exposure of *Corallina* to zinc for Case D and Case C are shown Figure 5 and Figure 6 respectively, together with locations where *Corallina* features are present. For zinc, the EQS is defined as an annual average. As described in Section 3.1, the modelling is performed above the background, and all tables and plots show the surplus concentration above background and refer to the EQS concentration above background levels. Zinc has a background concentration of 3.03 µg l^{-1} meaning that the threshold value for exceeding the EQS is 3.77 µg l^{-1} (Table 3). For Case C, the mean seabed concentration at each *Corallina* position increased by approximately 1% of the EQS (Table 7).

Importantly, dilution is significant across the main tidal excursion axis, i.e. there is a very rapid reduction in concentration to the north and south from the discharge plume.

The areas above the EQS for the surface are 0.125 Ha for Case D and 0.3 Ha for Case C.

Table 7. Zinc concentration (µg l^{-1}) at *Corallina* feature locations (Figure 5) for total zinc discharges corresponding to 22 l s^{-1} at 1620 µg l^{-1} Zn (Case D) and 46 l s^{-1} at 1620 µg l^{-1} Zn (Case C). The threshold for discharges to exceed the EQS is 3.77 µg l^{-1}, based on the background concentration.

Feature No. (see Figure 5)	**OSGB Easting**	**OSGB Northing**	**Latitude N (°)**	**Longitude E (°)**	**Mean Case D (µg l^{-1})**		**Max Case D (µg l^{-1})**		**Mean Case C (µg l^{-1})**		**Max Case C (µg l^{-1})**	
					Surface	Bed	Surface	Bed	Surface	Bed	Surface	Bed
1	319575	146280	51.2100	3.1527	0.10	0.10	0.37	0.37	0.24	0.24	0.87	0.87
2	319705	146290	51.2101	3.1509	0.10	0.10	0.64	0.64	0.24	0.24	1.50	1.50
3	319795	146290	51.2102	3.1496	0.11	0.10	0.61	0.61	0.26	0.24	1.44	1.15
4	319875	146290	51.2102	3.1484	0.12	0.12	0.39	0.39	0.28	0.28	0.92	0.92
5	320010	146285	51.2101	3.1465	0.12	0.11	0.49	0.49	0.29	0.26	1.15	1.15
6	318985	146225	51.2095	3.1612	0.10	0.10	0.59	0.59	0.24	0.22	1.38	1.38
7	319035	146165	51.2089	3.1604	0.11	0.10	0.29	0.29	0.25	0.23	0.69	0.69
8	319120	146230	51.2095	3.1592	0.11	0.10	0.29	0.29	0.25	0.23	0.69	0.69

Note, there is no exceedance of the EQS. Feature 5 has the highest mean concentration but feature 2 the highest maximum bed concentrations, however maximums are significantly below the EQS.

4.2 Modelling of the discharge for Zinc in relation to *Sabellaria*

On a larger spatial scale than the *Corallina* features, there are intertidal and subtidal patches of *Sabellaria* reef which may be exposed to the total discharge. The EQS for zinc is defined as a mean value and there is no intersection of discharge water above the annual average EQS (adjusted to 3.77 µg l^{-1}) with patches of *Sabellaria* (Figure 7 to Figure 10). The concentrations of zinc at *Sabellaria* features are summarised in Table 8. In all cases the mean EQS is not exceeded and the 95th percentile exposure is below the annual average EQS.

Table 8. Zinc concentrations at *Sabellaria* patches A and E (subtidal) and B, C, D, F and G (intertidal). For locations see Figure 8.

Feature	**Mean seabed µg l^{-1}**		**Seabed µg l^{-1} (95th percentile)**	
	Case D	**Case C**	**Case D**	**Case C**
Subtidal *Sabellaria* A (Easting 321350 Northing 147040)	0.03	0.14	0.09	0.20
Intertidal *Sabellaria* B (Easting 320800 Northing 146694)	0.10	0.24	0.23	0.54
Intertidal *Sabellaria* C (Easting 320300 Northing146351)	0.10	0.24	0.20	0.47
Intertidal *Sabellaria* D (Easting 319118 Northing 16309)	0.10	0.23	0.22	0.53
Subtidal *Sabellaria* E (Easting 320800 Northing 146800)	0.10	0.22	0.28	0.65
Intertidal *Sabellaria* F (Easting 321824 Northing146800)	0.11	0.25	0.23	0.55
Intertidal *Sabellaria* G (Easting 321529 Northing146793)	0.11	0.27	0.24	0.56

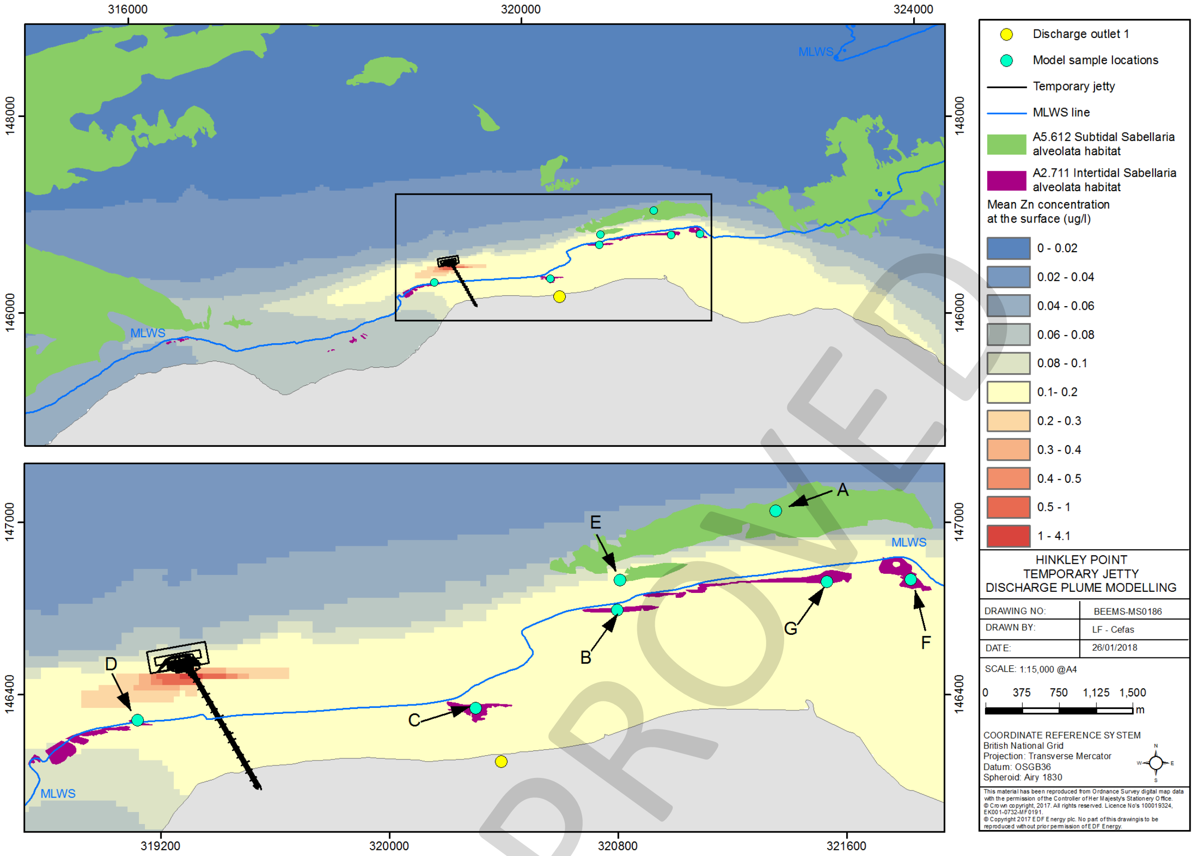

Figure 7. Mean surface discharge concentration of zinc in µg l^{-1} for case D with the location of *Sabellaria* shown (upper), and subtidal *Sabellaria* patch A and intertidal *Sabellaria* patch B, C, D, F and G marked. The EQS for zinc is 3.77 µg l^{-1} above background concentration. The cyan dots mark the *Sabellaria* positions that are listed in Table 8.

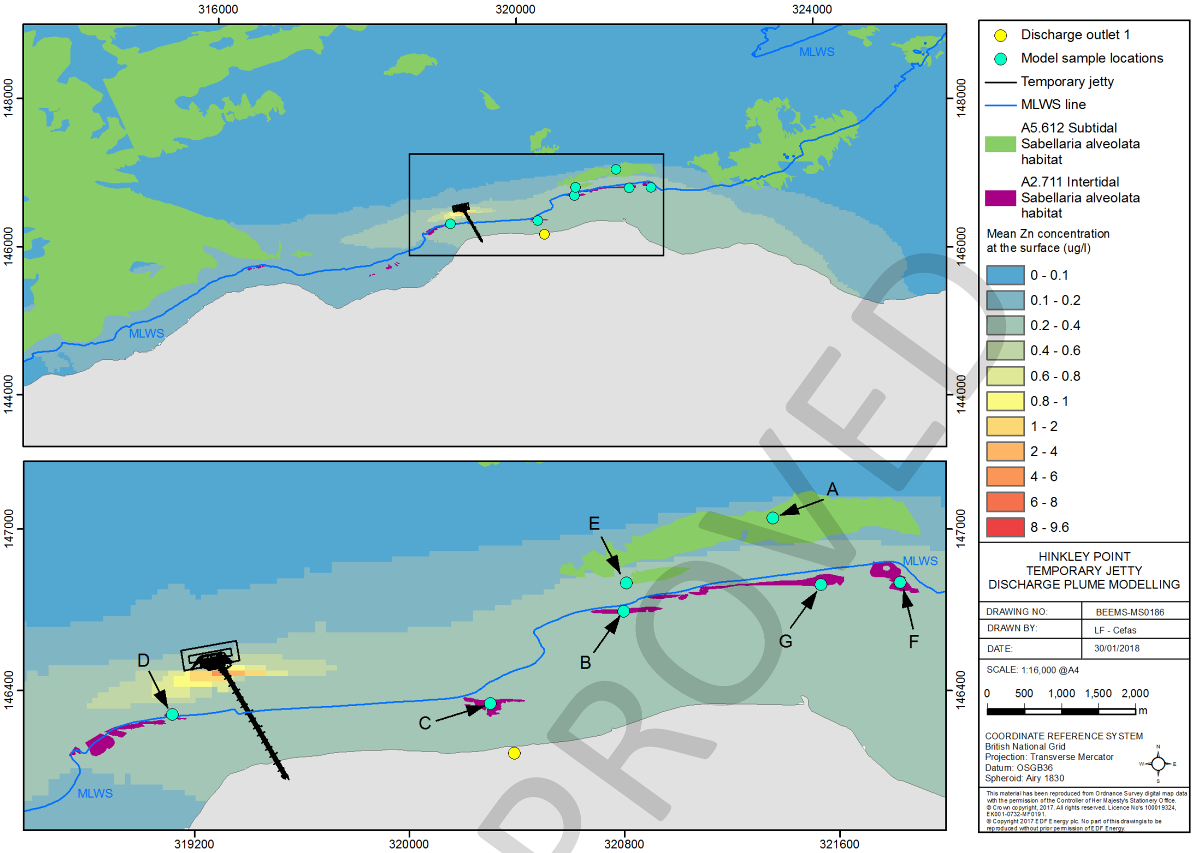

Figure 8. Mean surface discharge concentration of zinc in µg l^{-1} for case C with the location of *Sabellaria* shown (upper), and subtidal *Sabellaria* patches A and E, intertidal *Sabellaria* patches B, C, D F and G. The EQS for zinc is 3.77 µg l^{-1} above background concentration. The cyan dots mark the *Sabellaria* positions that are listed in Table 8.

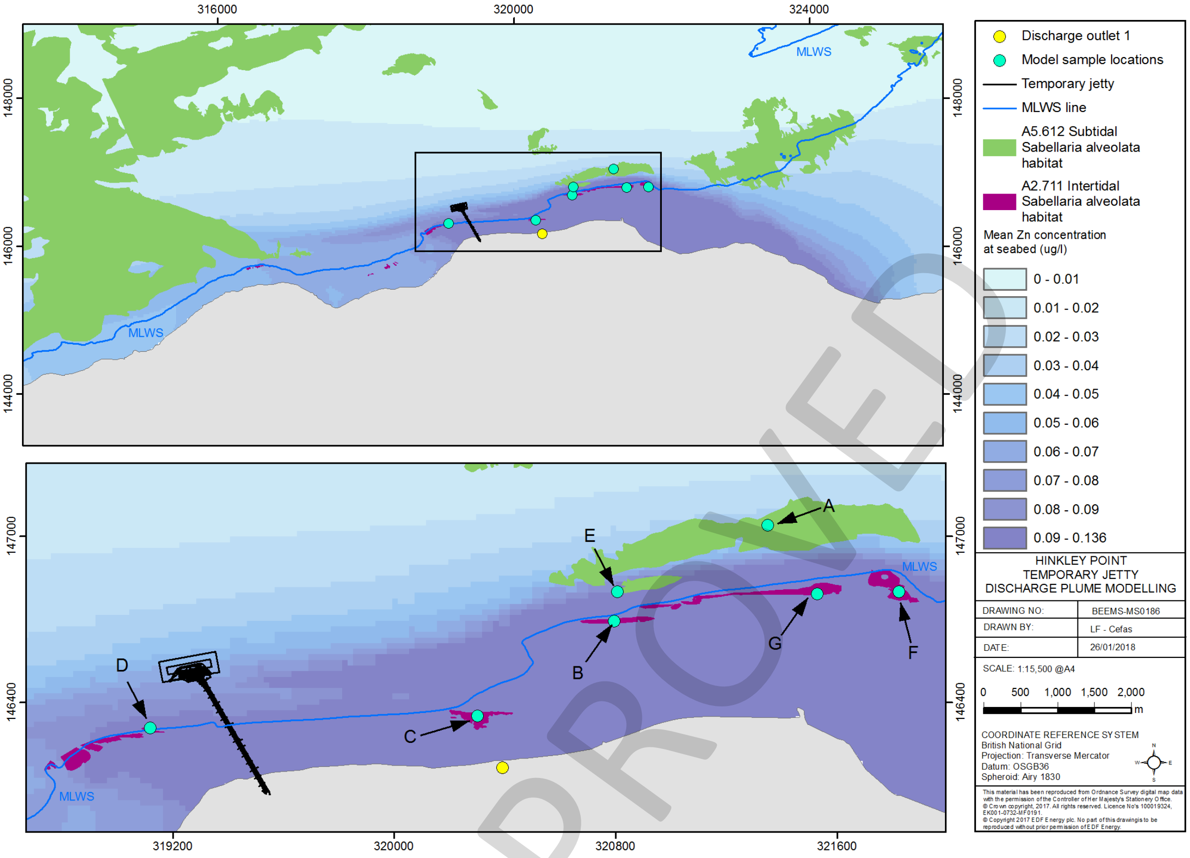

Figure 9. Mean bed discharge concentration of zinc in µg l^{-1} for case D with the location of *Sabellaria* shown (upper), and subtidal *Sabellaria* patches A and E, and intertidal *Sabellaria* patches B, C, D, G, F. The EQS for zinc is 3.77 µg l^{-1} above background concentration. The cyan dots mark the *Sabellaria* positions that are listed in Table 8.

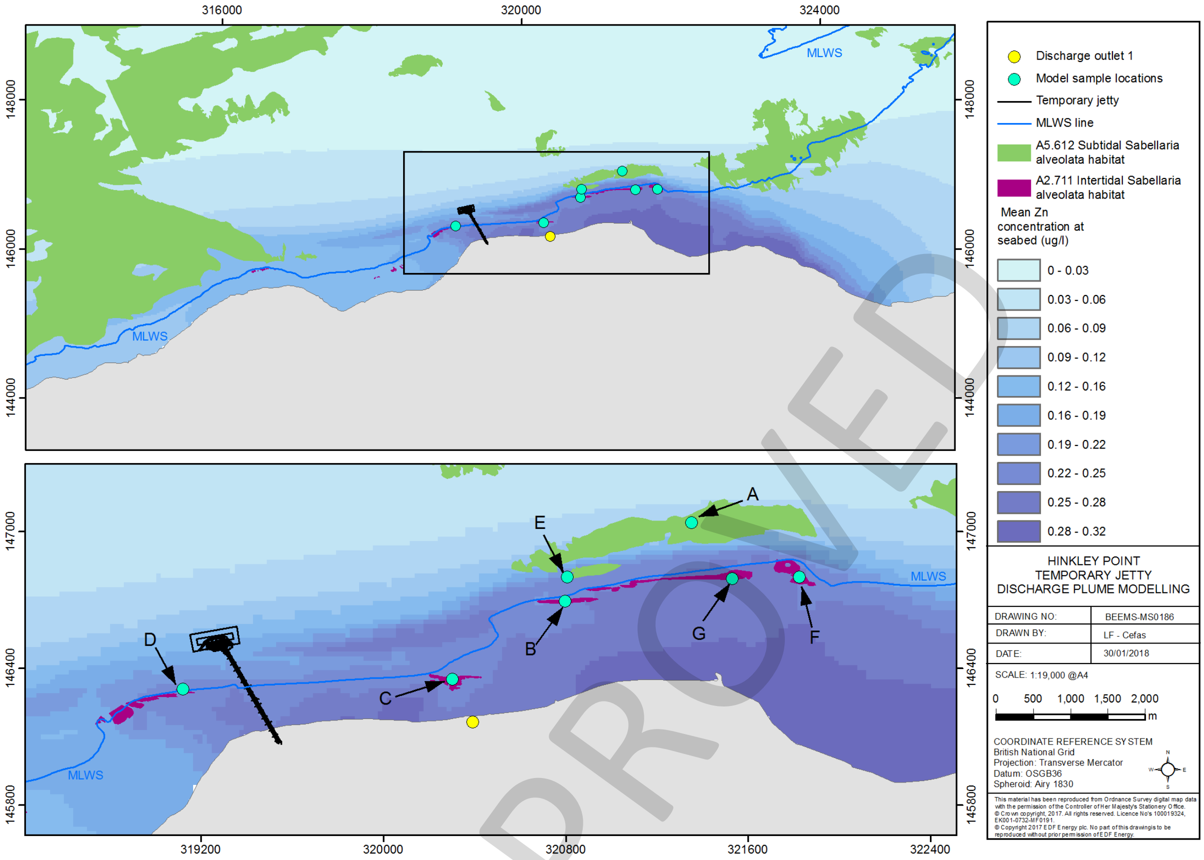

Figure 10. Mean bed discharge concentration of zinc in µg l^{-1} for Case C with the location of *Sabellaria* shown (upper), and subtidal *Sabellaria* patches A and E, and intertidal *Sabellaria* patches B, C, D, E, F and G marked. The EQS for zinc is 3.77 µg l^{-1} above background concentration. The cyan dots mark the *Sabellaria* positions that are listed in Table 8.

4.3 Modelling of conditioning chemical BASF Rheosoil 143 in relation to *Sabellaria*.

Having failed the screening test, this compound is modelled in an identical way to zinc. As the modelling of zinc does not assume any substance decay, and predicted concentrations come only from dilution, these results have been scaled from the model simulations undertaken for zinc by using a multiplier to correctly simulate the mass of discharged chemical. The exact chemical to be used may change depending on the tunnelling machine employed and substrata encountered. This modelling is included to show the likely spatial extent of a discharge of 40 l s^{-1} at concentration of 19.83 mg l^{-1} with an EQS of 40 µg l^{-1}. The tunnelling operations which use this chemical are likely to occur during the Case D period (40 l s^{-1}) however the results are insensitive to this flow volume as it is the total mass of material that is discharged that is the primary consideration.

The modelling results for BASF Rheosoil 143 are shown in
Figure 11 and Figure 12 which show that there is no exceedance of mean PNEC (surrogate EQS) at the bed; there is a small area at the surface where the EQS is exceeded. The 95th percentile concentrations at the bed are shown in Figure 13.

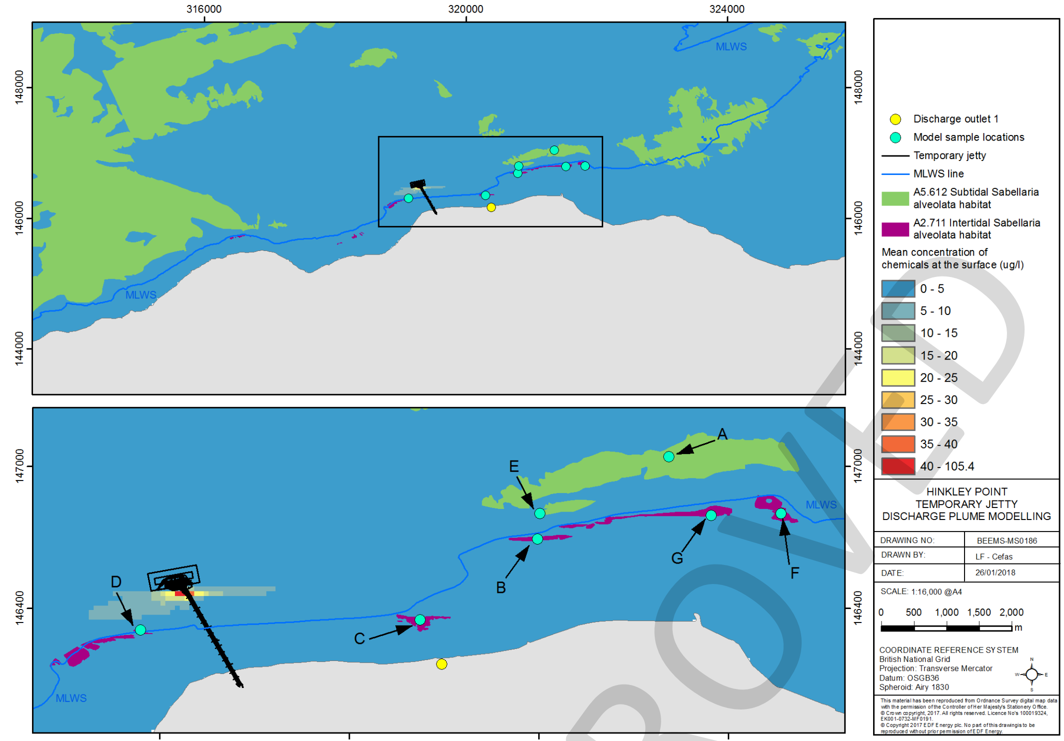

Figure 11. Mean surface concentration of BASF Rheosoil 143 in µg l^{-1}. The PNEC (surrogate EQS) is 40 µg l^{-1}. Subtidal *Sabellaria* patches A and E and intertidal patches B, C, D, E, F and G are marked.

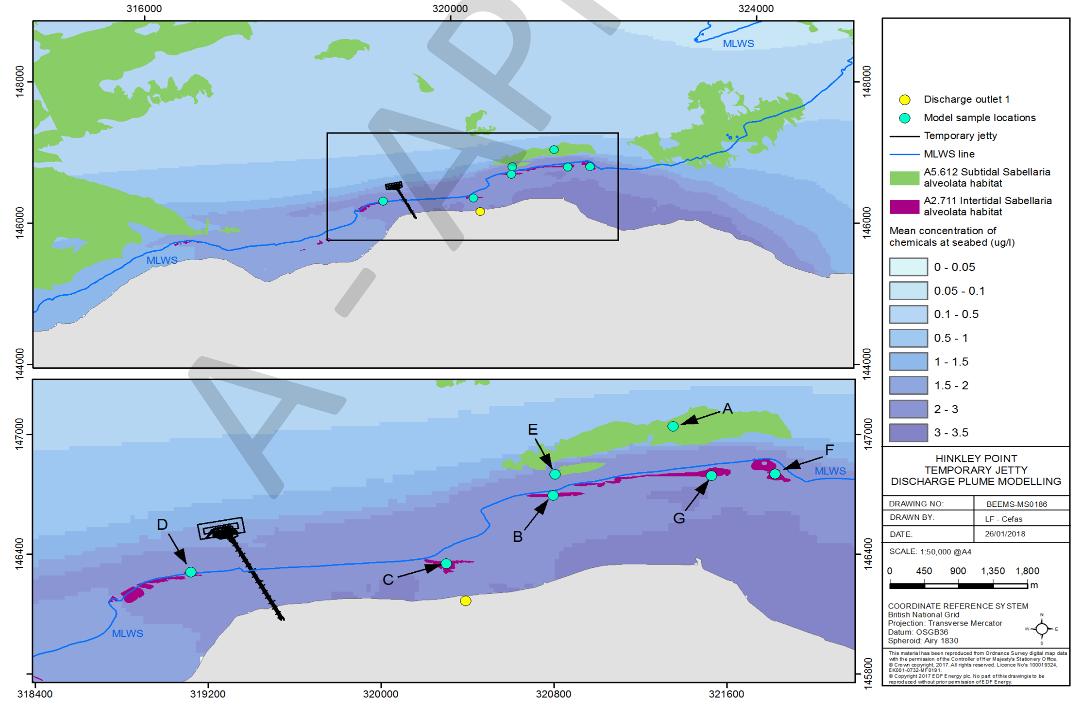

Figure 12. Mean bed concentration of BASF Rheosoil 143 in µg l^{-1}. The PNEC (surrogate EQS) is 40 µg l^{-1}. Subtidal *Sabellaria* patches A and E and intertidal patches B, C, D, F and G are marked.

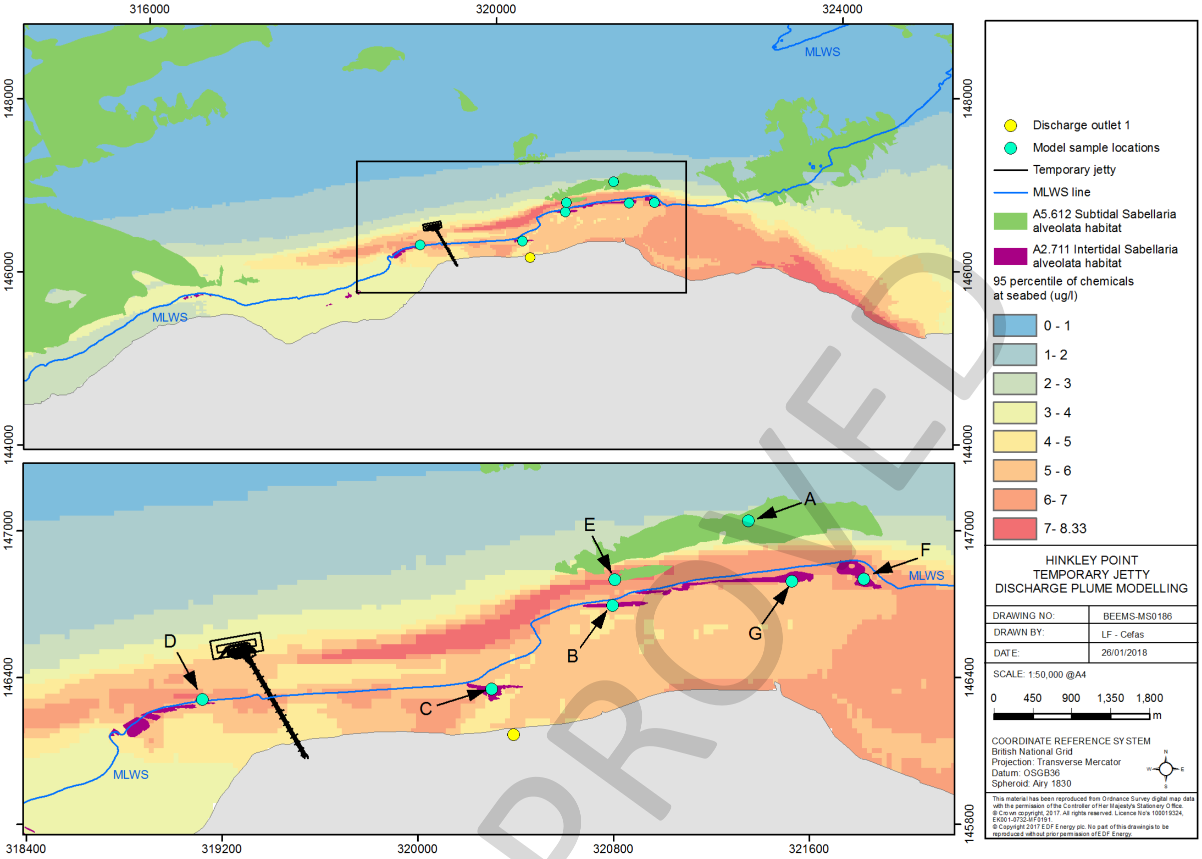

Figure 13. 95th percentile bed concentration of BASF Rheosoil 143 in µg l^{-1}. The PNEC (surrogate EQS) is 40 µg l^{-1}. Subtidal *Sabellaria* patches A and E and intertidal patches B, C, D, F and G are marked.

4.4 Modelling of conditioning chemical Condat CLB F5/M in relation to *Sabellaria*

Results of Condat CLB F5/M modelling are shown in Figure 14 and Figure 15. This modelling shows the likely spatial extent of a discharge of 40 l s^{-1} with a concentration of 6.6 mg l^{-1} and an EQS of 4.5 µg l^{-1}. No exceedance of the EQS concentration is predicted to occur at the bed, though a small area of exceedance (0.96 ha) is predicted at the surface. Note the scales are different between surface and bottom plots. 95th percentile concentrations at the seabed are shown in Figure 16.

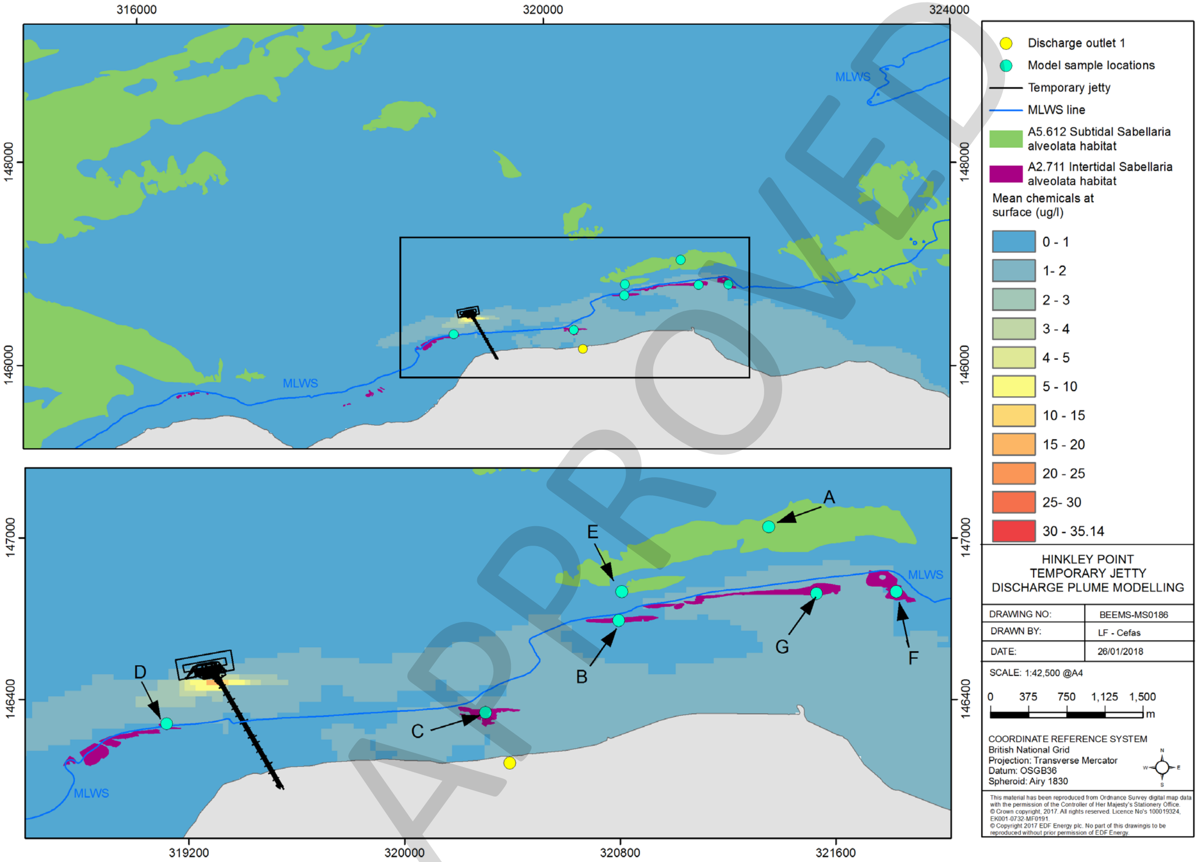

Figure 14. Mean surface concentration of CLB 5 in µg l^{-1}. The PNEC (surrogate EQS is 4.5 µg l^{-1}) with the location of *Sabellaria* delineated. Subtidal *Sabellaria* patch A, E and intertidal *Sabellaria* patches B, C, D, F and G marked.

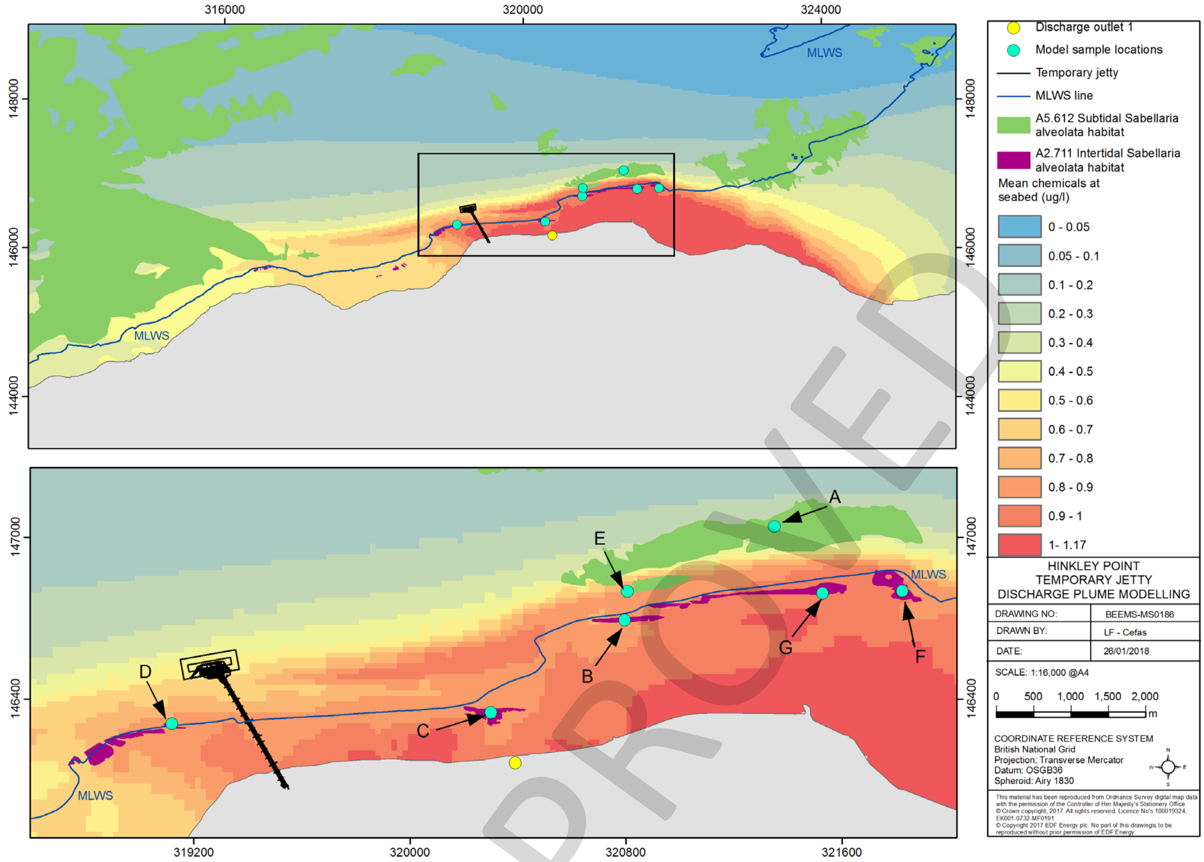

Figure 15. Mean bed concentration of CLB 5 in µg l^{-1}. The PNEC (surrogate EQS) is 4.5 µg l^{-1} with the location of *Sabellaria* delineated. Subtidal *Sabellaria* patch A, E and intertidal *Sabellaria* patches B, C, D, E and G marked. No exceedance of the PNEC is predicted at the bed.

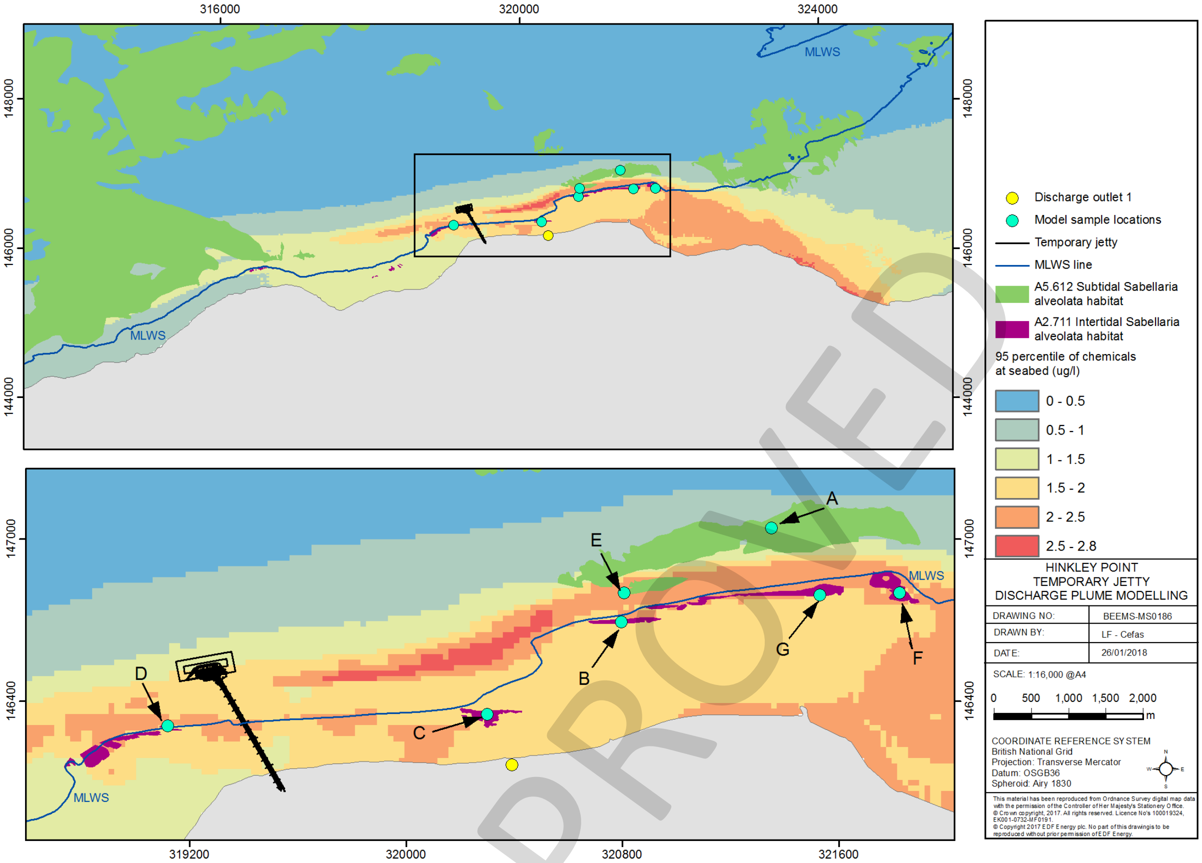

Figure 16. 95th percentile concentration of CLB 5 in µg l^{-1} at the seabed. The PNEC (surrogate EQS) is 4.5 µg l^{-1}. Subtidal *Sabellaria* patches A, E and intertidal *Sabellaria* patches B, C, D, E and G are marked.

Table 9. Concentrations of active substances of conditioning products, occurring at *Sabellaria* patches A, E (subtidal) B, C, D, F and G (intertidal). Feature locations are shown in Figure 16.

Feature	**Mean seabed concentration (µg l^{-1})**		**95th percentile seabed concentration (µg l^{-1})**	
	CLB 5 (PNEC/EQS 4.5 µg l^{-1}).	BASF Rheosoil 143 (PNEC/EQS 40 µg l^{-1})	CLB 5 (PNEC/EQS 4.5 µg l^{-1}).	BASF Rheosoil 143 (PNEC/EQS 40 µg l^{-1})
Subtidal *Sabellaria* A Easting 321350 Northing 147040	0.53	1.58	0.74	2.21
Intertidal *Sabellaria* B Easting 320800 Northing 146694	0.87	2.60	1.96	5.87
Intertidal *Sabellaria* C Easting 320300 Northing146351	0.86	2.57	1.70	5.10
Intertidal *Sabellaria* D Easting 319118 Northing 16309	0.84	2.52	1.93	5.79
Subtidal *Sabellaria* E Easting 320800 Northing 146800	0.79	2.37	2.37	7.12
Intertidal *Sabellaria* F Easting 321824 Northing146800	0.91	2.73	1.99	5.96
Intertidal *Sabellaria* G Easting 321529 Northing146793	0.97	2.90	2.03	6.09
Corallina Position 5 Easting 320010 Northing 146285	0.94	2.84	2.01	6.01

It can be seen from the figures and table above is that neither mean bed concentrations nor 95th percentile concentrations exceed the EQS, and benthic features should therefore remain unaffected. There is a small area of exceedance at the surface near the discharge (Table 10).

Table 10. Summary of exceedance areas for BASF Rheosoil 143 and CLB F5

Discharged chemical	**Area of exceedance at surface**	**Area of exceedance at bed**
BASF Rheosoil 143 (Sodium lauryl ether sulfate.)	1875 m^2 (0.19 ha)	0
CLB F5 (Mono-C10-16-alkyl, Sodium sulfate (≤10%))	10,000 m^2 (1 ha)	0

Location G has the highest mean concentrations of conditioning products (Table 9). A time series of CLB 5 concentration at this location is therefore shown in Figure 17 to demonstrate the nature of the exposure. The PNEC for CLB 5 is 4.5.

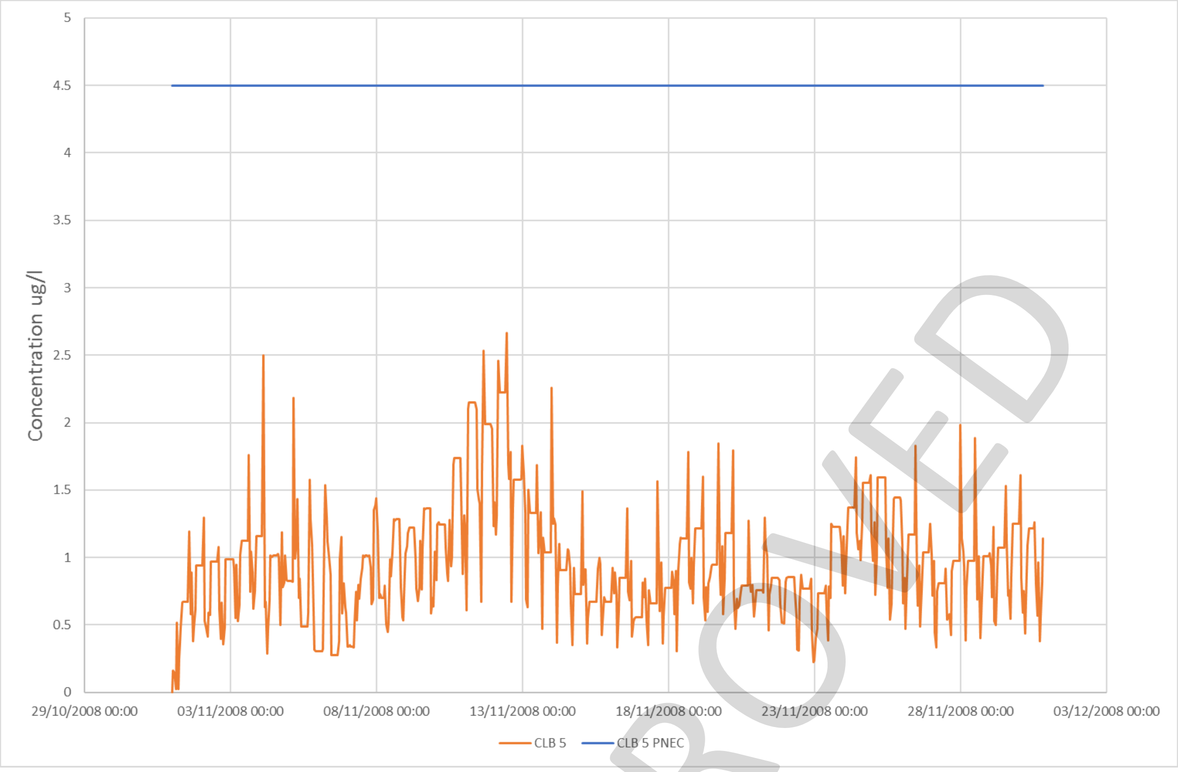

Figure 17. Time series at location G (see Figure 16)of concentration (µg l^{-1}) for CLB 5. The EQS is 4.5 µg l^{-1} and no effect concentration (NOEC) is 45 µg l^{-1}. The NOEC for Mono-C10-16-alkyl (active substance with lowest PNEC for CLB5) comes from HERA (2002) Risk Assessment.

The NOEC is a concentration which would be relevant to peaks, which could occasionally exceed the PNEC. Edition 5 of this reported indicated that a maximum spike would exceed the PNEC. However, in the revised modelling presented here in Edition 6, no values are expected to exceed the PNEC. Figure 17 shows that the concentration varies tidally, with peak concentrations around 2.7 µg l^{-1} on 11th Nov.

4.5 Total loading of Dissolved Inorganic Nitrogen (DIN) concentration during construction only (not including cold commissioning).

Background winter DIN concentrations in Bridgwater Bay, are typically 75 µmol (minimum 34.3, maximum 123) or, as N, 1.05 mg l^{-1} (minimum 0.5, maximum 1.7) (source: Environment Agency GB6708074, see Appendix B).

The discharge of DIN at the jetty is made up of the following sources:

1. The total dewatering discharge (with a maximum flow during Case D of approximately 25 l s^{-1}) with a groundwater mean concentration of 2.95 mg l^{-1} as N (this latter was recalculated by the Environment Agency and resulted in a reduced mean of 1.861 mg l^{-1} as N);

The sewage treatment from the main plant construction with a flow of 1150 m^{3} day^{-1} or 13.3 l s^{-1}. With secondary treatment, has maximum of 20 mg l^{-1} of ammoniacal nitrogen as N. This results in a DIN discharge of 38.3 l s^{-1} at 3.5 mg l^{-1} (2.95 x 25 +5 x 13.3/ 40) (the recalculated value is 1.86 x 25 + 5 x 13.3/ 40 =2.82 mg l^{-1} DIN calculations for different Case examples are provided in Appendix C Table 28.

Maximum concentrations and flow for nitrogen inputs during construction.

The maximum concentration in the sewage discharge could be up to 20 mg l^{-1} of ammoniacal nitrogen as N (based on permit limits for the sewage treatment plant). The mean flow rate is 13.3 l s^{-1} but flow may peak intermittently up to 30 l s^{-1}. It should be stressed that the 95th percentile concentration of the sewage treatment plant is still 5 mg l^{-1} as stated in Edition 5 of this report. This value has been used as previously and is still a conservative estimate of the total loading discharged. The original DIN discharge concentrations and their derivation for each discharge Case are shown in Appendix C Table 28. These values were updated following recalculation by the Environment Agency of groundwater DIN values and these figures are also shown. The updated groundwater values result in a decrease in DIN input concentrations for each Case. However, a more comprehensive assessment of nutrient loadings was subsequently made using a Combined phytoplankton macroalgal model and this is more relevant now than a consideration of individual Case discharge values.

4.5.1 Localised effect of elevated DIN.

The effect of increasing DIN concentration over a small area is unlikely to have any effect on localised phytoplankton production in the estuary as the extremely turbid conditions in the Bristol Channel cause phytoplankton production to be light limited (rather than DIN limited) throughout the year (Underwood, 2010). A more comprehensive updated assessment was made in this report version (Ed7) using a combined phytoplankton macroalgal model (CPM) (Aldridge et al., 2008), and taking account of combined construction and cold commissioning annual inputs of nitrogen and phosphorus and the results are provided in **section 4.10** and more details on the model are provided in Appendix F. Updated values for groundwater DIN based on a recalculation by the Environment Agency result in an overall lower annual loading of nitrogen as shown in Appendix F so the original CPM modelling is precautionary.

4.5.2 Cumulative annual loading for construction inputs of nitrogen only (not including cold commissioning) and effect on water body classification

Because of variations in groundwater discharge, the annual loading varies and is 4934 kg, 4655 kg, 4316 kg of N for years 1,2 and 3 respectively (the calculation of loadings is shown in Appendix C, Table 29). There are two Water Framework Directive (WFD) waterbodies close to the discharge: Bridgwater Bay (surface area 9183.5 ha) and the Parrett (7069.0 ha), with the discharge at the jetty location and Outlet 1 directly into Bridgwater Bay, and near to the Parrett. HPB discharges directly into the Parrett waterbody. The volume of Bridgwater Bay at Mean Sea Level (MSL) is 9.77×10^8 m^3 (a mean depth of 10.6m). The Parrett has a smaller volume (2.24×10^8 m^3) and mean depth (3.6 m).

Over a year the high degree of mixing is likely to spread the discharge throughout the waterbody. The DIN standard is usually expressed as µmol l^{-1}. The transitional and coastal waterbody is classified as turbid, with the standards as given in Appendix B. The annual uplift due to the jetty discharge in Bridgwater Bay for year 1 is 4934 kg = 3.52×10^5 µmol / 9.77×10^{11} litres = 0.36 µmol l^{-1}. The mean background concentration identified here is 75 µmol l^{-1} which falls within a good waterbody classification under the Water Framework Directive (99th percentile value 180 µmol^{-1} for turbid waters). The proposed discharge from the jetty is, therefore, a relatively small addition which would not change the classification. Even if the maximum flow of 30 l s^{-1} for the sewage discharge is considered to occur for the whole period (which is extremely unlikely) the discharge becomes 7566 kg and the uplift becomes 0.553 µmol^{-1} which would still not change the waterbody classification. Adopting the updated groundwater calculations derived by the Environment Agency the nitrogen loading figures and resulting uplift would be further reduced.

4.6 Consideration of un-ionised ammonia concentration for construction only (not including cold commissioning)

Ammonia enters freshwater and marine water bodies from sewage effluent inputs, from industrial and agricultural activities and from the breakdown of organic matter. In general, the unionised form of ammonia is more toxic than the ionised form. At higher pH values, unionised ammonia represents a greater proportion of the total ammonia concentration. Temperature increase also raises the relative proportion of unionised ammonia, but this effect is much less marked than for pH change, e.g. a temperature increase of 10°C (from

10 to 20°C) may double the proportion of unionised ammonia, but a pH increase from a pH of 7 to a pH of 8 produces an approximately tenfold increase (Eddy, 2005). A greater percentage of ammonia will also be in the un-ionised form when the salinity is lower.

The concentration of unionised ammonia can therefore be derived from knowledge of the total ammoniacal nitrogen concentration (i.e. NH_4 as N), the salinity, the pH and temperature using the EA calculator (Table 11). Of these factors pH is the most important with an approximate doubling in un-ionised ammonia concentration between pH 7.5 and 8.

The EQS for un-ionised ammonia is 21 µg l^{-1} expressed as an annual average, however being consistent with the previous screening, this value is compared with the 95th percentile source contributions. The 95th percentile values used for the source terms were a groundwater ammonium concentration of 6085 µg l^{-1} (6085 x 0.7777 (conversion of NH_4 to N only) = 4732 µg l^{-1} as N) and a treated sewage effluent maximum concentration of 20000 µg l^{-1} as N. 20000 µg l^{-1} as N represents the design standard of the sewage treatment plant. This is one end member of the mixing relationship and mean values of sea water temperature, pH, and salinity used for the other.

The data used in support of the two components of the mixing relationship have not been updated with more recent values from monitoring data as the variability around the starting parameters for the groundwater was not considered likely to significantly alter the starting proportion of un-ionised ammonia, and the seawater parameters were derived from a sampling grid over four quarters and provided a comprehensive assessment of variability. The original mixing relationship components were:

a. Construction wastewater discharge, with salinity derived from the average of groundwater conductivity data (1312 µs cm), average pH (7.3) and 95th percentile of ammoniacal nitrogen (Atkins, 2016 and permit), and an average temperature of 12.5ºC (BEEMS TR186).

b. seawater, with a mean temperature of 12.5ºC, 50th percentile of salinity (31.5) and seawater pH (7.86) (BEEMS TR186). The average ammoniacal nitrogen in the sea water background was 124 µg l^{-1} as N (Amec, 2009).

Cases C_{max}, $C1_{max}$, D_{max} and sewage only are considered. For Cases C and D, small sources which would dilute the concentration, but which may not be present all of the time have not been considered (e.g. there could be 4 litres per second of additional water not containing ammoniacal nitrogen).

1) Case C_{max} total discharge is 59.3 l s^{-1} with a 95th percentile concentration of 8157 µg l^{-1} ammoniacal Nitrogen as N. (4732 x 46 +13.3 x 20000/ 59.3)
2) Case $C1_{max}$ total discharge is 76.3 l s^{-1} with a 95th percentile concentration of 10759 µg l^{-1} ammoniacal Nitrogen as N. (4732 x 46 +30.3 x 20000/ 76.3)
3) Case D_{max} total discharge is 38.3 l s^{-1} with a 95th percentile concentration of 10034 µg l^{-1} ammoniacal Nitrogen as N. (4732 x 25 +13.3 x 20000/ 38.3)
4) Sewage only discharge is13.3 l s^{-1} at a planned maximum of 20,000 µg l^{-1} ammoniacal Nitrogen as N.

Table 11. Unionised ammonia concentrations for groundwater (GW), treated sewage (STW) and combined discharge derived using the EA calculator as a source term before mixing.

Discharge	**Ammoniacal nitrogen (N) (µg l^{-1})**	**Salinity**	**Temp °C**	**pH**	**Un-ionised ammonia (µg l^{-1})**
Case C $_{max}$	8,157	1	12.5	7.3	36.4
Case C1$_{max}$	10,795	1	12.5	7.3	48.1
Case D $_{max}$	10,034	1	12.5	7.3	44.8
Sewage discharge only	20,000	1	12.5	7.3	89.2

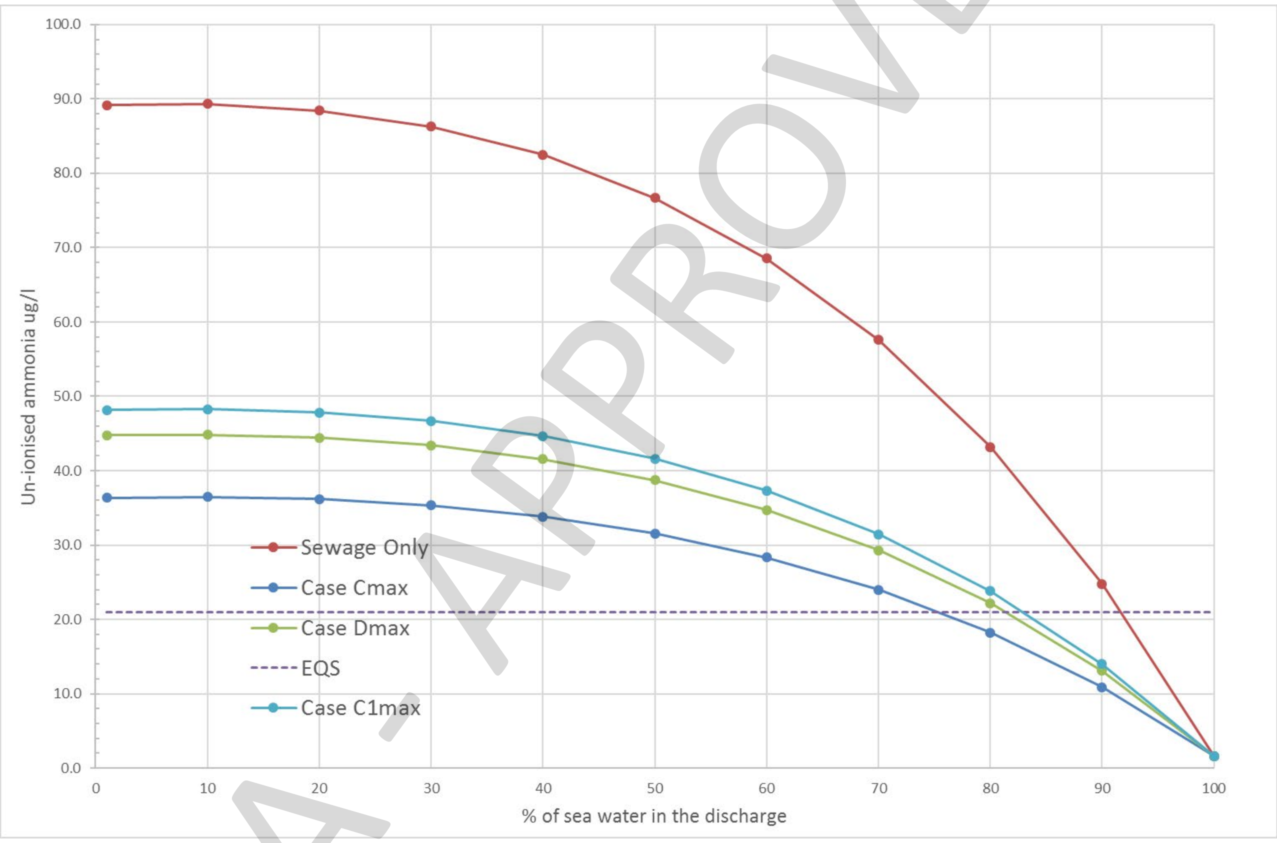

Figure 18. The change in production of un-ionised ammonia (µg l^{-1}) as the discharge is mixed with seawater for sewage only, and cases C, C1$_{max}$ and D$_{max}$.

The calculations shown in Figure 18 are independent of the volume of the discharge, this graph therefore must be considered in combination with the estimated dilution rates derived from the Cormix modelling. While the Case C discharge is mostly likely 63 l s^{-1} it has been conservatively modelled as a 90 l s^{-1} discharge as this is a potential permitting value, 90 l s^{-1} also incorporates the C1 case. The Case D discharge is mostly likely 36 l s^{-1} but has been considered has a 45 l s^{-1} to ensure that estimates are conservative.

It is evident from Figure 18 that there is exceedance of the EQS (21 µg l^{-1}) when less than 75% mixing has occurred for Case C, 82% mixing for Cases D and C1 and 92% for the sewage only case. In relation to Case C, it can be seen from

Figure 28 (Appendix D) that a dilution factor of 4, (80% mixing) occurs after 8m in the minimum dilution case at low tide for a discharge of 90 l s^{-1}.

Figure 28 is also relevant to case C1, showing that a 1:10 dilution occurs after approximately 16 m. The Case D situation corresponds to **Figure** 27 (45 l s^{-1}) where 82% mixing (required to dilute the discharge to EQS level) occurs approximately 7 m from the discharge point. The sewage only case **(**Figure 29), which is unlikely to occur, would be compliant with a dilution of between 1:9 and 1:10. This dilution is likely to have occurred within 3 m of the discharge.

4.7 Biological Oxygen demand.

The sewage treatment works is expected to achieve a maximum concentration of BOD of 40 mg l^{-1} (i.e. draw down over 5 days) and the indicative MAC to be applied in the permit is therefore 40 mg l^{-1}. The Severn has strong tides and the receiving waters near the discharge are well mixed vertically. Draw down of oxygen will only occur if the rate of consumption due to BOD is greater than the oxygen transfer across the water surface. Typical values of oxygen flux are 100 mmol m^{-2} d^{-1} (Hull, 2016) or 3.2 g m^{-2} d^{-1}. Using the 13.3 l s^{-1} discharge and a BOD of 40 mg l^{-1}, a daily BOD of 46 kg was calculated. This amount of oxygen would be transferred across 14364 m^2 in a day. The tidal excursion (how far a particle is advected) at Hinkley Point, even on the weakest (neap) tides, is many kilometres, thus there is ample resupply of oxygen from the atmosphere so that no change in oxygen concentration would be observed. The EQS for dissolved oxygen in the receiving water is 4.16 mg l^{-1} (5th percentile) and the likely background concentration is more than 7.5 mg l^{-1}.

4.8 Total Loadings of Suspended Solids

The background suspended solids concentration in the receiving water is relatively high (mean = 264 mg l^{-1}, minimum 33 mg l^{-1}). Commissioning activities such as hydrostatic testing and flushing will result in variable suspended solids loadings within resultant effluents. The Commissioning Effluent Treatment Plant (CETP) will incorporate methods to reduce suspended solids to achieve permitted levels prior to discharge.

4.9 Coliforms – bathing water standards and shellfish

Monitoring of the existing sewage treatment (EDFE, Proctor e-mail, 28th March) provides estimates of maximum discharge concentrations of inputs into the sewage treatment plant. Secondary treatment implies a 100 factor (2 log) reduction in Coliforms and Enteroccci. If UV treatment is applied a 5.4 log reduction would occur. The dilution factor required to reduce the coliform concentrations to levels that would comply with bathing water standards has been derived. The distance from the discharge point at which this dilution occurs has been estimated using the Cormix estimates of dilution rates relevant for the 13.3 l s^{-1} sewage discharge (Figure 29, Appendix D). The maximum flow rate of 30 l s^{-1} could potentially occur although only briefly, dilution has been conservatively estimated using the 45 l s^{-1} simulation (Case D, Figure 27, Appendix D). The discharge plume is buoyant and will be on the surface, but it should be noted that the Cormix modelling does not include mixing due to waves and that mixing rates are most likely a significant underestimate as surface wave mixing will increase the mixing rate. Typical wave conditions (1m Hs) will ensure rates of mixing 10 times higher than that estimated by Cormix hence the concentration of *E.coli* cells is likely to exceed the bathing water standard only within 200 m of the discharge for the 13.3 l s^{-1} case even without UV treatment. With UV treatment even at the higher discharge volume (30 l s^{-1}) exceedance is limited to within 1 metre of the discharge. Typically, the sewage discharge may not be discharged on its own, but as part of other discharges, these other discharges will add direct dilution which compensates for the inhibition of mixing. The discharge point is not in designated bathing waters. Treatment from the plant is sufficient to ensure that microbial concentrations in discharged waters comply with bathing water standards within a maximum of 2.8 km from the discharge point (without UV treatment) and within 10 m (with UV treatment). The nearest designated bathing waters (Blue Anchor West, latitude 51.18° N, longitude 003.401°

W and Berrow North of Unity farm, latitude 51.28º N, longitude 003.018º W) are approximately 12 km distant. This assessment is based on bathing water regulations (2013. No. 1675) for coastal and transitional waters for which Good status requires that the colony forming unit (cfu) counts for intestinal enterococci are ≤200 cfu/100ml and for *Escherichia coli* are ≤500 cfu/100ml. Porlock Bay Oysters is the shell fishery closest to the discharge (the fishery is approximately 32 km to the West). The predicted changes to coliform concentrations at this distance from the site are expected to be negligible and no effect to any shell fishery is therefore predicted.

Table 12 Estimate of coliform exceedance with treatment level.

Species	**Standard cells/ 100ml**	**Discharge concentration cells / 100ml**	**2^{nd} treatment 2 log reduction**	**Dilution factor required for discharge to meet bathing water standard**	**Maximum potential distance from the discharge for discharged water to meet bathing water standard**		**UV treatment reduction[1]**	**Dilution factor required for discharge to meet bathing water standard**	**Maximum distance from the discharge for discharged water to meet bathing water standard**
					$13.3\ l\ s^{-1}$	**$30\ l\ s^{-1}$**			
E.coli	500	240,000,000	2400000	4800	~1.8 km	~2.8 km	955.5	1.9	<1 m pass immediately on discharge, for both cases.
Entero-cocci	200	13,600,000	136000	680	<200 m	~520 m	541.4	2.7	<10 m from discharge, for both cases.

[1] a log 5.4 reduction is achieved by UV treatment for *E. Coli* and a log 4.4 reduction for enterococci, assuming background concentrations are zero

4.10 Construction and cold commissioning discharge

During the last period of construction, there will be cold commissioning of the turbines and the associated discharge of chemicals (denoted as Case J, Table 1) primarily hydrazine used to condition the turbines and associated pipework. During cold commissioning, the cooling water system is not available so discharges must occur via the jetty outfall. The modelling of hydrazine has been reported elsewhere (BEEMS TR445) however, ammonia, hydrazine and ethanolamine are added during commissioning and the breakdown of these will potentially contribute to DIN and un-ionised ammonia and so are further assessed in this report. Trisodium phosphate is also added during commissioning so phosphate contributions from this source are also considered with phosphorus inputs from sewage and groundwater. These discharges will occur during the Case D construction period when flows are around 38 l/s. Treated concrete wash water will also be discharged and inputs will overlap with Case D inputs of groundwater and treated sewage and the chemical breakdown products from the commissioning, so this is considered below.

4.10.1 Effect of nutrient (DIN and phosphorus) loading on primary production.

The total loading due to DIN and phosphorus has been considered using the CPM model (Aldridge *et al.*, 2008), more details of the model are given in Appendix F. The effect of the HPC construction and commissioning discharge has been included by incorporating additional total annual loadings of 14575 kg, and 4429 kg for nitrogen and phosphorus, respectively. A more detailed breakdown of source contributions is provided in Appendix C Tables 28 and 29.

To generate some phytoplankton growth data that could be compared between background and elevated nutrient input levels the model was run at a light attenuation coefficient of Kd =1. This is still a turbid environment, just not as turbid as the Severn is for most of the time. Results of the model output show that there is no difference between the Bridgwater Bay reference case or the HPC construction/commissioning run for either phytoplankton production or for macroalgae (Table 13). This can be simply explained as the system is always light limited (Underwood 2010), so that the addition of more nutrients does not affect production.

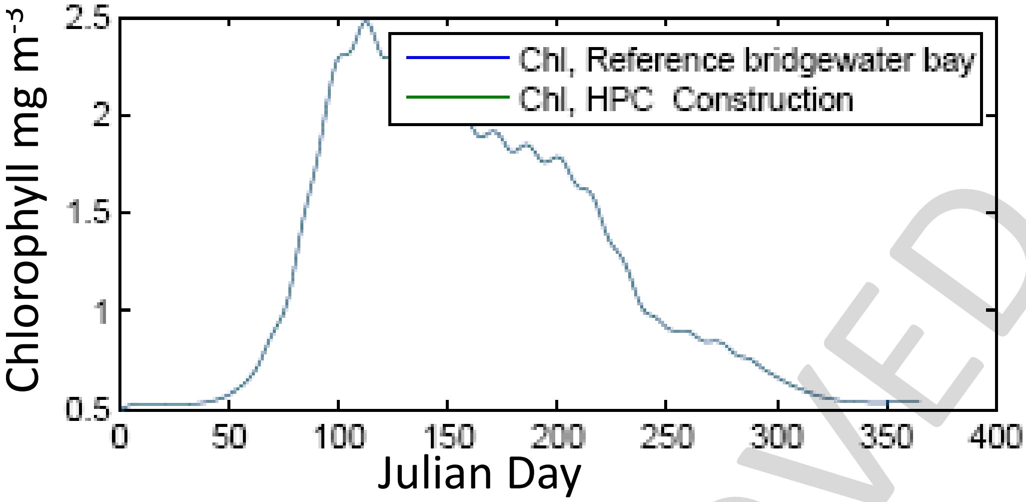

Figure 19 : Instantaneous phytoplankton levels (mg Chlorophyll m^{-3}), for Bridgwater Bay with no power station discharge, and HPC construction. Note that additional nutrient discharges from HPC have no effect on background chlorophyll concentrations (and the reference and construction lines are the same).

Table 13 Phytoplankton and macroalgae production

Scenario	**Phyto Annual Gross Production, (g C m^{-2} y^{-1})**	**Macro Annual Gross Production, (g C m^{-2} y^{-1})**
Bridgwater Bay	11.05	18.43
HPC Construction	11.05	18.43

4.10.2 Ammoniacal Nitrogen

Due to the breakdown of chemicals added during the commissioning process some ammoniacal nitrogen will be generated. This is estimated to have a concentration of 271 mg l^{-1} (Calculation of this value is shown Appendix C Table 28) which is discharged over 5.63 hrs at either 37 l/s or 70 l/s depending on whether there is drainage from one or two HXA tanks per day.

This cold commissioning discharge needs to be considered alongside the construction discharge from groundwater and sewage. As this will occur late in the construction process, Case D flow rate (38 l/s) is most appropriate. Thus, the cases with maximum load of total ammonia to consider are:

1. A continuous discharge (38.3 l/s, at 10.03 mg l^{-1}) + a pulse discharge at midday (37 l/s, 271 mg l^{-1}) for 5.63 h.
2. A continuous discharge (38.3 l/s, at 10.03 mg l^{-1}) + a pulse discharge at midday (70 l/s, 271 mg l^{-1}) for 5.95 h.

These two scenarios were therefore modelled in GETM and treated as passive tracers, in a similar manner to the approach adopted for the conditioning chemicals, using a month-long simulation of the likely behaviour over a spring-neap cycle.

There are also standards, for total ammonia, for which the concentration should not be exceeded:
a) 1100 µg l^{-1}-N annual average (AA)
b) 8000 µg l^{-1}-N maximum acceptable concentration (MAC) (interpreted as 95th percentile).

The mean background ammoniacal Nitrogen (NH_4-N) concentration is 124 µg l^{-1} measured in an annual survey at Hinkley Point (Amec, 2009). This has been included in the plots below (Figure 20 and Figure 21) which show the total ammonia discharge plume prediction in relation to the Corallina feature. For *Sabellaria* the nearest habitat to the discharge is in the intertidal area close to the *Corallina* at station 8. Other areas of *Sabellaria* (as shown in Figure 6) are more distant from the discharge.

As the discharge from the jetty is a fresh water source it is therefore very buoyant, and the highest concentrations will be associated with the surface. The results below are therefore shown for the surface and also from the highest volume case. The model output does **not** show a failure of either the mean or the 95th percentile for either model run, at either the surface or the bed. (There will most likely be a small area of exceedance at the discharge location, but this will be less than the 25m grid cell of the model). The maximum value in the mean file is 1031µg l^{-1} and 4450 µg l^{-1} for the 95th percentile.

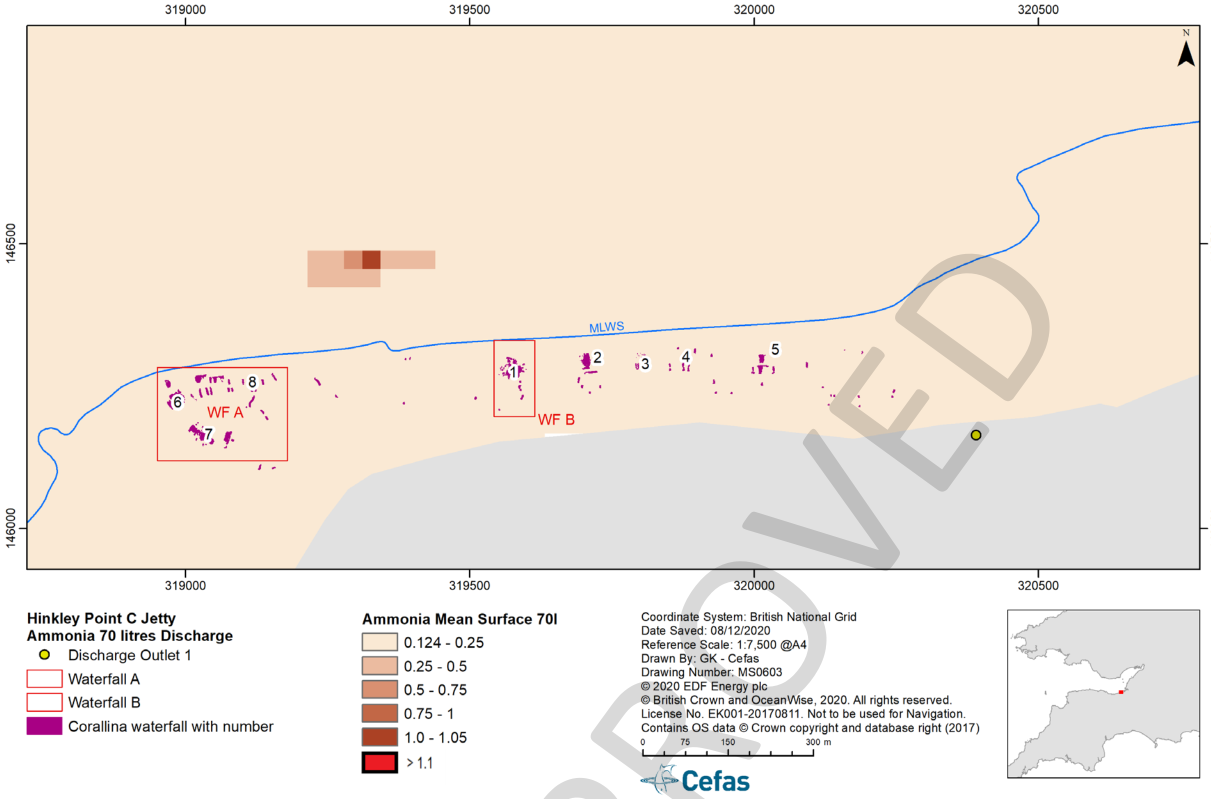

Figure 20 Surface mean ammonia concentration (mg l^{-1}) for the 70 l/s discharge simulation. No values > 1100 µg l^{-1} (PNEC). The figure includes *Corallina* waterfalls. The closest *Sabellaria* to the discharge is in the intertidal near station 8.

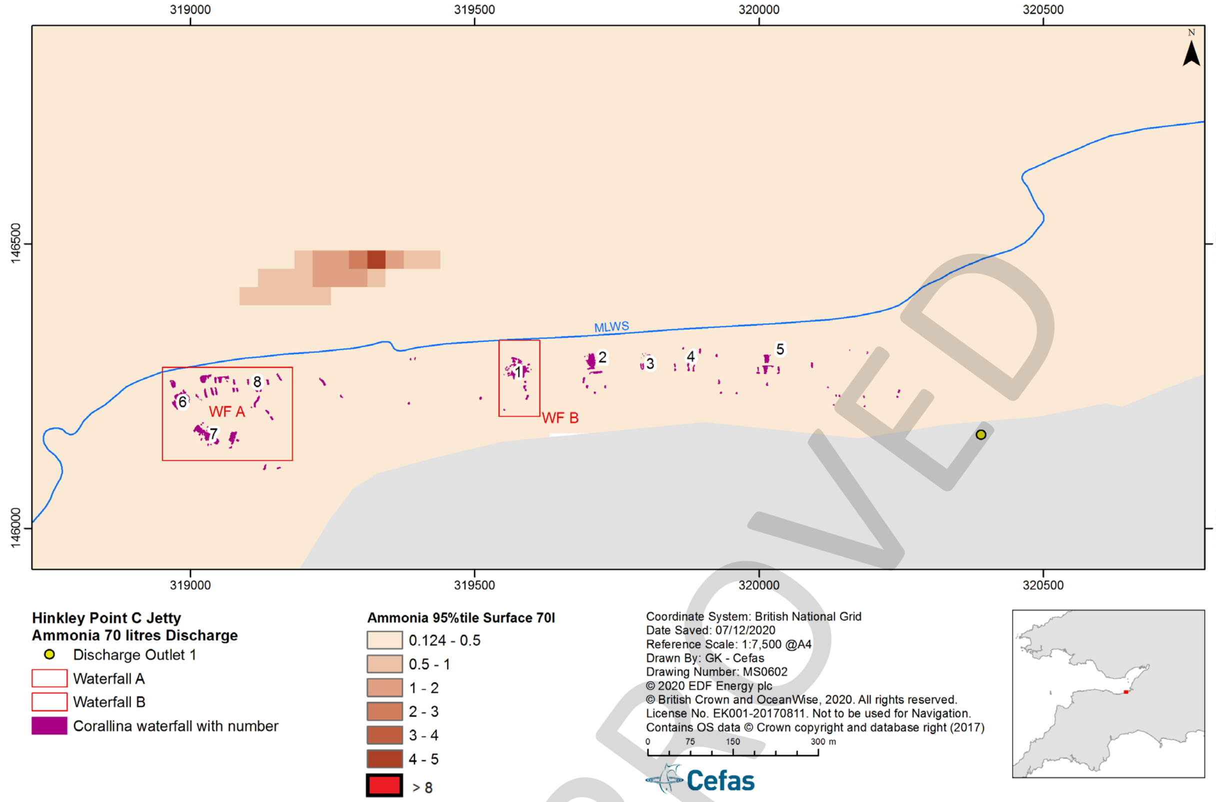

Figure 21 95th percentile surface concentration (mg l^{-1}) of ammonia for 70 l/s. No value exceeds > 8000 μg l^{-1} MAC. The figure includes Corallina waterfalls. The closest *Sabellaria* to the discharge is in the intertidal near station 8.

4.10.3 Consideration of un-ionised ammonia concentration

The concentration of un-ionised ammonia can be derived from knowledge of the total ammoniacal nitrogen concentration (i.e. NH_4 as N), the salinity, the pH and temperature using the EA calculator.

The EQS for un-ionised ammonia is 21 μg l^{-1} expressed as an annual average, however being consistent with the previous screening, this value is compared with the 95th percentile source contributions. The annual mean values were temperature 12.5 °C, pH 7.86 and salinity 31.5 g/kg. The values have been calculated by taking the GETM output, adding the total ammonia background (0.124 mg l^{-1}) and then using the EA calculator to generate the proportion of un-ionised ammonia.

4.10.4 Consideration of combined inputs of concrete washwater

During the period when commissioning chemicals and construction wastewater (as described for Case D) are being discharged at the jetty a maximum daily discharge of treated concrete wash water of 50 m^3/day may also occur. The discharge rate for the concrete wash water (CWW) would be equivalent to a very low continuous daily discharge of 0.57 l/s^{-1}. Preliminary characterisation of untreated concrete wash water indicates the presence of retarder and accelerator chemicals but also trace contaminant metals and ammoniacal and dissolved inorganic nitrogen. The CWW discharge represents just over 2% of the Case D groundwater discharge (25 l/s^{-1}). Because of the very low CWW discharge rate and its low relative percentage contribution compared to groundwater inputs there are likely to be some small but non-significant elevations in the overall discharge concentrations of selected metals. However, as the combined discharge rate of e.g. groundwater and CWW would still be very low ca. 26 l/s^{-1}, an increase of a few percent above that of the original groundwater metal concentrations would have negligible influence on the small mixing zone where the EQS might be exceeded. The dissolved nitrogen and ammoniacal nitrogen contributions are also indicated to be very small at around a half of that for the groundwater and so the concentration in the combined discharge is likely to be relatively unchanged or slightly lower than that already assessed.

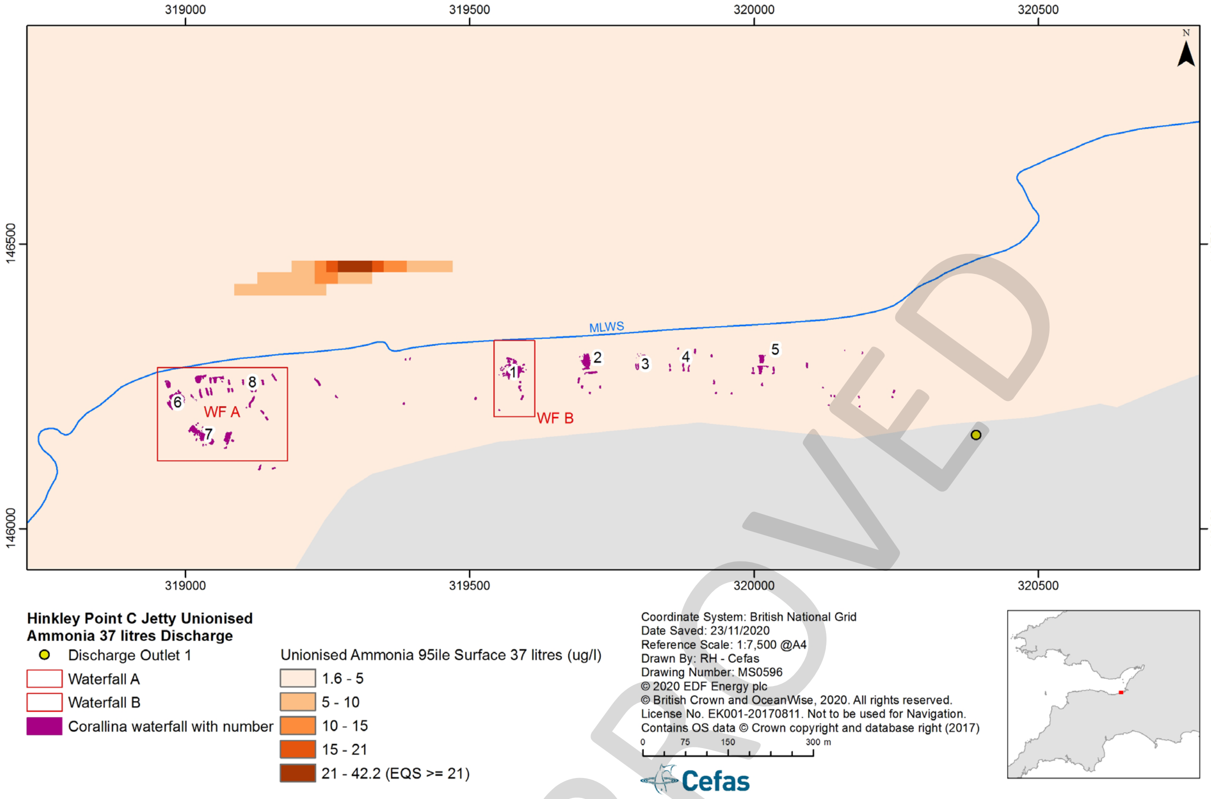

Figure 22 Un-ionised Ammonia Surface Scenario 1(38 l/second at 10 mg l^{-1}+ 37 l/second at 271 mg l^{-1}) 95th Percentile Ammonia. The figure includes *Corallina* waterfalls. The closest *Sabellaria* to the discharge is in the intertidal near station 8.

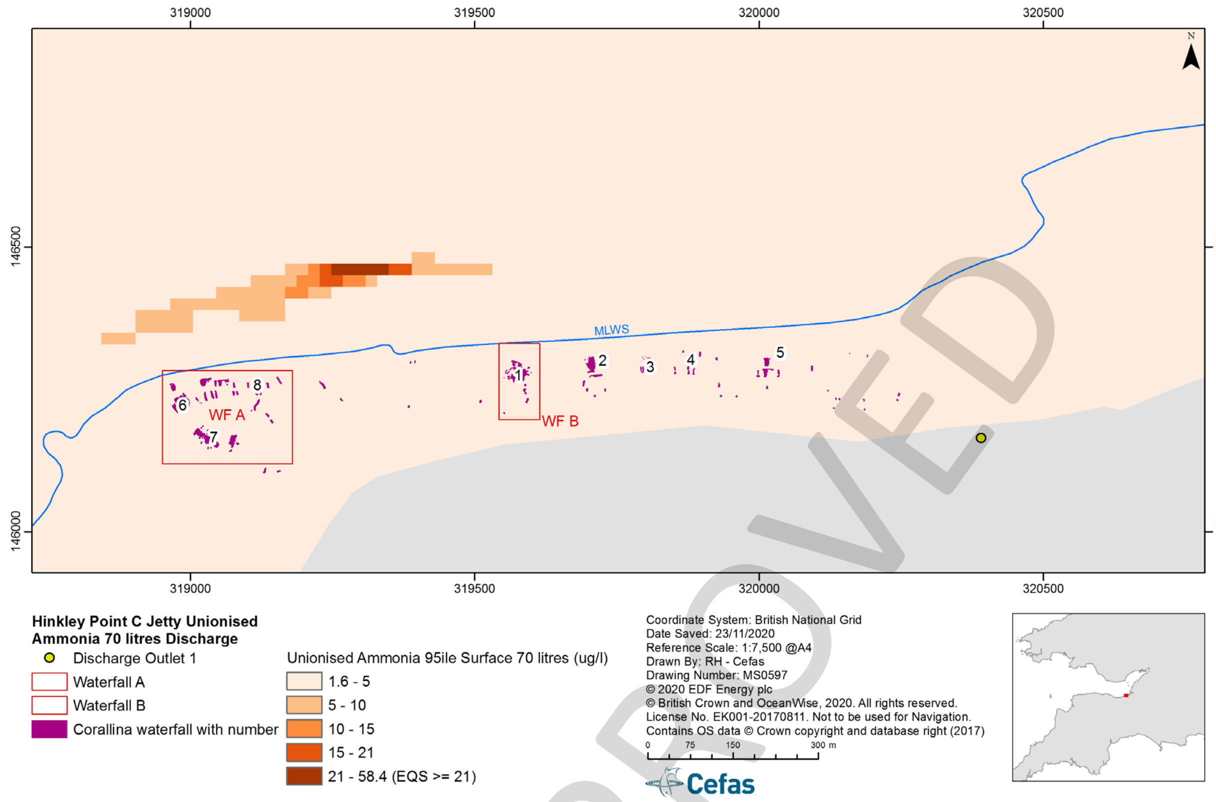

Figure 23 Un-ionised Ammonia Surface Scenario 2 (38 l/second at 10 mg l^{-1}+ 70 l/second at 271 mg l^{-1}) 95th Percentile Ammonia. The figure includes *Corallina* waterfalls. The closest *Sabellaria* to the discharge is in the intertidal near station 8.

Note the area above the 21 µg l^{-1} threshold, when using the 95th percentile of ammoniacal nitrogen is small. For the actual EQS when using the annual average there are no areas of exceedance.

Table 14 Area of exceedance for Un-ionised ammonia

Scenario	**Area > 21 µg l^{-1} Bed**	**Area > 21 µg l^{-1} Surface**
38 l/second at 10 mg l^{-1}+ 37 l/second at 271 mg l^{-1} Mean	No exceedance	No exceedance
38 l/second at 10 mg l^{-1}+ 70 l/second at 271 mg l^{-1}Mean	No exceedance	No exceedance
38 l/second at 10 mg l^{-1}+ 37 l/second at 271 mg l^{-1} 95th percentile	No exceedance	0.12 Hectares
38 l/second at 10 mg l^{-1}+ 70 l/second at 271 mg l^{-1} 95th percentile	No exceedance	0.20 Hectares

Evident from the above is that, based on mean and 95th percentile assessments, there are no areas of exceedance at the bed. However, there was a small area of exceedance of the un-ionised ammonia EQS of either 0.12 or 0.2 hectares dependent upon whether the contents of one HXA tank or two are discharged following treatment. As the areas of concern are the designated features of *Corallina* and *Sabellaria*, more detailed time series were assessed from the *Corallina* marked in Figure 22 and for the *Sabellaria* Figure 16 and are shown below. The values of un-ionised ammonia have been derived using mean temperature, salinity, and pH.

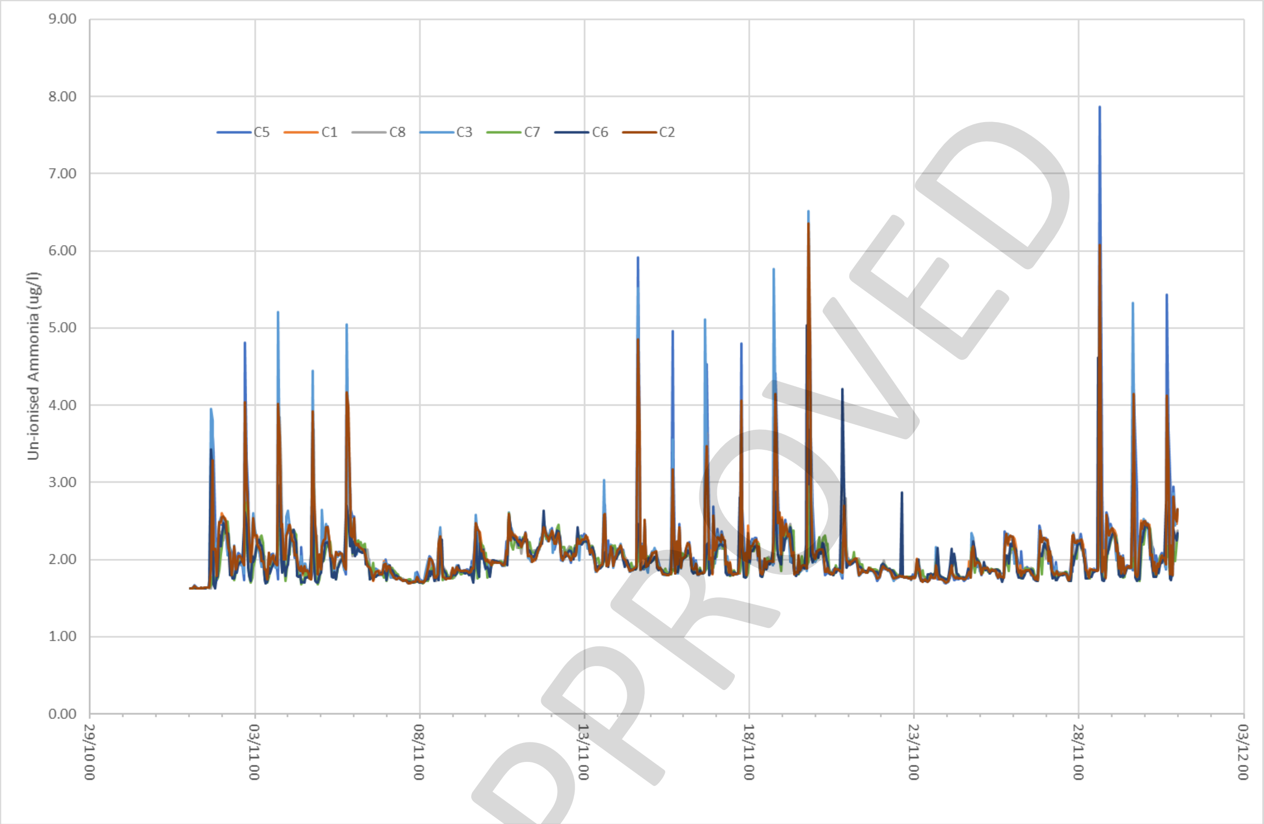

Figure 24 Time series of un-ionised ammonia at the locations of *Corallina* for the 38 l/second at 10 mg l^{-1}+70 l/second at 271 mg l^{-1} scenario.

Evident from Figure 24 is that no *Corallina* features are exposed to high level of un-ionised ammonia, using annual means (as is the standard) however during summer the temperature will be significantly elevated. Therefore, mean and 95th percentile values at this location have been derived for summertime when temperatures will be much higher, using the 98th percentile temperature of 20.4 °C. Apparent, from the table below is that even in summer mean values are still low <4 µg l^{-1}.

Table 15 Summary of Un-ionised ammonia (µg l^{-1}) at *Corallina* features (C1 – C8) for mean and elevated summer temperatures (letters correspond to the locations in Figure 20).

	C1	C2	C3	C4	C5	C6	C7	C8
Mean, using mean values	2.01	2.06	2.07	2.04	2.08	1.99	1.96	2.0
95th, using mean values	2.49	2.58	2.60	2.57	2.69	2.44	2.33	2.4
Mean Using summer T	3.65	3.74	3.75	3.70	3.78	3.61	3.56	3.62
95th, using summer T	4.51	4.67	4.72	4.67	4.87	4.42	4.22	4.35

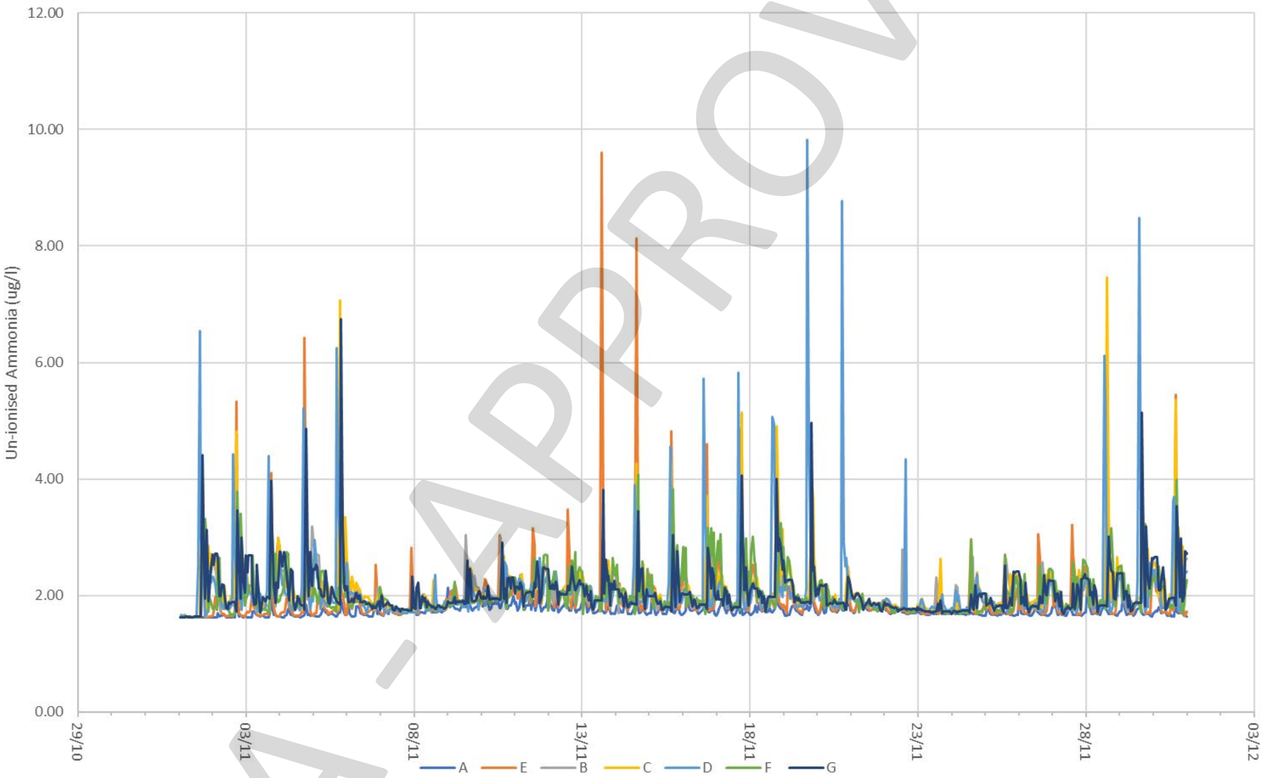

Figure 25 Time series of un-ionised ammonia at the locations of *Sabellaria* for the 38 l/second at 10 mg l^{-1}+70 l/second at 271 mg l^{-1} scenario using mean conditions of temperature, salinity, and pH.

Evident from Figure 25 is that no *Sabelleria* features are exposed to high level of un-ionised ammonia, using annual means (as is the standard) however during summer the temperature will be significantly elevated. Therefore, mean and 95th percentile values at this location have been derived for the summer period when temperatures will be much higher, using the 98th percentile temperature of 20.4 °C. Apparent, from the table below is that even in summer mean values are still low <5 µg l^{-1}.

Table 16 Summary of un-ionised ammonia (µg l^{-1}) at *Sabellaria* features (A – G) for mean and elevated summer temperatures (letters correspond to the locations on Figure 16).

Feature	**Mean seabed concentration (µg l^{-1})**		**95th percentile concentration (µg l^{-1})**	
	Annual	Summer	Using mean values	Summer
Subtidal *Sabellaria* A Easting 321350 Northing 147040	1.74	3.21	1.90	3.46
Intertidal *Sabellaria* B Easting 320800 Northing 146694	2.01	3.71	2.60	4.77
Intertidal *Sabellaria* C Easting 320300 Northing146351	2.08	3.85	2.68	4.91
Intertidal *Sabellaria* D Easting 319118 Northing 16309	2.07	3.83	2.56	4.67
Subtidal *Sabellaria* E Easting 320800 Northing 146800	1.95	3.61	2.54	4.67
Intertidal *Sabellaria* F Easting 321824 Northing146800	2.03	3.75	2.72	4.94
Intertidal *Sabellaria* G Easting 321529 Northing146793	2.05	3.79	2.71	4.94

5 Interactions between discharges

The HPC power station will include 2 reactors these being Unit 1 & Unit 2. Progress on the construction of Unit 1 is approximately one year ahead of Unit 2. This will mean that Unit 1 will reach HFT (Hot Functional testing) stage approximately one year ahead of Unit 2. At the point of HFT onwards resulting effluent will be managed under the OWDA permit. On this basis for a period of approximately one year effluent from Unit 2 will be discharging under the CWDA permit at the jetty and effluent from Unit 1 under the OWDA permit at the permanent power station outfall.

The un-ionised ammonia CWDA discharge at the jetty that includes the scenario of units 1 and 2 undergoing simultaneous cold flush testing is predicted to have limited influence on *Corallina* and *Sabellaria* features and any influence would be reduced at the jetty location once the first permanent outfall is operational. The permanent outfall discharge would occur further offshore, and dilution and dispersion of this un-ionised ammonia loading is expected to influence a very limited mixing zone around the discharge point, and to have negligible impact. The nutrient assessment was conducted using a box model so the location of the discharge would not, in this case, change the input parameters or final predictions (because a particularly conservative suspended particulate matter level of 10 mg/l was used in the model, see Appendix F).

5.1 Interaction with HPB thermal plume.

The best estimates of the geographic influence of the thermal plume from Hinkley B are found in BEEMS Technical Report TR267. This report uses high resolution modelling (25 m grid) to produce mean estimates of temperature uplift for the existing station.

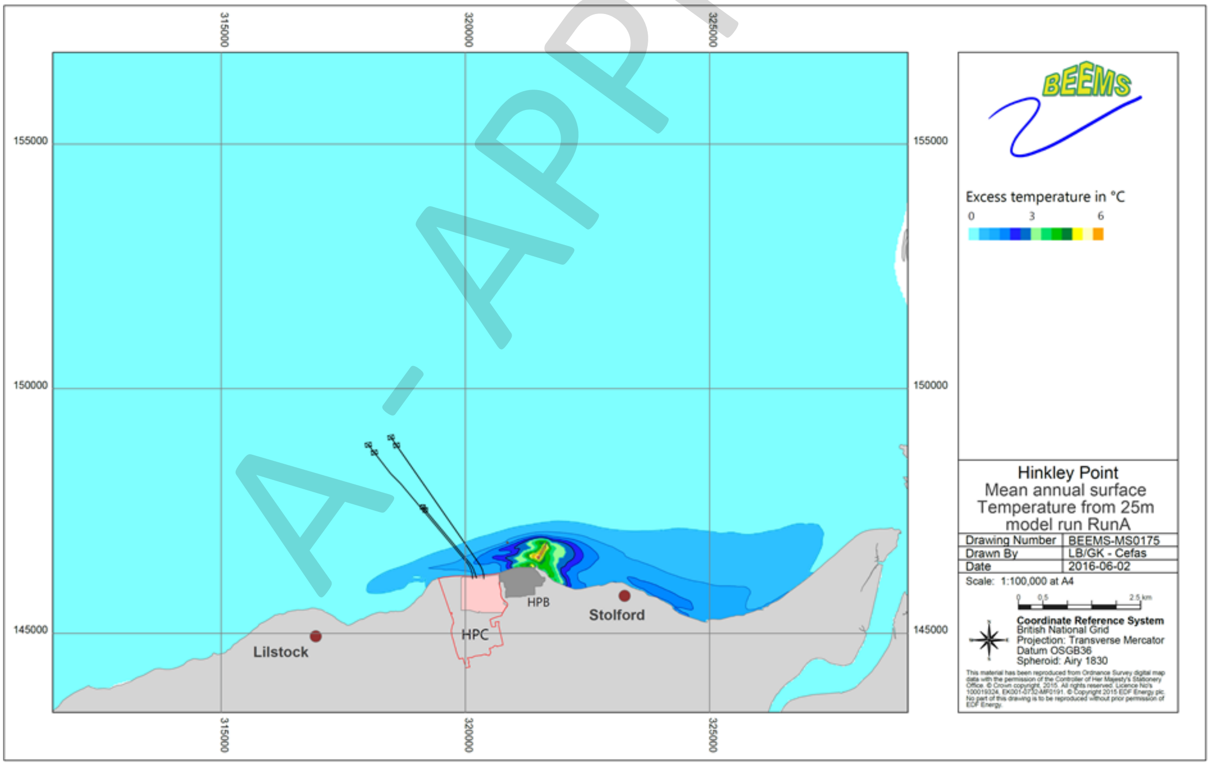

Figure 26. Mean thermal plume uplift due to HPB, from high resolution 25 m model, (BEEMS TR267)

At the location of the jetty outfall (which is where values above the EQS occur), the mean increase in temperature is 1.02°C. This should be viewed within the context of the natural seasonal cycle, where mean

February temperatures are 6.6°C and August 19.4°C (BEEMS Technical Report 187). The typical inter-annual variation in monthly mean temperatures is 1.1°C.

It is not anticipated that this temperature change would affect the chemistry or toxicity of metals in the jetty discharge. The mean temperature uplift at *Sabellaria* locations near HPC and HPB are shown in Table 17.

Table 17. Mean temperature uplift due to HPB at *Sabellaria* locations at the bed with positions as those previously e.g. Figure 16.

Location	Mean temperature uplift (°C)
A	0.41
B	1.18
C	0.78
D	0.68
E	0.94
F	1.27
G	4.17

5.2 Discharge of waste by Hinkley B and Hinkley A

There is permitted discharge of groundwater of 50 $m^3 d^{-1}$ until March 2018 from Hinkley Point A (permit EPR/EB3392VY). The discharge is confined to two hours before and two hours after high tide.

In addition to the thermal plume discharge (see above), Hinkley B has a permit (HPB Consent no 070408) to discharge up to 1000 $m^3 d^{-1}$ of treated sewage with ammoniacal nitrogen concentrations up to 30 mg l^{-1} and suspended solids up to 60 mg l^{-1}. For DIN, this equates to an annual load of 10950 kg. These discharges are released at a discharge point close to the sea wall.

There is an east west separation of approximately 2.4 km between the jetty discharge and HPB/HPA outlet channel.

From a DIN perspective it is unlikely that the total discharge from the jetty would be detectable beyond a short distance (<50 m) from the jetty. Similarly, the discharges from HPB and HPA are small and will have undergone significant dilution by the time they have been advected to the small area where the jetty discharge may be detectable. The physical separation of 2.4 km between the jetty discharge and the HPA/HPB discharge channel is therefore considered sufficient to ensure there is no interaction between the discharges.

For WFD purposes, the HPC sewage discharge(s) will increase the total loading of DIN in the two local waterbodies in addition to the uplift already caused by the HPB discharge. HPB discharges into the Parrett waterbody, and the permitted discharge of 10,950 kg annually is calculated to uplift the Parrett waterbody concentration by 3.49 µmol l^{-1} (if the discharge is completely released into the Parret water body alone). As the background DIN concentration is high this does not affect the WFD status classification. If the jetty discharge is added to the HPB DIN discharge, the uplift would increase to 5.05 µmol l^{-1}. The long-term fate of the DIN discharge from the temporary jetty is likely to be shared between the two WFD waterbodies (Bridgwater Bay and Parret), and this is also true of the HPB discharge because the outfall is near the junction of these two waterbodies. Thus, using a shared equal split between the two bodies the combined effect of HPC (construction discharge at the jetty) and HPB is calculated to uplift the Bridgwater Bay waterbody by 0.58 µmol l^{-1} and the Parrett waterbody by 2.52 µmol l^{-1}. The WFD classification of these waterbodies would be unaffected. Considering the additional inputs of nutrients during the commissioning period the results from the CPM model show that that there is no difference between the Bridgwater bay reference case or the HPC construction run for either phytoplankton production or for macroalgae.

5.2.1 Coliforms from HPB

CORMIX dilution rates (see Appendix D) have been used to determine the maximum distance from the discharge at which bathing water standards could be exceeded. The HPB discharge permit specifies that the discharge can only take place either side of high water when water depth is similar to that of the HPC discharge. The highly conservative Cormix estimates of mixing and the exceedance distances calculated are therefore a useful conservative guide.

Table 18 Coliforms discharge from HPB

Species	**Standard cells/100ml**	**Maximum discharge concentration cells/100ml**	**2nd treatment. 2 log reduction.**	**Dilution factor to meet standard**	**Extent of exceedance**
E.coli	500	240,000,000	2,400,000	4800	~ 1.8 km
Enterococci	200	13,600,000	136,000	680	<200m

It is not known what the actual microbiological discharge concentration is from Hinkley Point B, however assuming the same standard of secondary treatment as Hinkley C would imply a maximum potential extent of exceedance for *E.coli* of approximately 1.8 km (Table 18). This theoretical exceedance could only occur in very calm conditions. Under such calm conditions the plume would be long and thin and would not interact with the temporary jetty discharge, as the tidal stream lines are separate. In practice most of the time, wave mixing will mix the discharge rapidly so that no interaction could occur.

6 Consideration of effects of combined discharges for Water Framework Directive waterbodies and Habitats

This assessment determines whether there would be any deterioration in the water body status under the Water Framework Directive (WFD) from the combined construction discharges including cold commissioning discharges. The assessment considers effects on the WFD water bodies and associated Marine Strategy Framework Directive (MSFD) sea area within the local area of the HPC jetty outfall:

a. Bridgwater Bay (coastal water body, C21): construction and cold commissioning discharges will take place in this water body via the jetty outfall. The HPB intake is also in this water body.

b. Parrett Estuary (transitional water body, T18): The HPB cooling water discharge is into this water body.

c. MSFD sea area: Celtic Sea

This assessment considers the potential effects of the combined construction and cold commissioning discharge on nutrient concentrations, biochemical oxygen demand, total ammonia, un-ionised ammonia, phytoplankton production and specific habitats.

The assessment methodology considered whether there was any deterioration in status in either of the Bridgwater Bay or Parrett Estuary water bodies; if none were identified then no deterioration could be concluded for adjoining water bodies both upstream and downstream of the discharges. If a potential deterioration were identified, the resulting effect on other WFD water bodies outside of those initially selected would be undertaken within the WFD ‘Further Assessment’ stage. A comprehensive assessment of the effect of combined construction and cold commissioning discharges on all classification elements relevant to Hinkley Point are considered in BEEMS Technical report TR550.

6.1 Assessment Results

6.1.1 Water Quality

Dissolved inorganic nitrogen loading and nutrient influence on phytoplankton

The cold commissioning process is predicted to release additional dissolved inorganic nitrogen (DIN) into the construction discharge to the Estuary. Under the WFD standards, the Bridgwater Bay water body has ‘Moderate’ status for DIN. During Case D construction discharges include up to 25 $l\ s^{-1}$ groundwater (2951 $\mu g\ l^{-1}$ DIN) and 13.3 $l\ s^{-1}$ treated sewage (average value of 5000 $\mu g\ l^{-1}$ DIN). Over a year the high degree of mixing is likely to spread the discharge throughout the waterbody. The DIN standard is usually expressed as $\mu mol\ l^{-1}$. The transitional and coastal waterbody is classified as turbid, with the standards as given in Appendix C. The annual uplift in nitrogen due to the jetty discharge in Bridgwater Bay for construction inputs during Case D is 4423 kg = 3.16×10^5 µmol / the volume of Bridgwater Bay (9.77×10^{11} litres) = 0.32 $\mu mol\ l^{-1}$. During cold commissioning, an additional annual loading of nitrogen of 3862 kg may result from the breakdown of commissioning chemicals. The combined construction and cold commissioning loading of nitrogen is estimated as 8286 kg/year, and this would represent an addition of 0.61 $\mu mol\ l^{-1}$ to Bridgwater Bay. The mean background concentration identified here is 75 $\mu mol\ l^{-1}$ which falls within a good waterbody classification under the Water Framework Directive (99th percentile value 180 μmol^{-1} for turbid waters). The proposed discharge from the jetty including construction and cold commissioning inputs is, therefore, a relatively small annual addition which would not change the classification. The nitrogen loading is further reduced based on an Environment Agency recalculation of the groundwater source data (see Appendix C Table 29). The influence of both nitrogen and phosphorus inputs on phytoplankton status was evaluated using a Combined Phytoplankton and Macroalgae (CPM)model (Appendix F). Without using unrealistically low values of suspended sediment concentration (SSC), no phytoplankton production was predicted to occur, and this assessment considered maximal annual sewage treatment loadings (Table 26) which are likely to be more variable and lower over a whole year period.

In terms of the most recent MSFD eutrophication assessment, the elevated dissolved inorganic nitrogen and phosphorus from the combined construction and cold commissioning inputs have very localised influence and would not change the current MSFD status of “good” for the Atlantic Celtic Sea sub-region. The most recent eutrophication assessment published in 2019 (https://moat.cefas.co.uk/pressures-from-human-activities/eutrophication/) by Defra, showed that only a small number of eutrophication problems remain in coastal and estuarine waters, representing 0.03% of the total UK Exclusive Economic Zone, and 0.41% of estuarine and coastal waters. The closest “problem area” to HPC according to this assessment is the Loughbor estuary, West Wales, and as the additional output of nutrients would be very localised, it would not contribute to the elevated concentrations observed there. Currently, there are no major outstanding issues for eutrophication in the UK as a whole and the inputs indicated for this assessment would make a negligible contribution to the overall loading for the Severn.

Biochemical oxygen demand (BOD)

No change in oxygen status for the Bridgwater Bay waterbody is predicted from the discharges during construction or from the additional cold commissioning inputs.

Chemical inputs from groundwater, treated sewage, tunnelling and cold commissioning.

In addition to the potential influence of nutrient inputs via the jetty discharge from construction and cold commissioning other chemical inputs primarily those from groundwater and tunnelling chemicals must be evaluated for potential toxicological effects. A habitats assessment provided in BEEMS TR443 established that there was either no effects pathway or likely significant effects from jetty discharges of construction chemical inputs during Case C and Case D which are considered to encompass the most significant inputs of the construction period. Separately the predicted discharge concentrations of hydrazine which is used in cold commissioning were evaluated for toxicological effects in BEEM TR445. A discharge concentration of 15 μg l^{-1}, is sufficiently precautionary so that the acute PNEC is never exceeded at the *Corallina* features and only at *Sabellaria* stations D and E. Furthermore, the plume is very short lived (1-2 hours) and concentrations are well below the acute PNEC (4 ng l^{-1} as a 95th percentile) at all features.

6.1.2 Test for inclusion of habitats in the WFD assessment

The tests for inclusion of habitats in a WFD assessment are considered in Table 19:

Table 19 Tests to determine if habitats areas are affected by the combined construction and cold commissioning discharges.

Test	Predicted activity footprint	Result
i. 0.5 km² or larger	Heavy metals, Tunnelling chemicals, dissolved inorganic nitrogen and phosphorus, total ammonia and un-ionised ammonia, biological oxygen demand, suspended solids	Areas affected are below test value
ii. 1% or more of the water body's area	Heavy metals, Tunnelling chemicals, dissolved inorganic nitrogen and phosphorus, total ammonia and un-ionised ammonia, biological oxygen demand, suspended solids	Areas affected are below test value
iii. within 500 m of any higher sensitivity habitat	Heavy metals, Tunnelling chemicals, dissolved inorganic nitrogen and phosphorus, total ammonia and un-ionised ammonia, biological oxygen demand, suspended solids	The jetty discharge point is less than 500 m from *Sabellaria* and *Corallina* features
iv. 1% or more of any lower sensitivity habitat	Heavy metals, Tunnelling chemicals, dissolved inorganic nitrogen and phosphorus, total ammonia and un-ionised ammonia, biological oxygen demand, suspended solids	Is below test value

Tests i., ii. and iv. are met but the jetty discharge is within 500 metres of *Sabellaria* and *Corallina* habitat.

Potential effects on higher and lower sensitivity WFD habitats

The discharge from the jetty is within 500 m of higher sensitivity habitat polychaete reef and with *Corallina* habitat. However, the predicted plume discharge from the jetty is a fresh water source it is therefore very buoyant, the highest values are associated with the surface. The highest areas of exceedance of standards for all parameters of relevance to a WFD assessment was for one of the tunnelling chemicals Condat CLB F5/M for which an area of 1 ha at the surface exceeds the relevant EQS. At the bed, the relevant concentration was predicted to be below EQS within 5 metres of the discharge. Neither mean bed concentrations nor 95th percentile concentrations exceed the EQS, and benthic features should therefore remain unaffected. There is a small area of exceedance at the surface near the point of discharge.

For the other discharges considered the area above EQS was much more limited. The assessment of the ammoniacal nitrogen discharge when at maximum levels with combined construction and cold commissioning inputs showed no areas of exceedance for total ammonia concentrations nor at the mean un-ionised ammonia EQS at the surface or bed and an area of only 0.2 ha at the surface for the un-ionised ammonia as a 95th percentile. More detailed time series analysis considering more extreme summer temperatures when the proportion of un-ionised ammonia is likely to be maximal confirmed that concentrations were less than 25% of the EQS at the closest locations of *Corallina* and *Sabellaria* features. The same assessment would apply to lower sensitivity habitat close to the jetty discharge.

7 Summary for construction and commissioning

For the construction discharge there is a small (1 ha) mixing zone (the area where the relevant EQSs are exceeded) around the jetty point of discharge itself. The mixing zone will have EQS exceedances for concentrations of zinc, copper and TBM ground conditioning chemicals. There will also be localised increases in DIN. The area of exceedance is largest for zinc and conditioning chemicals and the modelling has therefore focused on these substances for the combined commissioning inputs and for those from CWW discharge is:.

- Case D, comprising 20 l s^{-1} groundwater, 13.3 l s^{-1} of treated sewage and ca., 5 l s^{-1} of tunnelling groundwater discharge).

Where discharges during the construction period contribute the highest loadings of a given contaminant, the summary text remains unchanged from earlier versions of this report. However, updates are provided for the assessment of ammoniacal nitrogen inputs as these receive contributions from both construction discharges and from the breakdown of commissioning chemicals and are assessed both in terms of the total ammonia and of the proportion of the input that would form un-ionised ammonia. Breakdown of commissioning chemicals will also contribute additional inputs to the nitrogen and phosphorus loading, and these are assessed using a combined phytoplankton and macroalgal box model.

Heavy metals

For Case D, both copper and zinc fail the Environment Agency screening tests. During peak ground water load (Case C) chromium also fails this test, although only marginally and for a period of approximately eight weeks when the flow is predicted to be at a maximum. If the annual average were used, then only zinc would be of potential concern as the copper Effective Volume Flux (EVF) is substantially below the threshold. As zinc was the substance of greatest exceedance this discharge was considered further by detailed modelling. The areas of exceedance for zinc at the surface were 0.3 Ha and 0.125 Ha for Cases C and D, respectively. As the discharge is buoyant, exceedance at the bed was only expected within a very short distance (less than 5 m) of the discharge itself. Some small additional metals inputs occur via the CWW discharge, but the discharge rate and concentrations are so low that this is not expected to change the present assessment.

There is no predicted exposure of designated bed features above the EQS at any time.

TBM soil conditioning chemicals

Chemical constituents of TBM ground conditioning products BASF Rheosoil 143 and Condat CLB F5/M failed the initial EQS screening and were investigated further using modelling approaches. With the worst-case chemical constituent (i.e., with the most toxic chemical group) there was no exceedance of the PNEC at the bed and the areas of exceedance at the surface were very small (0.19 ha for Rheosoil 143 and 1 ha for Condat CLB F5/M). This assessment used examples of typical soil conditioning chemicals (primarily different types of surfactants) with particularly low (i.e., the most conservative) PNEC values. Providing the chemical components of any other products selected for soil conditioning have an Effective Volume Flux value at or below 58.7, then areas of exceedance will be the same or less than those shown here for CLB F5 mono- alkyl sodium sulphate.

DIN and phosphorus inputs during construction and commissioning

The jetty discharge will release dissolved inorganic nitrogen (DIN) into the estuary. Under the Water Framework Directive Standards, the Bridgwater Bay waterbody has ‘Moderate’ status for DIN. The jetty discharges result in a very localised elevation in DIN in the receiving waterbody and the initial screening test was passed (Table 3).

The average annual uplift from the jetty discharge during year 1 was estimated at 0.36 μmol l^{-1} relative to a mean annual concentration of 75 μmol l^{-1} within Bridgwater Bay and status is unaffected. Due to the high turbidity environment, productivity in the Severn is light-limited (Underwood, 2010) and the effects of minor DIN loading on the designated Severn Estuary features are deemed insignificant and not assessed further. In-combination effects of discharges from HPB are considered in Section 5 and it is concluded that there is no direct intersection between the HPB discharge and the jetty discharge. Based on the results of a CPM model this assessment would also apply during the period when the breakdown of cold commissioning discharge inputs makes a further contribution to nitrogen and phosphorus loadings. Some small additional nitrogen inputs occur via the CWW discharge, but the discharge rate and concentrations are so low that this is not expected to change the present assessment.

Total and un-ionised ammonia during construction and commissioning

Using the EA calculator, the EQS for un-ionised ammonia (21 μg l^{-1}) was exceeded in Case C_{max} and D_{max}, but only in the immediate vicinity of the discharge (within less than 10 m). Rapid dilution rates mean that the EQS was only exceeded when groundwater discharges and sewage discharges were at their maximum. The total area of EQS exceedance was 0.005 ha and, even during maximum discharges, the initial screening test was passed (Table 3). When combined construction and cold commissioning inputs of un-ionised ammonia are considered the area above the 21 ug l^{-1} threshold, when using the 95th percentile of ammoniacal nitrogen is small (Maximum 0.2 hectares). For the actual EQS when using the annual average there are no areas of exceedance and the un-ionised ammonia concentrations associated with *Corallina* and *Sabellaria* features are less than 25% of the EQS. An additional assessment of the in-combination effects of concurrent sewage discharges from the temporary jetty and HPB are considered below. Some small additional ammoniacal nitrogen inputs occur via the CWW discharge, but the discharge rate and concentrations are so low that this is not expected to change the present assessment.

For total ammonia, the modelling shows that at the 25m resolution of the model for the construction and commissioning phase there is no exceedance of either the mean 1100 ug l^{-1} or of the MAC 8000 ug l^{-1}.

Biological oxygen demand

The sewage treatment works is expected to achieve a maximum concentration of Biological Oxygen Demand (BOD) of 40 mg l^{-1} (i.e., draw down over 5 days) and the indicative Maximum Allowable Concentration (MAC) to be applied in the permit is therefore 40 mg l^{-1}. Using the 13.3 l s^{-1} discharge and a BOD of 40 mg l^{-1}, a daily BOD of 46 kg was calculated. This amount of oxygen would be transferred across 14364 m^2 of the water surface in a day. The tidal excursion (how far a particle is advected) at Hinkley Point, even on the weakest (neap) tides, is many kilometres, thus there is ample resupply of oxygen from the atmosphere so that no change in oxygen concentration would be observed.

Suspended solids

The background suspended solids concentration in the receiving water is relatively high (with a mean of 264 mg l^{-1} and a minimum of 33 mg l^{-1}). Commissioning activities such as hydrostatic testing and flushing will result in variable suspended solids loadings within resultant effluents. The primary objective of the Commissioning Effluent Treatment Plant (CETP) is to reduce the hydrazine concentration in the final effluent discharge. However, the CETP will also incorporate methods to reduce suspended solids to permitted levels prior to discharge.

Coliforms – bathing water standards and shell fisheries

The discharge point is not in designated bathing waters. Model predictions (which do not consider wave-driven mixing) indicate that treatment from the plant is sufficient to ensure that microbial concentrations in discharged waters comply with bathing water standards within a maximum of 2.8 km from the discharge point (without UV treatment) and within 10 m (with UV treatment). The nearest designated bathing waters are 12 km distant from the jetty discharge and the closest shell fishery is 32 km distant and so no effects on these features is predicted.

Potential in combination effects with the HPB discharge

This report has considered the potential interaction of the jetty discharges and the sewage discharge from HPB (2.4 km distant). There is no overlap of the plume mixing zone and the HPB discharge, and no interaction occurs because of the physical separation and the small discharge volume from the jetty.

During the main construction period the total annual loading of DIN has been considered for the two impacted Water Framework Directive designated waterbodies (Bridgwater Bay and River Parrett). The combined effect of HPC (construction discharge at the jetty) plus HPB is to uplift the DIN concentration in the Bridgwater Bay water body by 0.58 µmol l^{-1} and the Parrett waterbody by 2.52 µmol l^{-1} (when all the discharge goes into one body). There would therefore be no change of status: the present mean is 75 µmol l^{-1} and the 99th percentile concentration for Good status in turbid waters is 180 µmol l^{-1}. These results have also been confirmed including additional nutrient inputs during commissioning using a CPM model with no difference shown between the Bridgwater bay reference case or the HPC construction and cold commissioning run for either phytoplankton production or for macroalgae.

It is not known what the actual discharge concentration of microbial discharge is from Hinkley Point B, however assuming the same standard of secondary treatment as Hinkley Point C would imply an extent of exceedance of approximately 1.8km. This theoretical exceedance could only occur in very calm conditions. Under such calm conditions the plume would be long and thin and would not interact with the temporary jetty discharge, as the tidal stream lines are physically separate. In practice for most of the time, wave mixing will mix the discharge rapidly so that no interaction could occur.

If UV treatment is applied at HPC no microbial interaction with HPB is likely.

The thermal plume discharge from HPB has been considered and is expected to raise the mean background sea temperature at the jetty discharge location (where exceedance of the EQS's occurs) by approximately 1°C, this small temperature rise compared to the annual seasonal variation is considered unlikely to have any effect on the toxicity of any of the chemicals or metals considered.

Test for inclusion of habitats in the WFD assessment

The tests for inclusion of habitats in a WFD assessment are if the footprint of the FRR discharge is any of the following:

i. 0.5km² or larger
ii. 1% or more of the water body's area
iii. within 500m of any higher sensitivity habitat
iv. 1% or more of any lower sensitivity habitat

For tests i., ii. and iv there is no exceedance of these areas, but the jetty discharge is within 500 metres of *Sabellaria* and *Corallina* habitat.

Potential effects on WFD habitat

Higher sensitivity habitats:

The predicted plume discharge from the jetty is a fresh water source it is therefore very buoyant; the highest values will be associated with the surface. The highest areas of exceedance of standards for all parameters of relevance to a WFD assessment was for one of the tunnelling chemicals Condat CLB F5/M for which an area of 1 ha at the surface exceeds the relevant EQS. At the bed, the relevant concentration was predicted to be below EQS within 5 metres of the discharge. Neither mean bed concentrations nor 95th percentile concentrations exceed the EQS, and benthic features should therefore remain unaffected. There is a small area of exceedance at the surface near the point of discharge.

For the other discharges considered the area above EQS was much more limited. The assessment of the ammoniacal nitrogen discharge when at maximum levels with combined construction and cold commissioning inputs showed no areas of exceedance for total ammonia concentrations nor at the mean un-ionised ammonia EQS at the surface or bed and an area of only 0.2 ha at the surface for the un-ionised ammonia 95th percentile. More detailed time series analysis considering more extreme summer temperatures when the proportion of un-ionised ammonia is likely to be maximal confirmed that concentrations were less than 25% of the EQS at the locations where *Corallina* and *Sabellaria* features are located. The same assessment would also apply to any lower sensitivity habitat close to the jetty discharge.

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Appendix A Background values for Severn Estuary

Reference for background for dissolved zinc concentration included in suite of determinands analysed by National Laboratories Service for seawater collected from the shore at Berrow, Somerset (Lat 52.208587, Long 1.623361), 23rd February 2015.

Zinc data has been provided by the environment agency from sample point 60510019 at ST 19230 49247, dating back to 2012.

Table 20. Zinc data provided by EA (mean 2.62 µg l^{-1})

10-Jul-12	2IZZ	Zinc, Dissolved	µg l^{-1}	2.52
13-Aug-12	2IZZ	Zinc, Dissolved	µg l^{-1}	2.42
10-Sep-12	2IZZ	Zinc, Dissolved	µg l^{-1}	3.57
07-Oct-12	2IZZ	Zinc, Dissolved	µg l^{-1}	2.5
04-Nov-12	2HZZ	Zinc, Dissolved	µg l^{-1}	2.58
13-Jan-13	2HZZ	Zinc, Dissolved	µg l^{-1}	2.84
07-Feb-13	2IZZ	Zinc, Dissolved	µg l^{-1}	5.68
17-Mar-13	2IZZ	Zinc, Dissolved	µg l^{-1}	3.06
25-Apr-14	2IZZ	Zinc, Dissolved	µg l^{-1}	3.04
26-Jun-14	2IZZ	Zinc, Dissolved	µg l^{-1}	2.61
07-Jul-14	2IZZ	Zinc, Dissolved	µg l^{-1}	5.66
07-Aug-14	2IZZ	Zinc, Dissolved	µg l^{-1}	2.06
20-Sep-14	2IZZ	Zinc, Dissolved	µg l^{-1}	1.85
19-Jan-15	2IZZ	Zinc, Dissolved	µg l^{-1}	2.51
02-May-17	2IZZ	Zinc, Dissolved	µg l^{-1}	2.63

Table 21. Background values for contaminants in the Severn Estuary (from Amec 2009 report)

Analyte	**Units**	**Concentration**
Cyanide as CN	mg l^{-1}	<0.500
Ammoniacal Nitrogen as N	mg l^{-1}	<0.01
Nitrite as N	mg l^{-1}	<0.004
Nitrogen: Total Oxidised as N	mg l^{-1}	1.43
Orthophosphate, reactive as P	mg l^{-1}	0.08
Fluoride	mg l^{-1}	0.857
Sulphide as S	mg l^{-1}	<0.01
Solids, Dissolved at 105 C	mg l^{-1}	615
pH	pH Units	8.09
Bromide	mg l^{-1}	43.4
Arsenic	g l^{-1}	1.99
Selenium	µg l^{-1}	<1
Beryllium	µg l^{-1}	<10
Cobalt	µg l^{-1}	<10
Molybdenum	µg l^{-1}	<30
Silver	µg l^{-1}	<1
Cadmium	µg l^{-1}	0.08
Copper	µg l^{-1}	4.17
Lead	µg l^{-1}	0.5
Nickel	µg l^{-1}	0.974
Zinc	µg l^{-1}	4.94
Boron, Dissolved	µg l^{-1}	2980
Calcium, Dissolved	mg l^{-1}	299
Iron, Dissolved	µg l^{-1}	<100
Magnesium, Dissolved	mg l^{-1}	873
Manganese, Dissolved	µg l^{-1}	<20
Potassium, Dissolved	mg l^{-1}	265
Sodium, Dissolved	mg l^{-1}	6990
Strontium, Dissolved	µg l^{-1}	5060
Sulphate, Dissolved as SO4	mg l^{-1}	1800
Boron	µg l^{-1}	2940
Calcium	mg l^{-1}	292
Iron	µg l^{-1}	153
Magnesium	mg l^{-1}	841
Manganese	µg l^{-1}	<20
Potassium	mg l^{-1}	255
Sodium	mg l^{-1}	6810
Strontium	µg l^{-1}	5000
Sulphate as SO4	mg l^{-1}	1750
Mercury	µg l^{-1}	<0.01
Nitrate as N	mg l^{-1}	<1.43
Carbon, Organic: Total as C :- {TOC}	mg l^{-1}	2.3

Appendix B Extract from The Water Framework Directive (Standards and Classification) Directions (England and Wales) 2015.

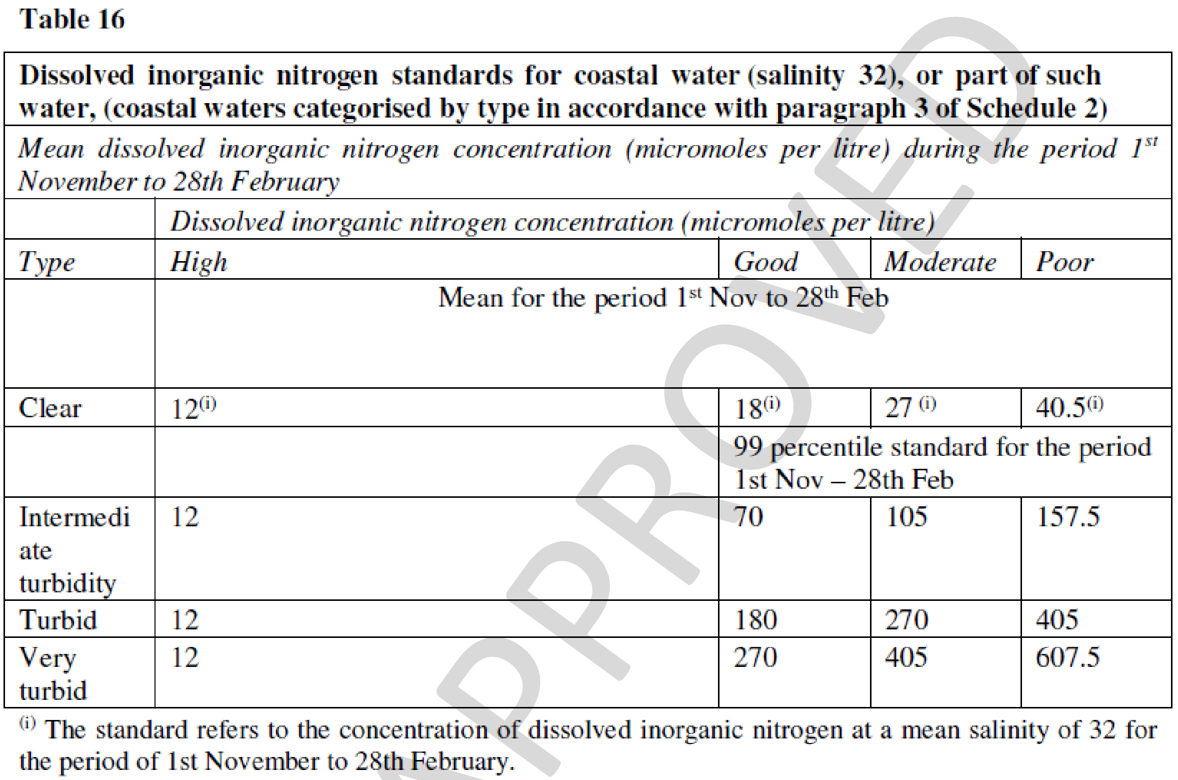


Table 16

Dissolved inorganic nitrogen standards for coastal water (salinity 32), or part of such water, (coastal waters categorised by type in accordance with paragraph 3 of Schedule 2)				
Mean dissolved inorganic nitrogen concentration (micromoles per litre) during the period 1st November to 28th February				
	Dissolved inorganic nitrogen concentration (micromoles per litre)			
Type	*High*	*Good*	*Moderate*	*Poor*
	Mean for the period 1st Nov to 28th Feb			
Clear	12(i)	18(i)	27 (i)	40.5(i)
		99 percentile standard for the period 1st Nov – 28th Feb		
Intermediate turbidity	12	70	105	157.5
Turbid	12	180	270	405
Very turbid	12	270	405	607.5

(i) The standard refers to the concentration of dissolved inorganic nitrogen at a mean salinity of 32 for the period of 1st November to 28th February.

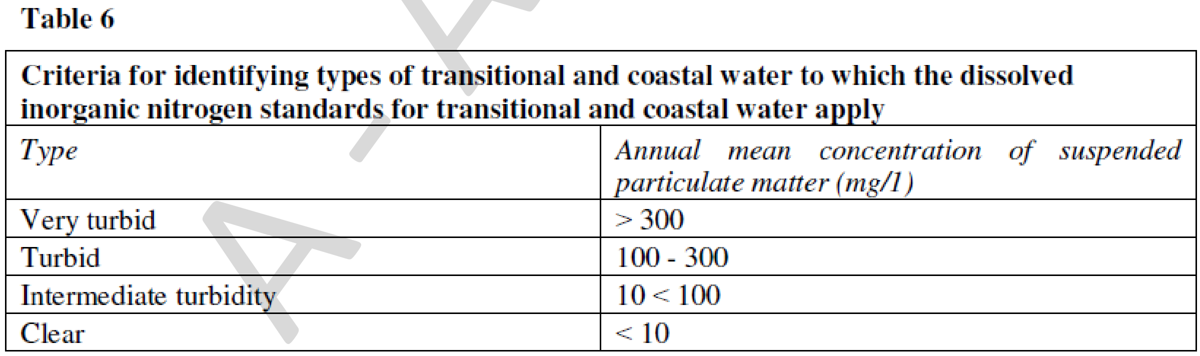


Table 6

Criteria for identifying types of transitional and coastal water to which the dissolved inorganic nitrogen standards for transitional and coastal water apply	
Type	*Annual mean concentration of suspended particulate matter (mg/l)*
Very turbid	> 300
Turbid	100 - 300
Intermediate turbidity	10 < 100
Clear	< 10

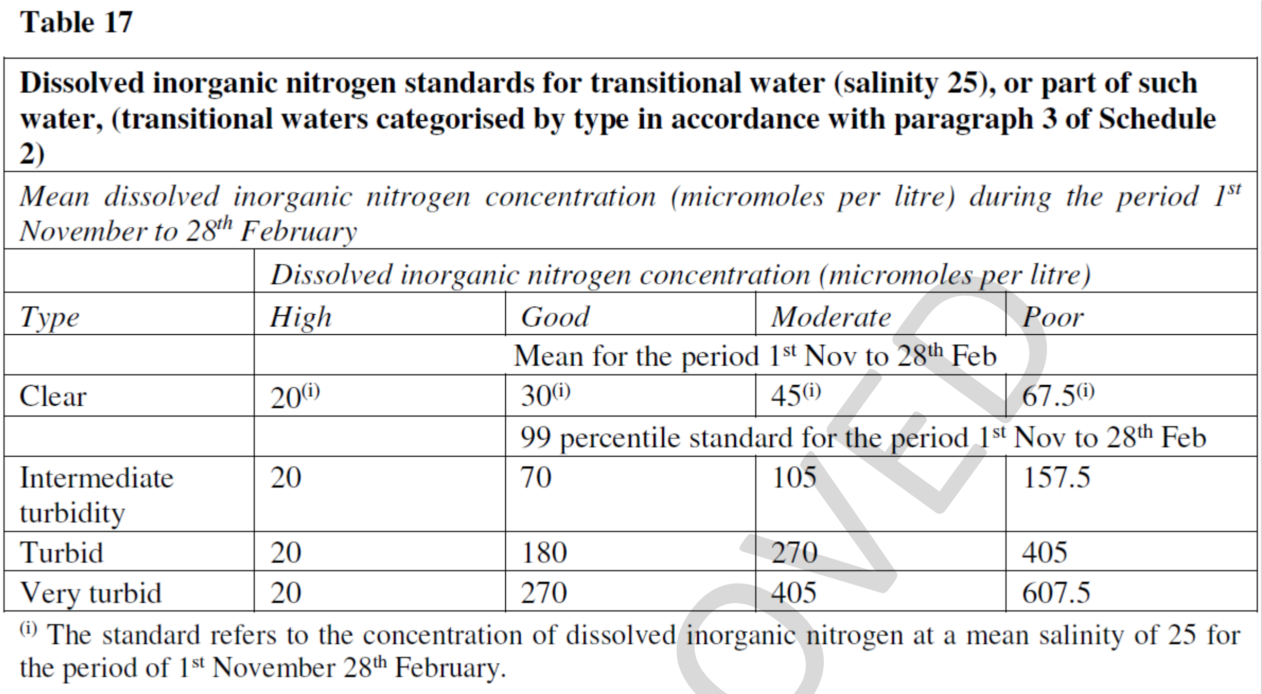


Table 17

Dissolved inorganic nitrogen standards for transitional water (salinity 25), or part of such water, (transitional waters categorised by type in accordance with paragraph 3 of Schedule 2)				
Mean dissolved inorganic nitrogen concentration (micromoles per litre) during the period 1st November to 28th February				
	Dissolved inorganic nitrogen concentration (micromoles per litre)			
Type	*High*	*Good*	*Moderate*	*Poor*
		Mean for the period 1st Nov to 28th Feb		
Clear	20(i)	30(i)	45(i)	67.5(i)
		99 percentile standard for the period 1st Nov to 28th Feb		
Intermediate turbidity	20	70	105	157.5
Turbid	20	180	270	405
Very turbid	20	270	405	607.5

(i) The standard refers to the concentration of dissolved inorganic nitrogen at a mean salinity of 25 for the period of 1st November 28th February.

Appendix C Calculations for discharge concentrations and Effective Volume Flux

Table 22. Groundwater contaminants and concentrations likely to be present in the construction dewatering discharge and comparison to EQS for three cases. AA refers annual average concentration and MAC refers to the maximum allowable concentration. EVF (m^3 s^{-1}) has been derived using 95th percentile discharge concentrations and the AA EQS (except for mercury where the MAC EQS has been used). The shaded values indicate those used in the screening test assessment.

Contaminant	**Assessed discharge concentration µg l^{-1} 95th percentile (used in EA Screening test)**	**Saltwater AA EQS (µg l^{-1})**	**Background concentration (µg l^{-1})**	**EVF Case A and Case D [(EFR x RC)/(EQS-BC) m^3]**	**EVF Case C [(EFR x RC)/(EQS-BC) m^3]**	**TraC Water test 5 EVF< 3.0 Pass/Fail**
Un-ionised ammonia (N)	123.5	21	4.6[4]	(123.5 x 0.02) / (21 – 4.6) = 0.15	(123.5 x 0.0467) / (21 – 4.6) = 0.352	Pass
DIN	4073	2520[5]	1050	(4073 x 0.02) / (2520 -1050) = 0.06	(4073 x 0.0467) / (2520 -1050) = 0.129	Pass
Cyanide	50	1	0	(50 x 0.02) / (1- 0) = 1	(50 x 0.0467) / (1- 0) = 2.3	Pass
Total cadmium	0.46	0.2	0	(0.46 x 0.02) / (0.2 – 0.0) = 0.05	(0.46 x 0.0467) / (0.2 – 0.0) = 0.12	Pass
Total chromium	24	0.61	0.02	(24 x 0.02) / (0.6 – 0.02) = 0.83	(24 x 00467) / (0.6 -0.02) = 1.93	Pass
Total lead	3	1.3	0.02	(3 x 0.02) / (1.3 – 0.02) = 0.05	(3 x 0.0467) / (1.3 – 0.02) = 0.11	Pass
Total copper	199.5	4.76	3.95	(199.5 x 0.02) / (4.76 – 3.95) = 5.46	(199.5 x 0.0467) / (4.76 – 3.95) = 12.74	Fail
Total zinc	1642.15	6.8	3.035	(1642.15 x 0.02) / (6.8 – 3.035) = 8.72	(1642.15 x 0.0467) / (6.8 – 3.035) = 20.37	Fail
Total mercury	0.49	0.07	0.02	(0.49*0.02) / (0.07-0.02) = 0.2	(0.49*0.0467) / (0.07-0.02) = 0.46	Pass
Sewage DIN (max value)	20,000	2520	1050	(20,000*0.014) / (2520-1050) = 0.19	(20,000*0.030) / (2520-1050) = 0.41	Pass

EFR = Effluent discharge rate which is 0.02 m^3/sec for case A and D and 0.047 m^3/sec for case C. In the case of the sewage it is 0.014 m^3/sec and 0.030 m^3/sec as max flow case.

Table 23. Example products for use in ground conditioning, their properties and percentage of key component substances and associated Predicted No Effect Concentrations for each substance or surrogate value for a group of similar substances

Chemical function	Product	Main active substance(s)	Active concentration per day assuming 100% use for 1 intake tunnel and 1 outfall tunnel. Mass (kg)	Predicted no effect concentration for aquatic environment (µg l^{-1})
Anti-clogging agent	BASF Rheosoil 143	Sodium lauryl ether sulfate (<30%)	(16 rings x 64 l sec^{-1} + 24 rings x 48 l sec^{-1}) x (30% in formulation, 0.3 x 0.1, 10% total residual from spoil x product density 1.05) = 68.5 kg[1]	40[2]
Soil conditioning-additive	CLB F5 M	2,4-Pentanediol, 2-methyl- (≤10%)	(16 rings x 64 l sec^{-1} + 24 rings x 48 l sec^{-1}) x (10% in formulation, 0.1 x 0.1, 10% total residual from spoil x product density 1.05) = 22.8kg[1] total	4300[3]
		Alcohols, C10-16, ethoxylated, sulfates, sodium salts – (≤10%)		35[2]
		Mono-C10-16-alkyl, Sodium sulfate (≤10%)		4.5[4]

[1] This value takes account of substance density (1.05), % active substance, and assumes 90% associated to spoil (see later discussion); [2]see Table 15 HERA; [3]see SIDS, 2001, [4]see Table 13 HERA, 2002

Table 24. Environment Agency screening assessment of surfactant components of products. Example chemicals for use in ground conditioning, their properties and fate

Conditioning product	Estimated Discharge concentration mg l^{-1} of active substance. Case D	Saltwater AA EQS[1] µg l^{-1}	Background concentration µg l^{-1}	Effective volume flux (Case D) (concentration in discharge (µg l^{-1}) x discharge volume (m^3 s^{-1})) / EQS or equivalent (µg l^{-1}) - background (µg l^{-1})	TraC Water test 5 EVF< 3.0 (Pass/Fail)
BASF Rheosoil 143	19.8	40	0	(19800 x 0.040) / (40 x 0) = 19.80	Fail
CLB F5 M Ethoxylated sulphates	6.6	35	0	(6600 x 0.040) / (35 x 0) = 7.54	Fail
CLB F5 M Mono- alkyl sodium sulphate	6.6	4.5	0	(6600 x 0.040) / (4.5 x 0) = 58.67	Fail

Table 25: H1 Test 1 and 5 for discharges of commissioning chemicals and construction inputs.

Substance	**Estimated discharge concentration µgl^{-1}**	**Saltwater AA EQS µgl^{-1}**	**Background concentration µgl^{-1}**	**Effective volume flux Total flow 70 l/s**	**TraC Water test 5 EVF < 3.0 (Pass/Fail)**
Ethanolamine	4000	160	-	1.75	Pass
Total ammonia from commissioning including Case D inputs	281240[1]	1100	124	21	Fail
Unionised ammonia - from construction wastewater and commissioning inputs including chemical breakdown products converted to un-ionised ammonia assuming commissioning wastewater pH 10 and mean temperature 12.5	187682	21	0.2	977	Fail
Hydrazine	10	0.0004	0.00015	2800	Fail

1Total ammonia includes 271206 µgl^{-1} from commissioning + 10034 µgl^{-1} from Case Dmax construction (see Table 8). Note that for modelling the construction discharges is modelled as a separate continuous input and the commissioning as a pulse discharge see section 4.10.2

Table 26. Groundwater and sewage contributions of ammoniacal nitrogen, nitrogen, and phosphorus for Case D1max

Case Dmax	**NH_4-N µg l^{-1}**	**Discharge rate litres/ second**	**Total mass NH_4-N µg**	**DIN µg l^{-1}**	**Discharge rate litres/second**	**Total mass DIN µg**	**PO_4-P µg l^{-1}**	**Discharge rate litres/second**	**Total mass phosphate PO_4-P µg**
Sewage	20000[1]	13.3	266000	20000	13.3	266000	10000[3]	13.3	133000
Groundwater	4732[1]	25	118300	2951[2]	25	73775	48[4]	25	1200
Total concentration in discharge		**38.3 (l/second)**	(total sewage + groundwater/ discharge rate) = **10034** (µg l^{-1})		**38.3 (l/second)**	(total sewage + groundwater/ discharge rate) = **8871** (µg l^{-1})		**38.3 (l/second)**	(total sewage + groundwater/ discharge rate) = **3504**(µg l^{-1})
Loading (kg/year)						**10713.44**[5]			**4227.40**[6]

[1] see section 4.6 for derivation of source values – these are 95 percentiles to assess most conservative case for toxicity.

[2] This is the mean dissolved inorganic nitrogen input level from groundwater to be used in support of annual assessment.

[3] A concentration 10mg l^{-1} as P was derived for treated sewage from package units based on Natural England, 2016; 4: For groundwater a 50th percentile value of 0.048mg l^{-1} as TP was derived for Wessex groundwater by Stuart and Lapworth, 2016 and is used here as a substitute prior to full site data becoming available. 5: ((38.3 x 60 x 60 x24) x(0.000008871) x 365 =10713.44 kg; 6: ((38.3 x 60 x 60 x24) x(0.000003504) x 365 =4227.40 kg. (Following Environment Agency recalculation of groundwater nitrogen inputs total sewage and groundwater inputs are 8160 (µg l^{-1}) and total loading kg/yr is 9855.9 (µg l^{-1}

Table 27. Potential ammonia, nitrogen, and phosphorus contributions from cold commissioning chemical breakdown products

Conditioning product	**Estimated conditioning concentration $\mu g\ l^{-1}$**	**Contribution as un-ionised ammonia (NH_3-N) $\mu g\ l^{-1}$**	**Nitrogen contribution (kg)**	**Phosphorus contribution (kg)**
Hydrazine	400000	175000[1]	3271	-
Un-ionised ammonia	12000	12000	505	-
Ethanolamine	1180	636.5	85.88	-
Total un-ionised ammonia	-	187637	-	-
Total equivalent proportion ammonia (NH4-N)[2]	-	**271206**[2]	-	-
Total nitrogen (cold commissioning)			**3862**	**-**
Total PO_4-P (cold commissioning)				**201.85**[3]
Total nitrogen construction Case D and cold commissioning (kg/year)			10713.44 + 3862= **14575**[4]	
Total phosphorus construction Case D and cold commissioning (kg/year)				4227.40 + 201.92= **4429**

[1] Hydrazine breakdown pathway assumed $2N_2H_4 + 0.5\ O_2 > N_2 + 2NH_3 + H_2O$; 2: This value is derived using the un-ionised ammonia calculator assuming conditioning solution parameters of pH of 10, salinity of 1 and annual average temperature at Hinkley Point 12.5 C.[2] This value was rounded up to 272 mg/l for GETM modelling.

[3] The total phosphorus contribution is based on maximum dose rate of 500ppm trisodium phosphate resulting in a maximum annual loading of 1068.35 kg trisodium phosphate which is equivalent to the PO_4-P loading shown.

[4] Following Environment Agency recalculation of groundwater nitrogen a value of 9,855.9 kg/y is added to the input for commissioning 3862 kg/y and results in an overall reduced loading of 13,717.9 kg/y

Table 28. Cumulative annual loading nitrogen based on variable groundwater discharge

Case	Calculation of DIN concentration
C	3.76 mg/l = (27.46 l s^{-1} x 2.951[1] mg/l N + 30 l s^{-1} x 5[2] mg/l N) / (27.46[3] + 30[4] + 4 l s^{-1}) a value of 4 litres is added to volume as tunnelling chemical make-up water with no DIN contribution (substituting the EA recalculated groundwater mean of 1.861 for 2.951 Case C =3.27
C1 max	13.2 mg/l = (27.46 l s^{-1} x 7.685 mg/l N + 30 l s^{-1} x 20 mg/l N)[1]/ (27.46[3] + 30[4] + 4[5] l s^{-1}) based on average dewatering volume Case C and maximum DIN in dewatering and maximum sewage flow and concentration (substituting the EA recalculated groundwater mean of 1.861 for 2.951 Case C1 max =11.58
D	3.5 mg/l =(based on average dewatering volume Case D and average DIN in dewatering and average sewage flow and average concentration (25 l s^{-1} x 2.951 mg/l N+13.3 l s^{-1} x 20 mg/l N / 40 l s^{-1}) (substituting the EA recalculated groundwater mean of 1.861 for 2.951 Case D =2.82
Dmax	11.45 mg/l = (25 l s^{-1} x 7.685 mg/l N + 13.3 l s^{-1} x 20 mg/l N)[1]/ (40 l s^{-1}) based on average dewatering volume and maximum DIN in dewatering and average sewage flow and maximum concentration (substituting the EA recalculated groundwater mean of 1.861 for 2.951 Case D =9.19

Notes: [1] average dewatering nitrogen value; [2]average sewage ammoniacal nitrogen

[3]average groundwater (l sec^{-1}); [4] maximum sewage (l sec^{-1}); [5] average tunnelling chemical makeup water volume (l sec^{-1});

Table 29. Cumulative annual loading nitrogen based on variable groundwater discharge

Year	Calculation of annual loading
Year 1	(365 x 24 x 3600)[1] x (2951[2] x 30.5[3] + 5000[4] x 13.3[5]) / (1000 x 1000000) [6] =4934 kg N (following Environment Agency recalculation of the groundwater nitrogen input a mean dewatering concentration of 1861 is substituted for 2951= total loading of 3886.8 kg N
Year 2	365 x 24 x 3600 x (2951 x 27.5 + 5000 x 13.3) / (1000 x 1000000) =4655 kg N (Updated loading 3710.6 kg N)
Year 3	365 x 24 x 3600 x (2951 x 23.8 + 5000 x 13.3) / (1000 x 1000000) =4316 kg N (Updated loading 3497.2 kg N)

Notes: [1]days, hours, minutes, seconds;

[2]mean dewatering concentration nitrogen (µg l^{-1}); [3]groundwater (l sec^{-1});

[4]ammoniacal nitrogen as a proxy for total nitrogen from sewage treatment (µg l^{-1}) as other contributions e.g. NO_2, NO_3 are small ; [5]discharge rate (l sec^{-1});

[6]conversion of units to kilograms.

Appendix D CORMIX modelling dilution rates.

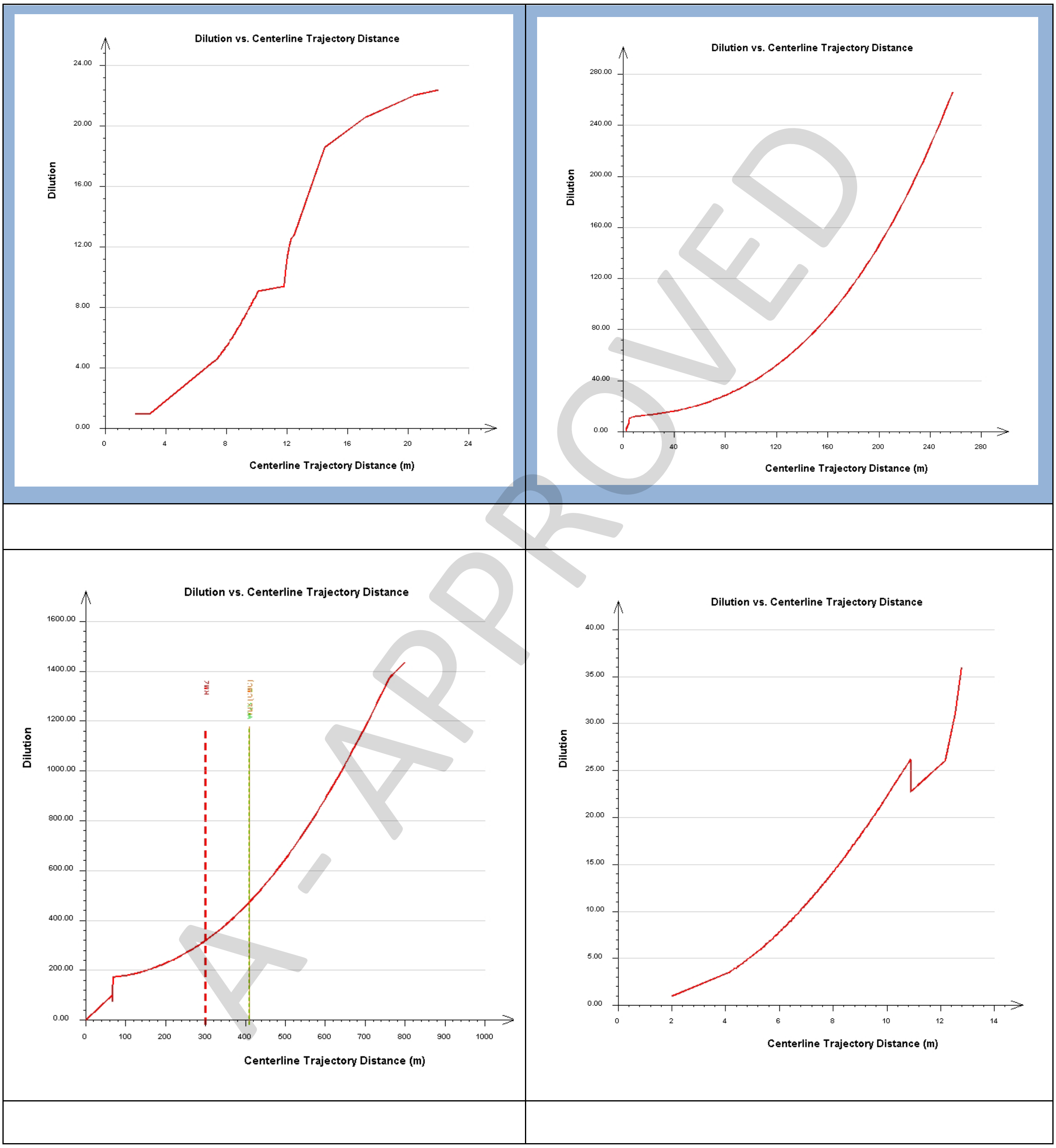
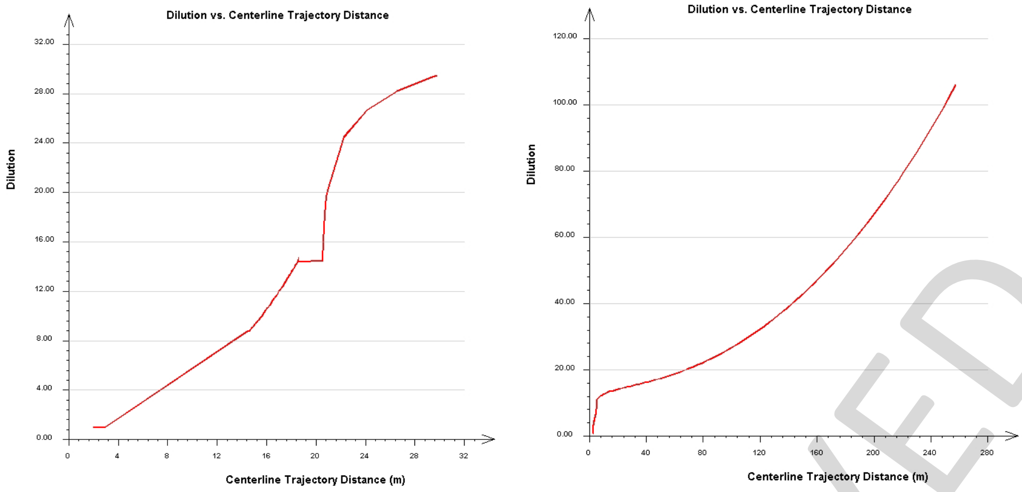
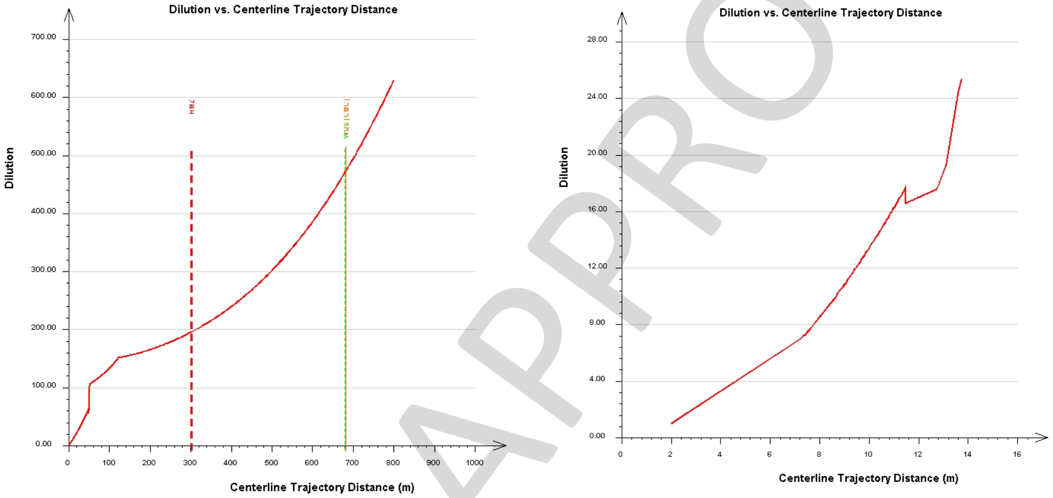


Figure 27. Dilution from low tide to high tide for a 45 l s^{-1} discharge at the jetty. Relevant for Case D.



Low Tide

Low Tide 1 hr



Mid Tide

High Tide

Figure 28. Dilution from low tide to high tide for a 90 l s-1 discharge at the jetty. Relevant for case C.

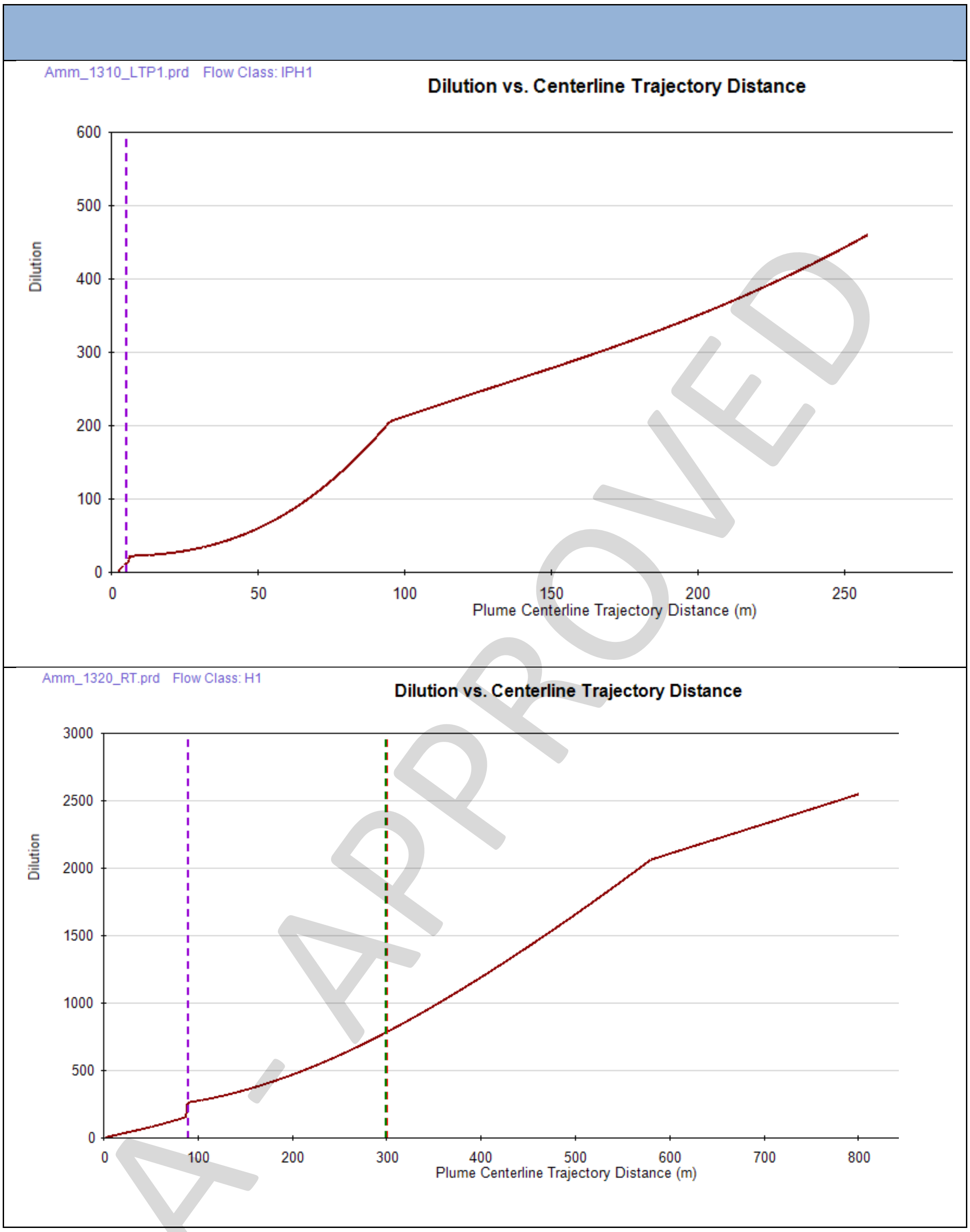


Figure 29. Dilution rates for 13.3 l s^{-1} simulation for 1hr after low tide (top) and mid tide (bottom).

It is evident from the figures above that it is the shape of the plume around the low tide simulation that is a potential concern as this is when high concentrations at the seabed are most likely to occur.

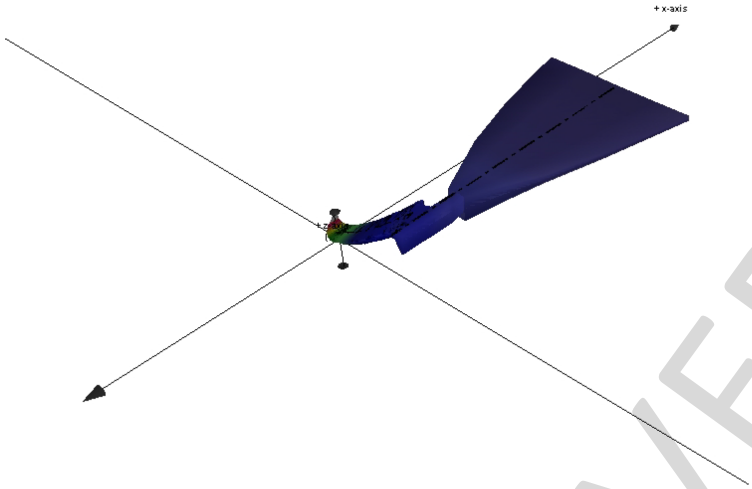


Figure 30. CORMIX output near low water slack, showing the buoyant nature of the plume for 45 l s^{-1} discharge.

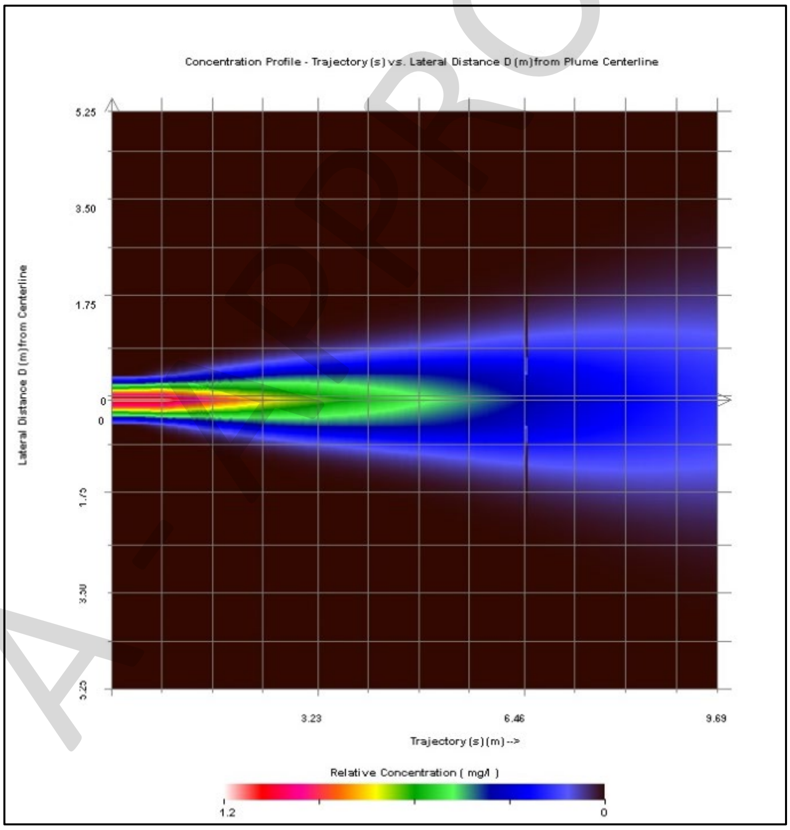


Figure 31. CORMIX outputs showing the dilution of the plume at higher spatial resolution than the GETM 25 m Hinkley Point model can achieve.

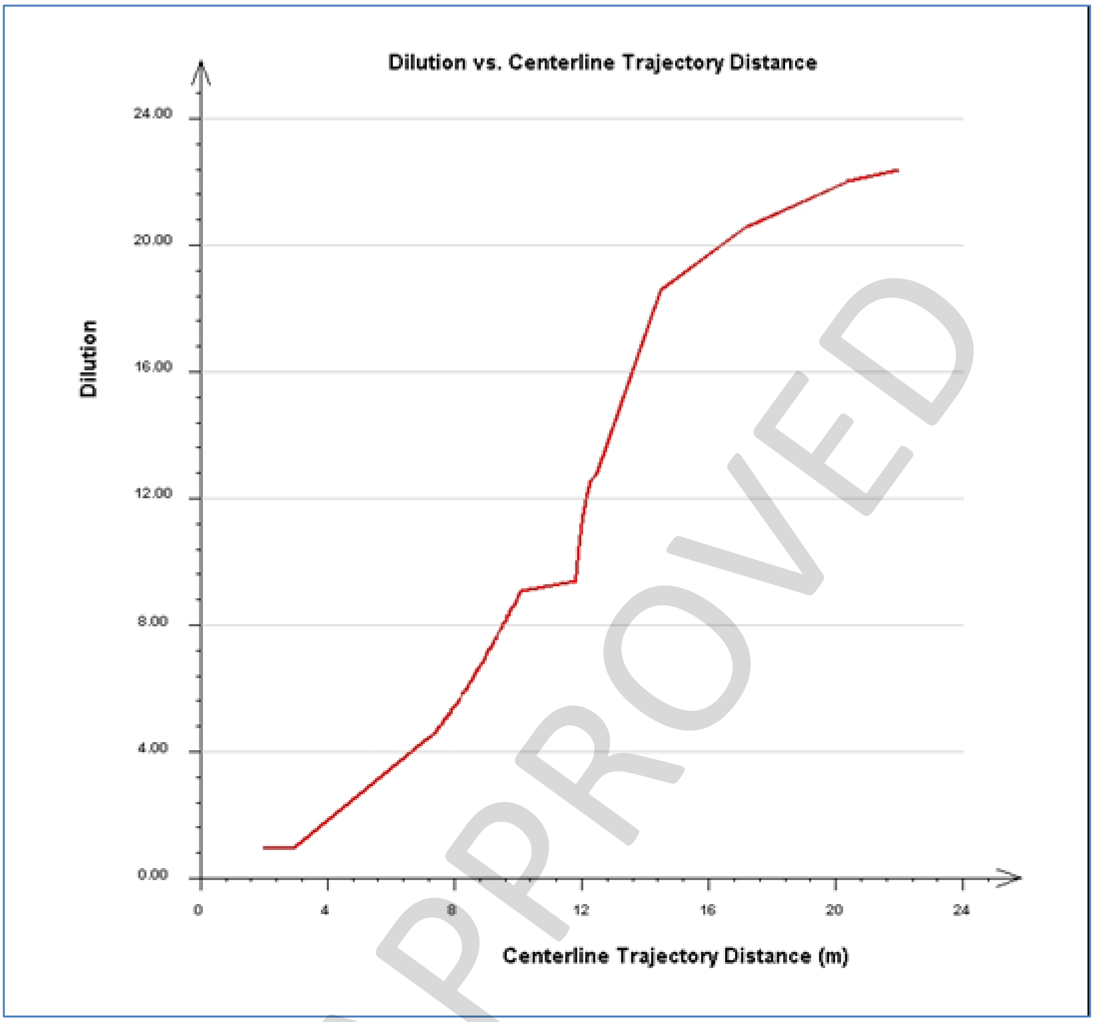


Figure 32. CORMIX outputs showing the dilution of the plume along the centreline 45 l s^{-1} simulation at low water. The size of GETM grid cells used in the Hinkley Point model was 25m. CORMIX predicted dilution is approximately 22-fold at 25 m from the discharge i.e. by the edge of the 1st GETM grid cell.

Appendix E Simulation of ponded water when high concentrations of Zinc could occur.

The purpose of this appendix is to demonstrate that the model accurately replicates potentially high concentrations of zinc which could be formed around periods of slack water. These periods are mostly likely to occur around neap tide, and so this period has been investigated.

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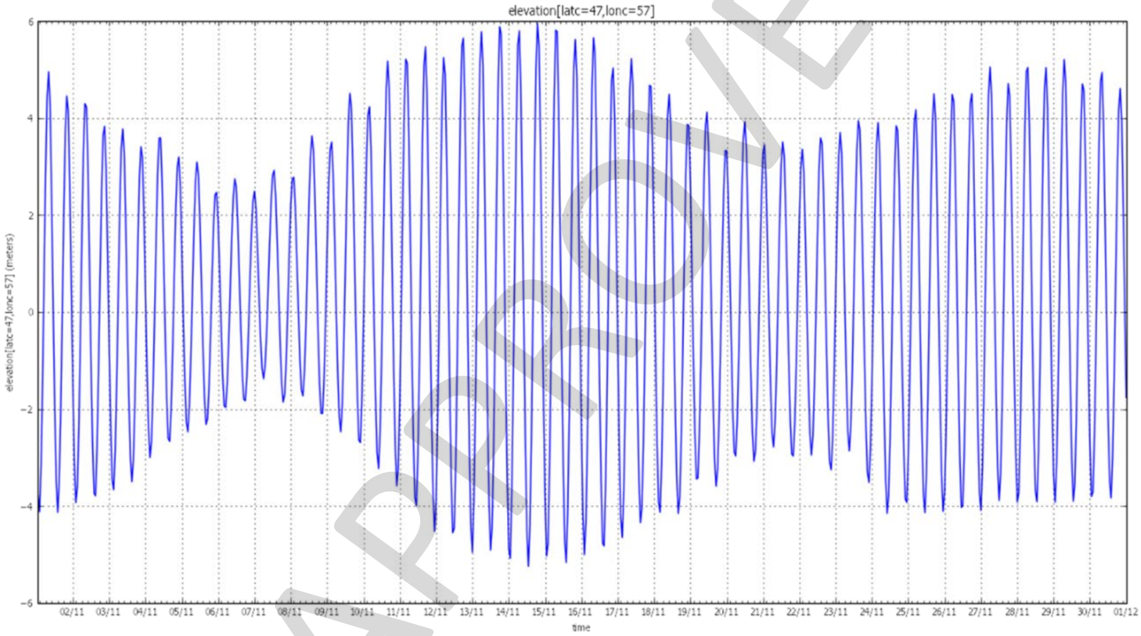

Figure 33. Spring Neap cycle (mean sea level) from model. Note the neap tides on 6th - 7th November, when it is most likely that water from the discharge will temporarily form a static pond.

As can be seen from the plots below, high concentrations above 0.06 mg l^{-1} (in fact up to 0.18 mg l^{-1}) are simulated at neap tides. This is consistent with a peak discharge of 1.2 mg l^{-1} and an expected dilution of approximately 20 m by 25 m distance from the discharge. At other tidal state dilution occurs much quicker, and the area of high values is confined to the discharge.

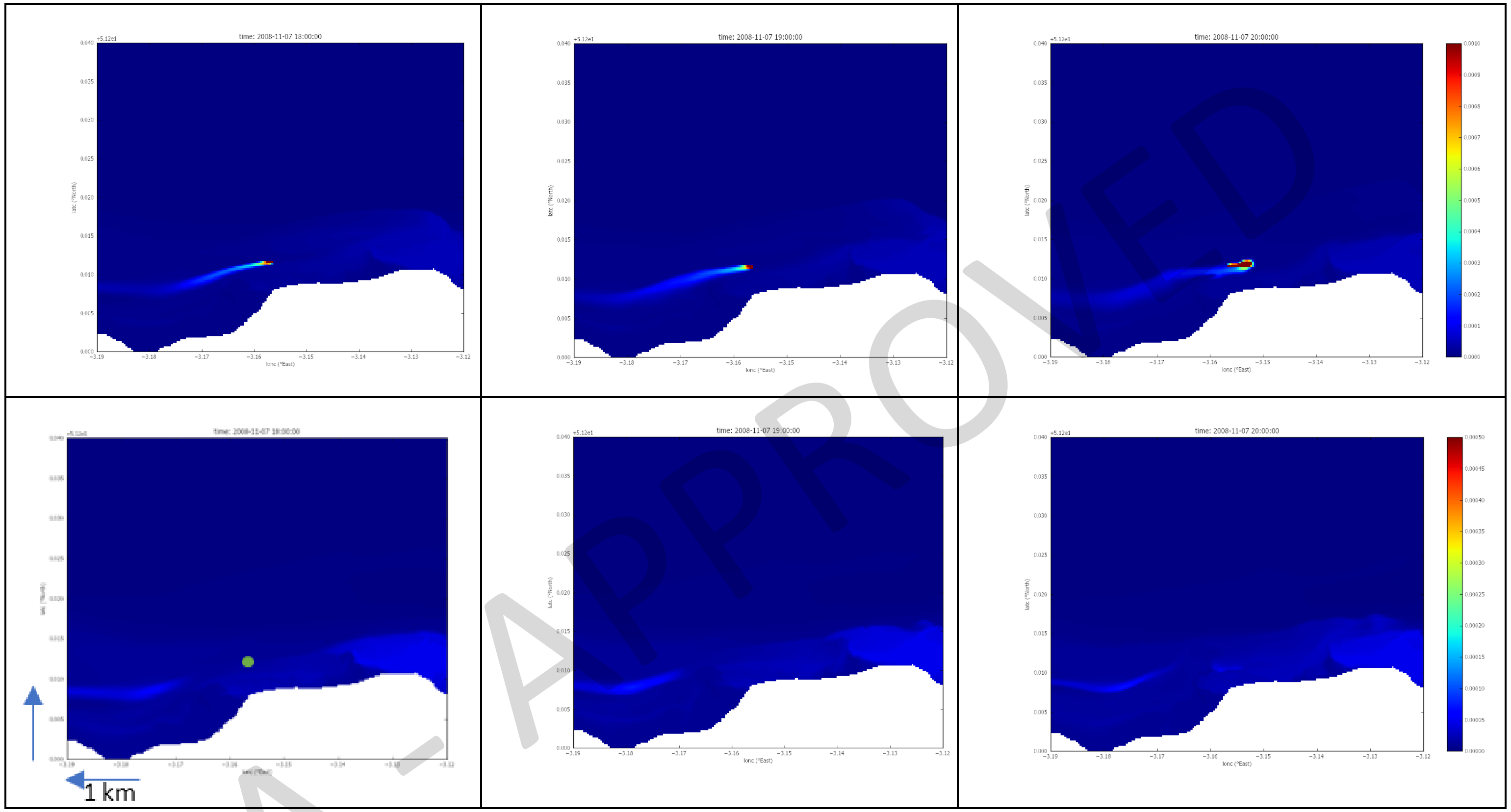

Figure 34. Top panel surface, bottom panel near bed (mg l^{-1}). EQS is 0.0038 mg l^{-1}. Green dot marks approximate position of the buoyant discharge. Note that the top panel concentrations are on different scale to the bottom panel concentrations, surface concentrations are approximately double those of the bottom. Tide is ebbing until 19:00 with low water slack at 19:30, the tide then changes to the flood tide, so that at 20:00 ponded water is in the same position at 18:00. Plots are not geographically projected thus the arrows indicate length of 1 km.

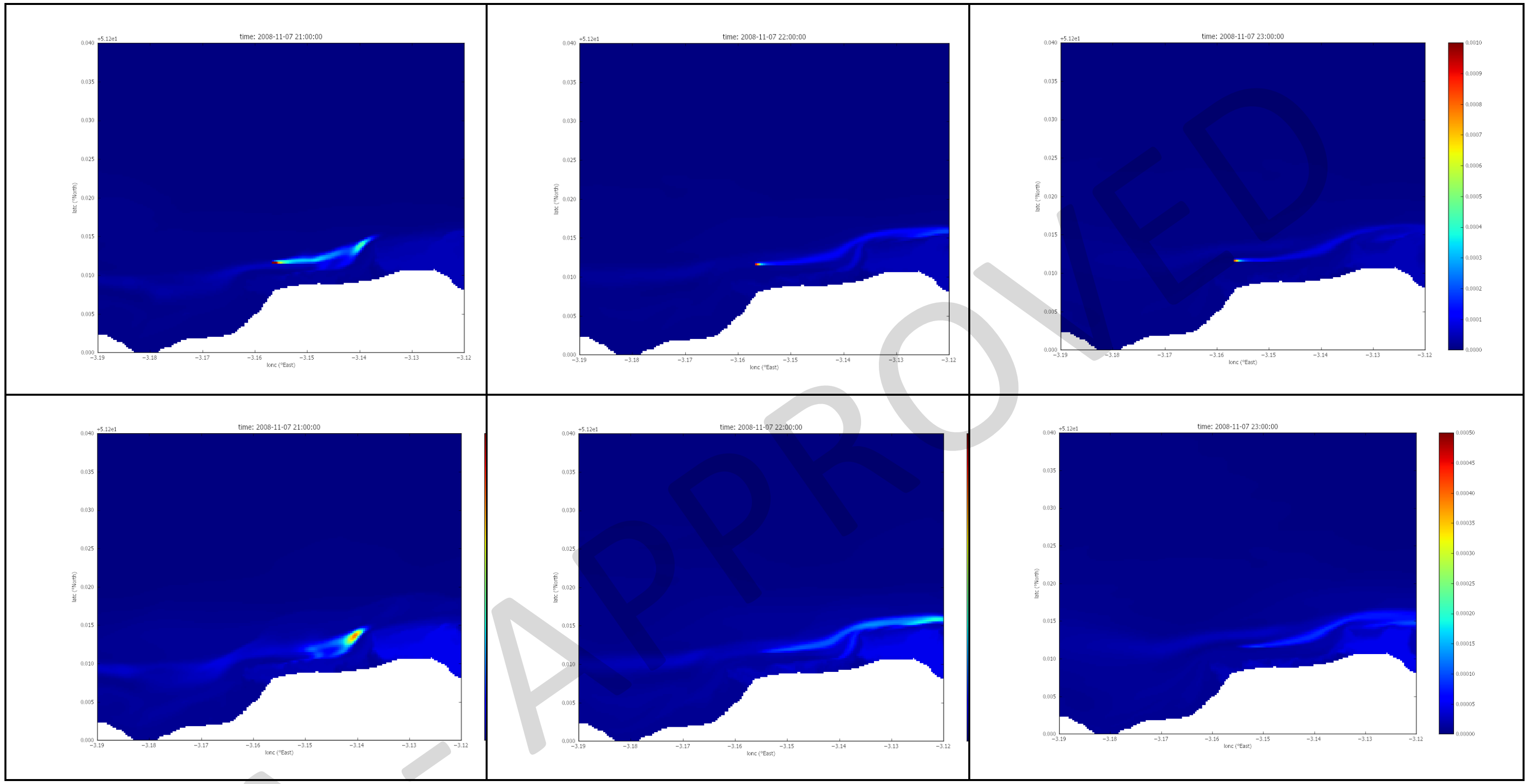

Figure 35. Top panel surface (mg l^{-1}), bottom panel near bed (mg l^{-1}). EQS is 0.0038 mg l^{-1}. Green dot marks approximate position of the buoyant discharge. Note that the top panel concentrations are on different scale to the bottom panel concentrations, surface concentrations are approximately double those of the bottom. 21:00 is during the flood tide, not the passage of the peak to the East, with high water at 24:00.

Appendix F Phytoplankton Modelling at Hinkley

F.1 Background and observational data relating to phytoplankton.

The Severn Estuary is a highly turbid estuary and has been known as such (Underwood 2010) production in the water column is likely to be very low and it is unclear if measurements of chlorophyll in the water column come from direct production, advection from elsewhere, or from chlorophyll derived from production occurring on the sediment mixed off the mudflat areas or broken up macroalgal material.

F.1.1 Observations of chlorophyll in Bridgwater Bay

As shown below, the mean concentrations of chlorophyll in Bridgwater bay are low and there is not a particular strong seasonal signal in phytoplankton concentration in the area; there are generally higher values in the summer months when primary production would be expected to occur, but only a couple of mg/l above the background winter levels. It is not clear if winter background levels come from advection from the wider environment or direct from the mudflat areas.

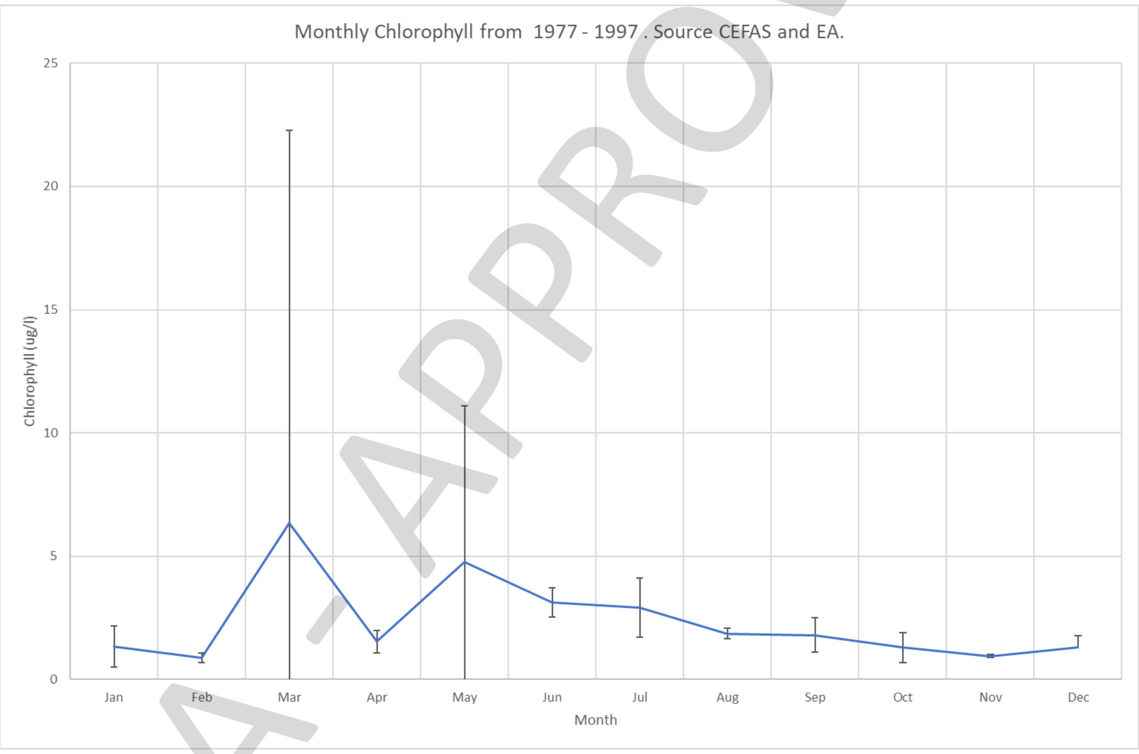

Figure 36: Observations of Chl-a, in Bridgwater bay per month from Cefas database 1977 – 1997. The March data has one data point at 48 μg l-1 which skews March datasets.

F.2 Model setup

F.2.1 Model description

We used the Combined Phytoplankton and Macroalgae (CPM) model to predict the effect of the discharge on phytoplankton community biomass. This model simulates the dynamics of phytoplankton biomass using data on known environmental drivers such as nutrients and light.

The original CPM model combined two earlier models developed for the Environment Agency (EA): one for phytoplankton, based on the UK Comprehensive Studies Task Team (CSTT) (CSTT, 1994, 1997; Painting *et al.*, 2003, 2007) and one for macroalgae (Cefas, 2003; Aldridge and Trimmer, 2009). The first version of the CPM model (Aldridge *et al.*, 2008) was developed as a static equilibrium model based on summer or annual average values, the subsequent version (used here) implements a dynamic model that does not rely on equilibrium assumptions and permits daily estimates of phytoplankton growth.

F.3 Basic concepts ('how the model works')

A detailed presentation of the physical, biological, and mathematical structure of the model is given by Aldridge and Tett, 2011. A schematic summary of the main features of the model is shown in Figure 37. Several kinds of primary producers are found in coastal environments. Microalgae are found in the water column, as the phytoplankton, and in or on the seabed, as the microphytobenthos. Associated larger producers include seaweeds (macroalgae) and aquatic macrophytes (seagrasses and saltmarsh). The current CPM model simulates phytoplankton and macroalgae. It does not simulate seagrasses or saltmarsh, but this is of no import for the current application because there are no seagrass or saltmarsh habitats in the vicinity of the HPC discharge.

At any instant the total biomass of producers is controlled by the least available, or limiting, resource. This can be a nutrient (nitrogen or phosphorous), or light. If nutrients control biomass, then the total biomass of primary producers stops increasing when the rate of nutrient input equals the rate of consumption. However, the limiting resource changes with time and the dynamic model solves the underlying equations for the rate of change of phytoplankton biomass without requiring assumptions of equilibrium. The version of the dynamic CPM model represented here is a single box with an exchange rate with outside waters.

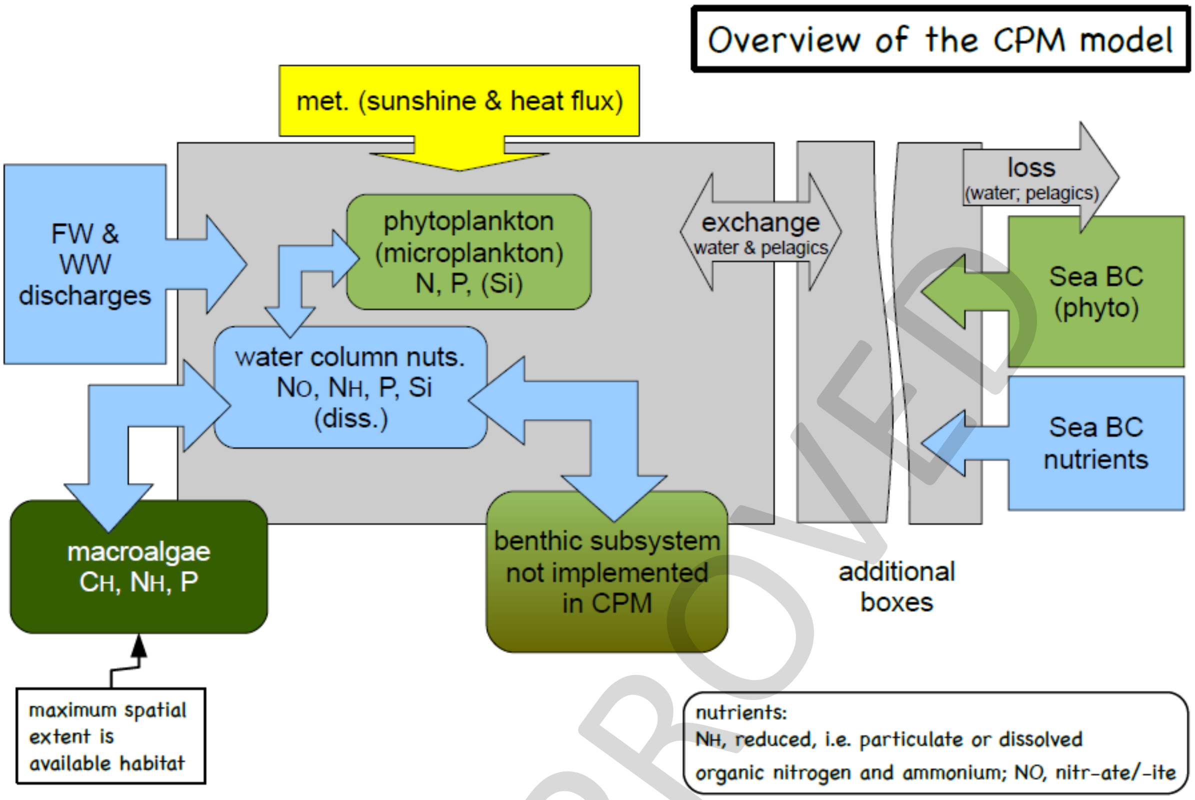

Figure 37: Schematic of CPM model components and processes (Aldridge et al., 2011)

Where FW is fresh water, WW wastewater, N nitrogen, P phosphorous, Si silicate, BC boundary conditions, No nitrate and nitrite, N_H organic ammonium and Nitrogen, C_H Carbon,

Table 30 Selective input parameters for model

Area (km2)	Avg. depth (m)	Light attenuation coefficient (Kd)	Winter back-ground N (µmol)	Winter back-ground P (µmol)	Summer back-ground N (µmol)	Summer back-ground P (µmol)	Tidal Range (m)	% Intertidal habitat for Macro Algal	Loss of micro-plankton (L), (d-1)
91.84	10.6	1	75	1.9	50	1.9	11.5	20	0.125

The value for the light attenuation coefficient or Kd of 10, is consistent with an SPM of about 160 mg l^{-1} using the equation of Devlin 2008. Values in the surface waters around Bridgwater bay are generally in the range of 100 – 800 mg l^{-1} (Underwood 2010). It is theoretically possible that in periods of neap tide, with little winds, that suspended sediment could be less than typically observed, a Kd of 1 consistent with an SPM of 10 mg l^{-1} has been used as an extreme worst case (i.e., for which light penetration with depth would be higher and hence potential for algal growth increased).

F.3.1 Incorporation of nutrients.

The model runs are a baseline run, with no additional nutrients, and a HPC construction and commissioning discharge run including the nutrients due to the discharge from conditioning chemicals, treated sewage, groundwater discharge, and due to the breakdown products of the hydrazine and other commissioning chemicals.

Table 31 Nutrient inputs to model

Waterbody Name	**Nutrient addition per year kg**	**Phosphate per year kg**
Bridgwater Bay Reference	No additional input	No additional input.
HPC Construction nutrients.	14575[1]	4429

1 Based on updated calculation by the Environment Agency of groundwater nitrogen inputs an adjusted total loading of nitrogen from groundwater+ sewage+ commissioning inputs is calculated as 13,717.9 kg/year

Model Results - production

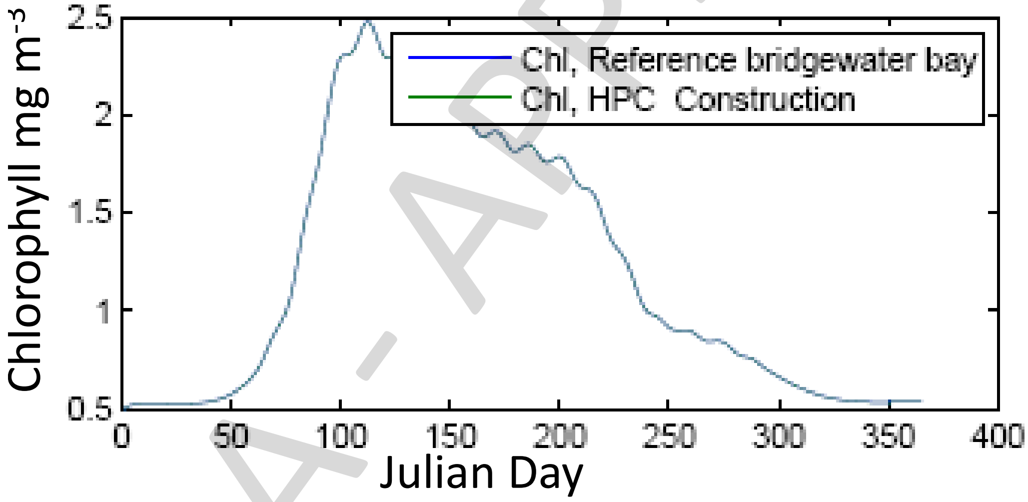

Figure 38: Instantaneous phytoplankton levels (mg Chlorophyll m^{-3}), for Bridgwater Bay with no power station discharge, HPC construction, Note there is no discernible difference, construction and reference lines are the same.

Table 32 Phytoplankton and Macro Algae production

Scenario kd (1)	**Phyto Annual Gross Production, (g C m^{-2} y^{-1})**	**Macro Annual Gross Production, (g C m^{-2} y^{-1})**
Bridgwater Bay	11.05	18.43
HPC Construction	11.05	18.43

Evident from above is that there is no difference between the simulations, which is entirely consistent with the known understanding of this high turbidity environment where nutrients are never limiting. Model results using Kd of 1 give estimates of 18 g C m^{-2} y^{-1} for macroalgal production which is broadly similar to values as estimated by Underwood (2010) of 33 g C m^{-2} y^{-1}, which applies to a wider geographic context.

F.3.2 Limiting factors that control phytoplankton growth.

The model shows which factors are limiting, during the annual cycle, as demonstrated below. Light is the limiting factor throughout the entire year. Therefore, additional nutrient input makes no difference to the output production.

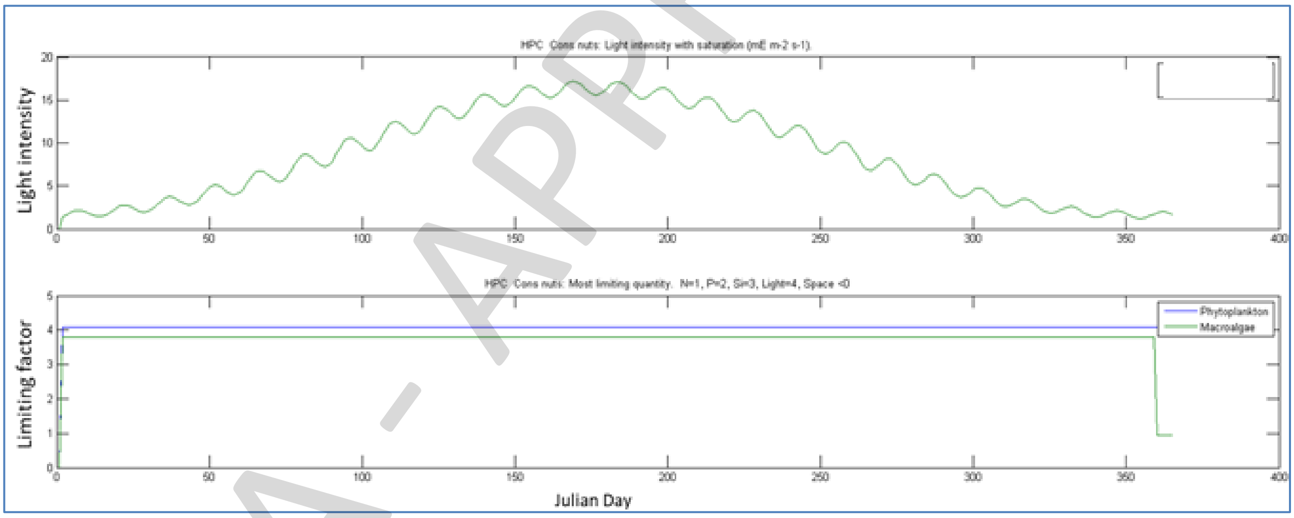

Figure 39: Limiting factors controlling phytoplankton growth, top figure is light intensity, bottom figure is the limiting parameter. Factor 4 'light' is the limiting factor for both phytoplankton and macroalgae.

F.4 Summary

The area of Bridgwater bay is severely light limited, and the available nutrients are not utilised. Therefore, the addition of more nutrients from the power-station has no effect on water column Phytoplankton production in the Bridgwater Bay area. Similarly, there is no predicted effect on the macroalgal production.

F.5 References

Aldridge, J.N., Trimmer, M. 2009. Modelling the distribution and growth of ‘problem’ green seaweed in the Medway Estuary, UK. Hydrobiologia. 629: 107-122.

Aldridge, J.N., Painting, S.J., Mills, D.K., Tett, P., Foden, J. and Winpenny. K. 2008. The Combined Phytoplankton and Macroalgae (CPM) Model: predicting the biological response to nutrient inputs in different types of estuaries in England and Wales. Report to the Environment Agency. CEFAS Contract C1882.

Devlin, M.J., Barry, J., Mills, D.K., Gowen, R.J., Foden, J., Sivyer, D., Tett, P. 2008. Estuarine, Coastal and Shelf Science 79, 429-439.

Cefas. 2003. Investigation of Factors Controlling the Presence of Macroalgae in some Estuaries of South East England. Cefas contract C1642 contract for the Environment Agency**.**

CSTT. 1994. Comprehensive studies for the purposes of Article 6 of DIR 91/271 EEC, the Urban Waste Water Treatment Directive. Published for the Comprehensive Studies Task Team of Group Coordinating Sea Disposal Monitoring by the Forth River Purification Board, Edinburgh.

APPENDIX G: CEFAS BEEMS TECHNICAL REPORT TR550, HINKLEY POINT C COMBINED CONSTRUCTION AND COMMISSIONING JETTY DISCHARGE – EVIDENCE TO INFORM HABITATS REGULATIONS ASSESSMENT (HRA)

Cefas BEEMS Technical Report TR550, Hinkley Point C combined construction and commissioning Jetty discharge – Evidence to inform Habitats Regulations Assessment (HRA)

NOT PROTECTIVELY MARKED

DOCUMENT TITLE	Cefas BEEMS Technical Report TR550, Hinkley Point C combined construction and commissioning Jetty discharge – Evidence to inform Habitats Regulations Assessment (HRA)

ISSUE REASON	P6 - For Construction

CONTRACTOR DETAILS

CONTRACTOR NAME	Cefas

CONTRACTOR DOCUMENT NUMBER	BEEMS Technical Report TR550	**CONTRACTOR REVISION**	04

ECS CODES

REVISION HISTORY

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01	29/06/2021	David Sheahan and Holly Buckley	Water Quality Programme Lead Senior Marine Ecologist	Sophie Lozach	Senior Marine Ecologist	Andrew Griffith	Principal Investigator
02	11/10/2023	Andrew Griffith	Water Quality Programme Lead	Sophie Lozach	Senior Marine Ecologist	Holly Buckley	Nuclear Programme Site Lead (Hinkley Point)
03	06/11/2023	Andrew Griffith	Water Quality Programme Lead	Holly Buckley	Nuclear Programme Site Lead (Hinkley Point)	Holly Buckley	Nuclear Programme Site Lead (Hinkley Point)
04	11/04/2024	Andrew Griffith	Water Quality Programme Lead	Holly Buckley	Nuclear Programme Site Lead (Hinkley Point)	Holly Buckley	Nuclear Programme Site Lead (Hinkley Point)

Hinkley Point C | 101231911 / 001 | P1 - For Implementation | 15-Apr-2024 | NOT PROTECTIVELY MARKED

Cefas BEEMS Technical Report TR550, Hinkley Point C combined construction and commissioning Jetty discharge – Evidence to inform Habitats Regulations Assessment (HRA)

NOT PROTECTIVELY MARKED

REVISION STATUS/SUMMARY OF CHANGES

Revision	Purpose	Amendment	By	Date
01	P6	Initial submission to NNB HPC.	Cefas	29/06/2021
02	P6	Second revision – updates to evidence	Cefas	11/10/2023
03	P6	Third revision – updated following NNB Genco (HPC) comments	Cefas	06/11/2023
04	P6	Fourth revision – updated to include demineralised water plant effluent	Cefas	11/04/2024

Cefas BEEMS Technical Report TR550, Hinkley Point C combined construction and commissioning Jetty discharge – Evidence to inform Habitats Regulations Assessment (HRA)

Cefas BEEMS Technical Report TR550, Hinkley Point C combined construction and commissioning Jetty discharge – Evidence to inform Habitats Regulations Assessment (HRA)

Andrew Griffith, Dave Sheahan and Holly Buckley

Version and Quality Control

	Version	Author	Date
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Internal QC	0.02	S. Lozach	17/06/2021
Revision	0.03	H. Buckley	21/06/2021
Executive QC	0.04	A. Griffith	23/06/2021
Revision	0.05	H. Buckley	28/06/2021
Executive QC & Final Draft	0.06	A. Griffith	29/06/2021
Submission to EDFE	1.00		29/06/2021
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Revision	1.03	A. Griffith	03/10/2023
Executive QC & Final Draft	1.04	H. Buckley	05/10/2023
Submission to EDFE	2.00		11/10/2023
Revision	2.01	A. Griffith	27/10/2023
Executive QC & Final Draft	2.02	H. Buckley	28/10/2023
Submission to EDFE	3.00		06/11/2023
Revision	3.01	A. Griffith	10/04/2024
Executive QC & Final Draft	3.02	H. Buckley	10/04/2024
Submission to EDFE	4.00		11/04/2024

Table of contents

List of Tables and Figures

Tables

Figures

Executive summary

The purpose of this document is to provide the information to inform a Habitat Regulations Assessment (HRA) of the construction and cold commissioning water discharge activity (CWDA) associated with Hinkley Point C (HPC). Possible Likely Significant Effects (LSE) are assessed for features and conservation objectives of the Severn Estuary Special Protection Area (SPA), Severn Estuary Special Area of Conservation (SAC) and Severn Estuary Ramsar site. Designated features under the Bridgwater Bay Site of Special Scientific Interest (SSSI) are also considered.

Construction phase discharges of sewage, dewatered groundwater, cementitious wash water (CWW) and tunnelling effluent from the drilling of cooling water intakes and outfalls will be discharged into the receiving waterbody from a subtidal discharge point near the seaward end of the jetty. During ‘cold’ commissioning (prior to hot functional testing), additional chemicals associated with the testing and flushing of the power station’s systems, including demineralised water plant reject, will also be discharged via the same outfall.

The chemical composition of the discharge, and the discharge volumes, change throughout the construction and commissioning phases. The assessment focuses on the worst-case phases for the peak flows and concentrations of substances of concern. During the construction phase prior to commissioning, discharges may contain metals, dissolved inorganic nitrogen (DIN) and ammonia associated with the groundwater and treated sewage flows. During cold commissioning additional discharges include conditioning chemicals such as hydrazine and ammoniacal nitrogen as well as concentrated fresh potable water from the demineralisation process.

Two potential effects categories (or pressures) were identified; non-toxic contamination and toxic contamination. LSE from other possible effects, such as physical loss, physical damage and biological disturbance were excluded on the basis that the activity does not have the potential to generate these pressures.

The potential for LSE was considered for the three elements of the discharges: the groundwater and treated sewage, the tunnelling effluent, and the commissioning. Overlapping discharges were considered where applicable, for example during commissioning ammonia was assessed as the total from commissioning plus construction and treated sewage flows. The assessment considers the potential for LSE both alone and in-combination with other plans, projects or permissions.

Non-toxic contamination

Possible LSE from non-toxic contamination was excluded from all three elements of the discharges. Particular consideration was given to nutrient inputs such as DIN and phosphate. The maximum additional loading of nutrients was modelled to evaluate potential implications for primary production (plankton or algae growth). The model showed that there was no difference in phytoplankton or macroalgae production with added nutrients. DIN levels were also screened against the Water Framework Directive (WFD) standards and it was shown that there would be no deterioration in the waterbody status as a result of the discharges. Therefore, LSE from non-toxic contamination was excluded.

Toxic contamination

Potentially hazardous chemicals were screened following the Environment Agency guidelines with comparison to relevant Environmental Quality Standards (EQS) or proxy EQS thresholds such as Predicted No effects Concentrations (PNEC). For the groundwater (including groundwater in tunnelling effluent) and treated sewage discharges all substances except zinc and copper were screened out. Zinc exceeded the EQS by the largest margin and so was modelled to represent the worst-case plume extent for metals. The modelling showed that zinc levels would not exceed the EQS level at the seabed as a result of the discharge. The maximum surface plume, in exceedance of the EQS for zinc was 0.3 ha (hectare) and there

was no, overlap with any sensitive features (such as *Sabellaria* reef or *Corallina*). The potential for indirect effects (for example by food web interactions) was considered and it was shown that effects were highly unlikely. Therefore, due to the small size of the plume and the fact that it did not overlap with sensitive features it was concluded that the zinc (and by extension other metals) discharge would not lead to a reduction in the quantity of quality of any designated habitats or species and would not limit the potential for restoration of any features. LSE from toxic contamination associated with the groundwater and treated sewage discharges was therefore excluded.

Conditioning chemicals associated with the tunnelling effluent were screened and assessed. Two chemicals, BASF Rheosoil 143 and CLB F5 M were modelled to show the plume extents associated with the discharges. Modelling showed the PNEC (proxy EQS) was not exceeded at the seabed and the maximum extent of the surface plume was 1 ha. As with zinc, there was no exceedance of the thresholds at the locations of sensitive features. It was concluded that LSE could be excluded on the basis that the very small and localised plumes in excess of the PNEC levels would not lead to a reduction in the amount or quality of any designated habitat or species.

For the cold commissioning phase (prior to the hot function testing), the worst-case combination of substances from commissioning and overlapping construction discharges were assessed (demineralisation effluent has a lower concentration of metals compared to groundwater, therefore the addition of this waste stream acts to dilute the concentration and therefore the worst-case is based on undiluted groundwater). Hydrazine (a commissioning chemical) and un-ionised ammonia (associated with the treated sewage, groundwater, commissioning, and also derived from the breakdown of hydrazine) could not be screened out and discharges were modelled to show the extents of plumes. Plume extents for both were very small, and neither showed any excess of the EQS at the seabed (for the currently permitted 15 µg l^{-1} hydrazine limit). Surface plumes in excess of the EQS (or PNEC as a proxy EQS) where shown to be small and did not overlap with any sensitive features (e.g., *Sabellaria* or *Coralina*). In regard to fish species, both migratory fish of conservation status and the wider designated typical fish assemblage, the small spatial extent of the buoyant plume, coupled with the motility of the fish species indicates the proportion of the population exposed to areas in excess of the EQS is likely to be negligible, and exposure times extremely brief. It is therefore considered highly unlikely that the construction and cold commissioning discharges could have a significant effect on fish. No contamination effects are predicted across the important bird foraging areas to the east of the Steart mudflat; and no significant effects are predicted on the food sources of designated bird assemblages in Bridgwater Bay, therefore direct and indirect effects on designated bird features were excluded. It was concluded that LSE could be excluded on the basis that the very small and localised plumes in excess of the EQS (or PNEC as a proxy EQS) levels would not lead to a reduction in the amount or quality of any designated habitat or species.

Combined effects

The potential for the interaction of toxic effects of discharged substances was considered. For the combined construction and cold commissioning inputs described an area of ca., 0.2 ha (at the surface) is likely to be affected by a combined toxic effect at or above individual EQS/PNEC level. Beyond this immediate mixing zone, the combined chemical plumes contribution at the location of the *Corallina* or *Sabellaria* receptors may be equivalent to a mean combined concentration of around 80% of the PNEC/EQS level for any individual substance. Overall, the areas that have the potential to experience combined chemical toxicity are very limited and are not considered to make a significant additional contribution to toxic effects relative to that predicted for individual substances.

In-combination effects

The potential for in-combination effects of the construction and cold commissioning discharges in relation to the plans, projects and permissions (PPP) outlined in the original HPC HRA (Environment Agency, 2013) and updated in 2020 (Environment Agency, 2020), were considered.

There is an east west separation of approximately 2.4 km between the jetty discharge and HPB/HPA outlet channel, which is therefore considered sufficient to ensure there is no interaction between the effluent discharges. It is not known what the actual microbiological discharge concentration is from HPB, however assuming the same standard of secondary treatment as HPC would imply a maximum potential extent of exceedance for *E.coli* of approximately 1.8 km (BEEMS Technical Report TR428). This theoretical exceedance could only occur in very calm conditions. Under such calm conditions the plume would be long and thin and would not interact with the jetty discharge, as the tidal stream lines are separate. In practice most of the time, wave mixing will mix the discharge rapidly so that no interaction could occur.

The in-combination effects of a small temperature uplift from the HPB thermal discharges at the jetty site and the restricted spatial area of EQS exceedance for contaminant metals and Tunnel Boring Machine (TBM) surfactants was considered (note that HPB ceased operations in 2022 however the assessment is retained as a record of the scenarios assessed). Neither component of the construction and cold commissioning discharges exceed the applied EQS/PNEC concentrations at any of the *Sabellaria* or *Corallina* sensitive feature locations. Accordingly, no significant effects are predicted resulting from the in-combination effects of increased temperature-dependent toxicity of construction contaminants due to thermal discharges from HPB on designated features of the Severn Estuary/ Môr Hafren SAC, SPA, Ramsar site and Bridgwater Bay SSSI.

As no in-combination effects of the proposed construction and cold commissioning discharges from the jetty and the PPP on designated features are predicted, LSE were therefore excluded.

Summary of Conclusions

Designated feature of the Severn Estuary/ Môr Hafren SAC, SPA, Ramsar site and SSSI	**Pressure: Toxic contamination**	**Pressure: Non-Toxic contamination**
Estuaries	**No LSE**	**No LSE**
Mudflats and Sandflats not covered by seawater at low tide	No pathway	No pathway
Atlantic salt meadows (*Glauco-Puccinellietalia maritimae*)	No pathway	No pathway
Sandbanks which are slightly covered by seawater all the time	No pathway	No pathway
Reefs (including *Sabellaria*)	**No LSE**	**No LSE**
Hard Substrate Habitats (including *Corallina*)	**No LSE**	**No LSE**
Migratory Fish and Typical Fish Assemblage	**No LSE**	**No LSE**
Bird Assemblages (indirect prey effects):	**No LSE**	**No LSE**
Marine Invertebrate Assemblages as a food source for birds and fish (as SSSI designated features)	**No LSE**	**No LSE**
In-combination effects with other PPP (including HPB operations)	**No LSE**	**No LSE**

No effect pathway means that the discharge plume does not intersect this habitat and no further assessment is made.

Changes to this Report

Revision 2 of this report incorporated all the construction discharges originally reported in BEEMS Technical Report TR443, with relevant sections updated to reflect the latest modelling evidence published in BEEMS Technical Report TR428. This revision also considers proposed variations to the discharge permits in relation to maximum permissible concentrations of ammoniacal nitrogen (BEEMS Technical Report TR581), DIN, chromium and cadmium.

Revision 3 of this report addressed comments from NNB GenCo (HPC) with minor edits for clarification and consistency.

Revision 4 of this report includes considerations of the demineralisation effluent included in variation 12 of the CWDA permit (Activity I) which will be discharged during the commissioning phase.

1 Background

The construction phase of the Hinkley Point C (HPC) nuclear power station requires the discharge of groundwater, sewage, and tunnelling effluent. Prior to operation, 'commissioning' with associated commission discharges is also required. The cold commissioning phase[1] involves the testing the function and performance of individual components, items of equipment, and systems. This includes flushing and pressure testing (using demineralised water) to check leak tightness and remove any residual debris that is present. Several chemicals are used in this process and will be discharged. During this phase of commissioning, the cooling water pumps will not have been commissioned therefore the cooling water system will be static (no significant flow) and unsuitable for receiving effluent for discharge through the cooling water outfall. Cold commissioning discharges will be made via the jetty discharge route (Outlet 12) following appropriate treatment to ensure suspended solids and chemical (including hydrazine) discharges are at levels where they will not have an unacceptable impact on water quality or marine ecology. The cold commissioning discharge is planned to occur via the jetty during a period when construction activities are ongoing.

These discharges are permitted under two water discharge activity (WDA) permits under the Environmental Permitting (England & Wales) Regulations 2016. Permit EPR/JP3122GM/V009&010 covers the construction and commissioning discharge excluding the treated sewage, and is referred to as the construction and cold commissioning water discharge activity (CWDA) permit. Permit EPR/XP3321GD/V004 covers the Construction Sewage Treatment System.

A previous report has assessed the priority substances and specific pollutants present in the construction discharges on the designated features in the Severn Estuary (BEEMS Technical Report TR443), which was informed by detailed assessments and modelling presented in an early revision of BEEMS Technical Report TR428. This report (BEEMS Technical Report TR550) considers the combined construction and cold commissioning discharges and supersedes BEEMS Technical Report TR443. This report also considers two recent proposed variations to the water discharge permits which would the limits of ammoniacal nitrogen, DIN, cadmium and chromium (further described in Section 2).

In England and Wales, the Nature Directives comprising the Directive on the conservation of wild birds (Birds Directive) and the Directive on the conservation of natural habitats and of wild fauna and flora (Habitats Directive) are implemented under the Conservation of Habitats and Species (Amendment) (EU Exit) Regulations 2019 (the 'Habitats Regulations'). The Secretary of State for the Environment, Food and Rural Affairs (DEFRA) and the Welsh Ministers have made changes to parts of the previous 2017 Regulations (implemented in 2019 regulations) so that they operate effectively (Defra, 2021). Special Areas of Conservation (SACs) and Special Protection Areas (SPAs) in the United Kingdom (UK) no longer form part of the EU's Natura 2000 ecological network, however the 2019 Regulations have created a national site network on land and at sea, including both the inshore and offshore marine areas in the UK. The national site network includes existing SACs and SPAs.

The Habitats Regulations require that, where the possibility of an LSE on a national site cannot be excluded (either alone or in-combination with another plan or project), a competent authority must undertake an Appropriate Assessment (AA) as part of the Habitats Regulations Assessment (HRA) process. The assessment process is described in Defra *et al.* (2021). The Habitats Regulations state that it is the developer's responsibility to provide sufficient information to the competent authority to enable them to assess whether there are LSE and to enable them to carry out the AA, where necessary.

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[1] Effluents generated by the Hot Functional Testing (HFT) are outside the scope of the construction and commissioning permit variation.

The purpose of this document is to provide the Competent Authority, the Environment Agency, with the information required for them to undertake the HRA. This report further develops a previous HRA evidence report (BEEMS Technical Report TR443) to include the commissioning discharge associated with the cold commissioning phase. As well as two variations to the discharge activity permits (described in Section 2).

The assessment herein draws upon the results of model predictions of the dilution and dispersion of priority substances and specific pollutants within the various discharges (BEEMS Technical Report TR428, BEEMS Technical Report TR445 and BEEMS Technical Report TR581) and relevant available evidence of the potential impacts of known chemical discharges on designated features.

The Project site is located within the Severn Estuary SPA and the Severn Estuary/ Môr Hafren SAC. The area is also designated as a Ramsar site for its internationally important wetland habitats. The site also falls within the Bridgwater Bay Site of Special Scientific Interest (SSSI), protected and managed under the Countryside and Rights of Way (CRoW) Act 2000.

2 Description of Activities and Discharge Screening Process

2.1 Construction discharge schedule

Water discharge associated with construction and commissioning activities containing substances such as metals, Dissolved Inorganic Nitrogen (DIN), hydrazine, and treated sewage effluent is currently consented to be released under two Environment Agency permits (Permit: EPR/JP3122GM/V009&010, and EPR/XP3321GD/V004), into the Severn Estuary via subtidal pipelines, 1 m above the seabed, near the seaward end of the HPC jetty. The point of discharge is situated beyond 50 m from Mean Low Water Spring (MLWS) tide in a minimum of 3 m water depth at low water (-8.9 m Ordnance Datum Newlyn (ODN)). The discharge permit also consents the discharge of substances associated with (cold) commissioning activities.

Two recent variations (pending at the time of writing) seek to vary the permissible limits for DIN, total cadmium and total chromium (permit EPR/JP3122GM/V009&010) and total ammoniacal nitrogen (permit EPR/XP3321GD/V004). The potential effects of these proposed changes are assessed in this revision.

The activities covered by this assessment include:

1. Main site dewatering discharges of groundwater from deep excavations from a network of boreholes to prevent excavations becoming inundated with water. Discharges of 20 $l\ s^{-1}$ are anticipated throughout the construction phase and contain metals, DIN and ammoniacal nitrogen.
2. Effluent from tunnel excavations during the construction of the cooling water intake and outfalls. This discharge is primarily groundwater containing metals, DIN and ammoniacal nitrogen (the same characteristics as the main site groundwater), however, small amounts of soil conditioning chemicals associated with Tunnel Boring Machine (TBM) tunnelling operations will also be discharged. Up to 26.7 $l\ s^{-1}$.
3. Cementitious wash water discharge (CWW).
4. Discharges of secondary treated sewage from the construction sewage treatment system containing DIN and ammoniacal nitrogen will be released at a rate of 1,150 $m^3\ d^{-1}$ (13.3 $l\ s^{-1}$).
5. Cold commissioning discharge, which may include hydrazine (and ammoniacal nitrogen and therefore, un-ionised ammonia, as a breakdown product of hydrazine), ethanolamine and trisodium phosphate.

Details of the specific chemical discharges and screening process are provided in BEEMS Technical Report TR428. BEEMS Technical Report TR581 provides an updated detailed screening and assessment of un-ionised ammonia associated with the proposed variation to treated sewage discharge limits. The results of the screening and assessments are summarised in the sections below to inform the HRA.

The relative timeline for construction activities (as of August 2017) and associated discharges is presented in Table 2.1 and illustrated in Appendix A (Figure 10.1). The construction is multi-phasic with discharge constituents and volumes changing over the course of the construction period. The 'cases' considered represent the highest inputs of different chemicals of concern and reflect the worst-case conservative assessments (BEEMS Technical Report TR428 and BEEMS Technical Report TR581). For example, for commissioning, Case J is considered whereas for groundwater and tunnelling discharges case C is considered. The applicable discharge cases used in the assessment are detailed in the following sections.

As detailed in Table 2.1, at the onset of construction, in Case A, groundwater dewatering discharges commence at 20 l s^{-1} and remain at this level throughout construction (this phase is now complete). During tunnelling works tunnelling effluent contribute to an increase in total groundwater discharges. At their maximum point, during Case C, discharges peak at up to 63 l s^{-1} (Figure 10.1 in Appendix A), with a typical groundwater component constituting 46.7 l s^{-1} (dewatering groundwater + groundwater associated with tunnelling waste). Maximum discharges of metals and ammoniacal nitrogen at the jetty will occur during Case C. During the final construction phase, Case D, discharges from the tunnelling decrease to low levels resulting in a reduction in the total groundwater discharges to approximately 25 l s^{-1}. During Case J groundwater flow rate is set at 25 l s^{-1} as for the original Case D construction assessment of DIN and ammoniacal nitrogen but additional commissioning inputs of these substances are also included. For conservative screening assessments of groundwater derived substances only the volume of groundwater has been used, with no assumption of diluting water (e.g., from tunnelling).

The TBM soil conditioning chemicals are at their highest concentrations during Case D. The total discharge during Case D is 38.3 l s^{-1} (40 l s^{-1} was used for the tunnelling chemicals assessment as this includes minimum groundwater flow 20 l s^{-1}, 13.3 l s^{-1} sewage and tunnelling chemicals) and this value has been used in the calculation of conditioning chemical discharge concentration and effective volume flux (EVF).

Cases in Table 2.1 were used to assess the maximal inputs of different contaminants of concern. This approach covers the plausible worst-case volume and contaminant concentrations to be considered for permitting. The schedule will inevitably change, but the summary of the worst-case conditions should cover the likely changes. Case E is omitted as it is covered by other cases, but covers the latter period of construction when tunnelling inputs are completed. For the assessment of the inputs from the CWW and cold commissioning discharges the construction activities and discharges that are occurring in combination are best represented by those described for Case D. No seasonal dependence of the schedule has been considered therefore changes to the start or end times do not affect conclusions in the assessment.

Table 2.1: Indicative sequencing of the relevant discharges based upon August 2017 construction plans (note some activities are complete, but all are shown for context). Case column indicates the maximal inputs of different contaminants of concern which are used for the assessment of impact, refer to BEEMS Technical Report TR428 for further details.

Main site Groundwater	Sewage	Week	Tunnelling wastes (and associated) discharges	Case
De-watering discharge at Jetty, 20 l s^{-}		1	NA	**Case A** 20 l s^{-1} (jetty)
20 l s^{-1}		17	Approximately 7 l s^{-1}	N/A
20 l s^{-1}	sewage treatment plant discharge (jetty) 13.3 l s^{-1}	25	12 l s^{-1} ramping up to 22 l s^{-1} as SCL works ramp up. Tunnelling for intake 1 continues.	**Case B** 55 l s^{-1} (jetty)
20 l s^{-1}	13.3 l s^{-1}	49	30 l s^{-1} (ca. 26.7 l s^{-1} groundwater also including ca.,3 l s^{-1} soil conditioning chemicals from the use of 1 TBM).	**Case C** Peak Ca.,63 l s^{-1} (jetty)
20 l s^{-1}	30 l s$^{-1.}$ Rare but potentially maximum discharge.	49	30 l s^{-1} (ca. 26.7 l s^{-1} groundwater also including ca.3 l s^{-1} soil conditioning chemicals from the use of 1 TBM).	**Case C1max** Peak Ca., 80 l s^{-1}
20 l s^{-1}	13.3 l s^{-1}	81	SCL works complete. Tunnelling continues HPC Intake 1, Outfall, and Intake 2. Maximum use of TBM soil conditioning chemicals corresponds to the output from 2 TBMs working simultaneously. 6 l s^{-1}	**Case D** 40 l s^{-1} (original tunnelling assessment) [1] 38.3 l s^{-1} assessed for combined commissioning input at jetty[2]
(20 l s^{-1})[3]	(13.3 l s^{-1})[3]	NA[4]	CWW plus other Case D inputs	**Case F** (0.6 l s^{-1} CWW) [5]
(20 l s^{-1})[3]	(13.3 l s^{-1})[3]	NA[4]	Commissioning discharge – this input contributes nitrogen and ammoniacal nitrogen from addition of ammonia and breakdown of hydrazine, ethanolamine, and phosphorus from trisodium phosphate, plus other Case D inputs	**Case J** [6] (70 l s^{-1} commissioning discharge)

[1] For the original 2017 assessment of tunnelling chemicals a minimal groundwater dilution flow (20 l s^{-1}) was assumed during Case D. This effectively produced a most conservative scenario for tunnelling chemicals as it minimises dilution (assuming 20 l s^{-1} groundwater + 13.3 l s^{-1} treated sewage + 6 l s^{-1} tunnelling chemical which was rounded up to 40 l s^{-1} discharge).

[2] The total volume for assessment of DIN during Case D 38.3 l s^{-1} includes 13.3 l s^{-1} sewage contribution + 20 l s^{-1} general groundwater input + 5 l s^{-1} groundwater from tunnelling. The additional 6 l s^{-1} tunnelling chemical make-up water will not add DIN but will dilute the overall concentration so to provide the most conservative assessment this was not included in the flow rates for the DIN calculation.

[3] The total volume of groundwater (including 5 l s^{-1} from tunnelling) and sewage contributions of chemicals of concern during Case D are considered in combination with additions of the same contaminants from CWW or commissioning inputs.

[4] NA - not applicable as start timing not identified in 2017 scheduling.

[5] During Case F CWW input contributions are evaluated in combination with those for Case D.

[6] During Case J the construction discharge for DIN and ammoniacal nitrogen uses the Case D example at 25 l s^{-1} groundwater with additional contributions from commissioning inputs.

2.2 Characteristics of the discharges (screening and plume modelling)

2.2.1 Groundwater, treated sewage and CWW

The concentration of groundwater contaminants was assessed by initial screening tests, referred to previously as H1 screening. The screening provides an assessment to determine conformity to specified EQS in accordance with the surface water risk assessment (Environment Agency and Department for Environment Food and Rural Affairs, 2016). Potential EQS exceedance was tested for metals and inorganic chemicals in groundwater discharges relative to their baseline concentrations in the receiving waters (BEEMS Technical Report TR428). The original assessment presented in BEEMS Technical Report TR428 was based on groundwater borehole sample data prior to any discharges to inform the original application. Since this original assessment effluent testing has been undertaken and this offers an opportunity to check that the observed concentrations of contaminants are within the assessed envelope. Table 2.2 gives a summary of the original screening assessment and average concentrations of contaminants measured in the effluent to date. The comparison with the measured concentrations shows that all contaminants are within the envelope of the original assessment. Detail of the screening results is provided in Appendix B (Table 10.1) and in BEEMS Technical Report TR428.

Copper and zinc could not be screened out and therefore warranted further investigation. Metals are modelled as 'passive tracers' meaning no sediment absorption, biological uptake or other loss from the environment is accounted for (this is conservative). Therefore, zinc, which exceeded the EQS by the greatest margin was modelled as a proxy for the maximum impact range of all metals (Section 2.2.1.1).

A recent variation request for the construction and commission permit (EPR/JP3122GM/V009&010) proposed higher maximum limits for DIN, cadmium and chromium. As demonstrated in Table 2.2, the average concentrations of these contaminants in the effluent are considerably below the screening values and therefore the assessment remains valid. Chromium has a Maximum Allowable Concentration (MAC) EQS, for which maximum rather than average values are applicable. The proposed new limit for chromium (144 µg l^{-1}) passes the screening test for the MAC (32 µg l^{-1}) with an EVF of 0.2[2], below the allowable EVF limit of 3.0 and therefore can be screened out of further assessment.

Table 2.2: Summary of groundwater contaminants and screening.

Contaminant	Screening concentration* µg l^{-1}	Saltwater AA EQS[1] µg l^{-1}	Saltwater MAC EQS (as 95%ile) (µg l^{-1})	Screening test pass/fail	Average effluent concentration µg l^{-1} (Outlet 12 2018 – 2023)	Effluent value within assessment envelope?
Un-ionised ammonia (N)	123.5	21	-	Pass	12.0	Yes
DIN	4073	2520		Pass	2330	Yes
Cyanide	50	1	-	Pass	Below detection	Yes
Total cadmium	0.46	0.2	-	Pass	0.08	Yes
Total chromium	24	0.6	32	Pass	2.65	Yes
Total lead	3	1.3	14	Pass	0.85	Yes
Total copper	221	4.76	-	Fail	7.70	Yes
Total zinc	1642.15	6.8	-	Fail	342	Yes
Total mercury	0.49	-	0.07	Pass	0.04	Yes

* Following the values applied in Table D of Environment Agency Stage 1 Habitats Regulations Assessment (Environment Agency, 2017).

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[2] Calculation as follows: (144*0.046) / (32 – 0.02) = 0.2.

Treated sewage discharges are described and assessed in BEEMS Technical report TR581. The assessment in BEEMS Technical report TR581 takes into account a recent variation request to increase the ammoniacal nitrogen limit in the treated sewage discharge to a maximum of 80 mg l^{-1}. For the construction and treated sewage discharge (excluding commissioning) discharges of ammoniacal nitrogen (assessed based on calculated un-ionised ammonia as this is the most hazardous form) passed the screening tests. Additional modelling was however carried out to demonstrate the size of the mixing zone (see Section 2.2.1.2).

During the period when cold commissioning chemicals and construction waste water (as described for Case J, Table 2.1) are being discharged at the jetty, a maximum daily discharge of treated CWW of 50 m^3 per day may also occur (Case F, Table 2.1). The discharge rate for the CWW would be equivalent to a very low continuous daily discharge of 0.57 l s^{-1}. Preliminary characterisation[3] of untreated CWW indicates the presence of retarder and accelerator chemicals but also trace contaminant metals. The CWW discharge represents just over 2% of the Case J groundwater discharge (25 l s^{-1}). Because of the very low CWW discharge rate and its low relative percentage contribution compared to groundwater inputs there are likely to be some small but non-significant elevations in the overall discharge concentrations of selected metals. However, as the combined discharge rate of groundwater and CWW would still be very low ca. 26 l s^{-1}, an increase of a few percent above that of the original groundwater metal concentrations would have negligible influence on the small mixing zone where the EQS might be exceeded (BEEMS Technical Report TR428). Therefore, no significant changes to the main groundwater assessment (see section 5) are predicted from the CWW discharge.

2.2.1.1 *Zinc discharge plume modelling*

Discharges of zinc were modelled using a 25 m by 25 m resolution, 3D hydrodynamic General Estuarine Transport Model (GETM) model with an inbuilt passive tracer representing zinc (BEEMS Technical Report TR428). Briefly, the passive nature of the tracer assumes that there is no loss of zinc due to sediment absorption or biological uptake, furthermore, the effects of waves, which enhance vertical mixing and increase dilution, are not incorporated into the model. Thus, the estimated plume dynamics are conservative, based only on dilution by hydrodynamic forces. Meteorological conditions, primarily wind speed and direction, can influence the plume trajectory and were modelled based on a worst-case scenario for specific designated features.

The mean background concentration of dissolved zinc in the waterbody is 3.03 µg l^{-1} (see Appendix B in BEEMS Technical Report TR428) while the AA EQS is 6.8 µg l^{-1}. When comparing the model results against the EQS, a value of 3.77 µg l^{-1} was used as a threshold to account for the background concentration of zinc, calculated by simply subtracting the background concentration from the EQS concentration. This can be thought of as the amount of zinc which can be added to the current baseline without exceeding the EQS.

The total sea surface area exceeding the EQS for zinc, based on maximum potential groundwater discharges (BEEMS Technical Report TR428, Case C Table 2.1), is 0.30 ha. Longer-term discharge rates, expected during construction operations described under Case D (Table 2.1) and most likely overlapping with cold commissioning, result in a sea surface area of 0.1 ha in exceedance of the EQS. The model inputs and results are discussed in relation to the individual receptors, principally *Sabellaria* reefs and *Corallina* waterfalls, in Section 5, however notably there was no exceedance of the EQS at any of the locations of sensitive receptors.

Modelling of the dispersion of zinc from the discharge was based on the assessed concentration of 1,620 µg l^{-1}, however as shown in Table 2.2 the measured concentration of zinc in the effluent to date is considerably below this (342 µg l^{-1}), therefore the modelling results are highly conservative.

2.2.1.2 *Un-ionised ammonia (treated sewage) modelling*

The construction and treated sewage discharge was further investigated with near field-dilution modelling using Cormix (CORMIX Version 12.0GT HYDRO1 Version 12.0.1.0 January 2023). The modelling showed that the

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[3] NNB HPC will provide a CWW characterisation report as per permit condition PO2 when the required information becomes available. NNB HPC recognise that no discharge can commence under Case F until a submission under PO2 is approved by the EA.

maximum range of un-ionised ammonia above the EQS associated with the discharge would be <50 m, and during most tidal conditions the extent of the plume would be significantly smaller than this, typically <15 m (BEEMS Technical Report TR581). This small plume is highly localised to the discharge point and does not overlap with any sensitive receptors (e.g., *Corallina* or *Sabellaria*).

2.2.2 Tunnelling Discharges

Tunnel boring machines (TBMs) are being used to excavate the two cooling water intake tunnels and the cooling water discharge tunnel. The tunnels are constructed in sections with a ring added for each 1.5 m of drilling. At the maximum drilling rate 24-rings per day can be installed by each TBM for the intake tunnels and 16-rings per day for the outfall tunnel. For operational reasons including power availability, all three TBMs will not be operating at full capacity simultaneously and a realistic maximum construction estimate is 40 rings per day.

The greatest discharge produced during tunnelling is groundwater. Groundwater, generated from digging the galleries allowing access to the tunnels, is considered in the assessment in combination with dewatering discharges of similar chemical composition (BEEMS Technical Report TR428, Case C Table 2.1).

In addition to groundwater, smaller quantities of water containing chemicals emanating from tunnelling operations will be produced. Chemical use in tunnelling is associated with three broad functions including:

- Fuelling and lubrication of the TBM
- Sealing the tunnel walls against water/soil ingress
- Ground conditioning

Management protocols will be implemented to minimise losses of fuelling and TBM lubricants and oil/chemical spills will be contained by appropriate treatment and disposal. Sealants and greases are, by their nature, impervious to water and will remain associated with the tunnel walls or be retained within the spoil (with the remainder to be disposed of through an appropriate licensed disposal route).

The active substances in the TBM chemical products were identified from respective datasheets. The substances identified are surfactants from chemical groups commonly found in household detergent products for which there are a range of toxicity studies available. Based upon common elements of their chemical composition, PNECs have been established for representative surfactants and these have been applied in a detailed screening assessment in BEEMS Technical Report TR428.

The discharge contaminants considered in greater detail following the initial screening assessment were tunnelling chemicals BASF Rheosoil 143 and Condat CLB F5/M (TBM soil conditioner). Having failed the 'H1' style screening test[4], these compounds were modelled in an identical way to the zinc.

BASF Rheosoil 143 had an established PNEC (proxy EQS) of 40 μg l^{-1}, whilst the applied PNEC (proxy EQS) for Condat CLB F5/M is 4.5 μg l^{-1}. Unlike groundwater contaminants, the greatest discharge of TBM ground conditioning chemicals is expected during the longer-term construction phase, Case D (Table 2.1) when cold commissioning discharges also occur.

The modelling results for BASF Rheosoil 143 (See Sections 4.3 and 4.4 of BEEMS Technical report TR428) show that there is no exceedance of mean PNEC (proxy EQS) at the bed; there is an area 0.19 ha at the surface where the EQS is exceeded. The modelling results for Condat CLB F5/M (See Sections 4.3 and 4.4 of BEEMS Technical report TR428) show that there is no exceedance of mean PNEC (proxy EQS) at the bed; there is an area 0.96 ha at the surface where the EQS is exceeded.

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[4] Ground conditioning chemicals failed the TraC Water test 5 (EVF< 3.0), see Section 3.4.1 of BEEMS Technical Report TR428.

2.2.3 Commissioning discharges

During cold commissioning of the components, systems and reactor a range of tests and flushing will be conducted with demineralized water in some cases containing ammonia, hydrazine and ethanolamine, the breakdown products of which will contribute to nitrogen, and ammoniacal nitrogen inputs. Trisodium phosphate is also added during cold commissioning and a conservative assumption is made that it breaks down completely to contribute an equivalent phosphorus loading. At the same time construction activities taking place on site will contribute treated sewage, CWW (Case F, Table 2.1) and total groundwater (i.e., the combined product of dewatering groundwater and groundwater produced during the construction and cold commissioning of cooling water tunnels) (Case J, Table 2.1).

During cold commissioning various chemicals may be present in discharges. Results for the 'H1' style screening process (see Appendix C Table 25 in BEEMS Technical Report TR428), show the substances that exceed the screening tests and that require more detailed modelling. Additionally, effluent from the demineralisation process may be discharged during the commissioning phase. The demineralisation effluent would be concentrated potable water with low levels of process chemicals for cleaning the plant. The demineralisation effluent is described and assessed in variation 12 of the CWDA permit (NNB GenCo (HPC), 2024). Notably most substances were screened out of detailed assessment. Copper, zinc and free chlorine (assessed as total residual oxidant, TRO) may be concentrated from the potable water to levels above their respective EQS levels. However, it was shown in NNB GenCo (HPC) (2024) that the concentrations of zinc would be below the screening (EVF) threshold, and discharges of copper and TRO would be lower than the existing assessment for groundwater discharges (described in Section 2.2.1) when compared to their relative EQS levels, and as such the groundwater assessment represents a worst-case scenario. The concentrations of metals in the demineralisation effluent are lower compared to the assessed groundwater values, therefore, as described in NNB GenCo (HPC) (2024), coincident groundwater and commissioning demineralisation discharges would act to dilute the maximum groundwater discharge case assessed (commissioning plus Case D) and therefore the discharge is within the envelope of the existing assessment.

During cold commissioning the high discharge concentration relative to the very low chronic PNEC (as a proxy EQS) for hydrazine means that it required detailed modelling (Section 2.2.3.1). Un-ionised ammonia is also discharged during commissioning and furthermore, hydrazine (N_2H_4), can breakdown to un-ionised ammonia and therefore potential additional ammonia from hydrazine breakdown was also taken into account (see Appendix C Table 27 in BEEMS Technical Report TR428). The assessment of un-ionised ammonia also included consideration of coinciding construction groundwater and treated sewage discharges which also contain ammonia (Section 2.2.3.2)

The loadings of phosphate and nitrogen from cold commissioning were evaluated as nutrient inputs in a combined phytoplankton macroalgal box model (See Section 3.5.1 of BEEMS Technical Report TR428) also factoring in relevant inputs from construction activities as described in Case J (Table 2.1), which uses the Case D example with additional contributions from cold commissioning inputs. As the breakdown of hydrazine and ethanolamine also has the potential to contribute to ammoniacal nitrogen in the cold commissioning discharge, this was evaluated in a detailed modelling assessment in combination with inputs from the overlapping construction activities as described for Case J.

2.2.3.1 *Hydrazine plume modelling*

Hydrazine has been modelled, using a 25 m by 25 m resolution, 3D hydrodynamic GETM model including hydrazine decay functions, over a 30-day period with a discharge of 83.3 l s^{-1} at the jetty, in daily pulses of 5 h starting at noon. To investigate the effect of the release concentration, three different concentrations have been considered, 10 µg l^{-1}, 15 µg l^{-1} and 30 µg $^{-1}$l. As the plume is initially buoyant, due to the low salinity release, the model results show higher hydrazine concentrations at the surface compared to the seabed (BEEMS Technical Report TR445). The current permitted maximum concentration is 15 µg l^{-1}.

At the highest modelled concentration of 30 µg l^{-1}, in terms of the acute and chronic PNEC values, which are considered more precautionary, the areas of exceedance at the surface are the largest at 14.55 and 36.63 ha respectively. The 30 µg l^{-1} release concentration also led to small areas of exceedance at the seabed also predicted (1.86 and 5.98 ha for acute and chronic PNECs respectively).

For the 15 µg l^{-1}, no areas of the seabed were in excess of the either the chronic or acute PNEC thresholds. The plume extents at the surface are modelled as 15.89 ha (average, chronic PNEC) and 5.47 ha (95th percentile acute PNEC).

Based on these assessments, all the hydrazine release concentrations are likely to have localised effects predominantly in the water column. In the context of the more recent Canadian Federal Water Quality Guidelines for hydrazine (Environment Canada, 2013), 200 ng l^{-1}, there is no exceedance in terms of 95th percentile concentrations at the surface or bed (BEEMS Technical Report TR445).

Hydrazine has been demonstrated to decay rapidly in natural seawater from Hinkley Point with a half-life of ca. 49 minutes (BEEMS Technical report TR390). Also, hydrazine is not indicated to bioaccumulate based on its low bioconcentration factor (BCF) in studies with fish (Slonim, 1977) and its low partition coefficient (-2.07 log K_{ow} reported in Environment Canada and Health Canada, 2011). These properties make food chain bioaccumulation unlikely (U.S. Department of Health and Human Services, 1997).

2.2.3.2 *Ammonia plume modelling*

Ammoniacal nitrogen is assessed as different forms of ammonia; both un-ionised ammonia and total ammonia have been modelled based on combined commissioning, groundwater and treated sewage sources (BEEMS Technical Report TR428). This modelling has been updated following the variation request to increase the total ammoniacal nitrogen from the treated sewage. The updated modelling is described in BEEMS Technical report TR581.

The partitioning between ammonium (NH_4^+) and un-ionised ammonia (NH_3) is controlled by environmental variables, principally, pH, temperature and salinity. At higher pH values, un-ionised ammonia represents a greater proportion of the total ammonia concentration. Temperature increase also raises the relative proportion of un-ionised ammonia, but this effect is much less marked than for pH change. A greater percentage of ammonia will also be in the un-ionised form when the salinity is lower. Un-ionised ammonia concentrations have been calculated using the Environment Agency calculator (following the formulas in Clegg & Whitfield,1995) with calculations described further in BEEMS Technical Report TR581.

For un-ionised ammonia the initial mixing results in the concentration exceeding the EQS being limited to the immediate vicinity of the discharge. There is no area of EQS exceedance based on the average assessment. Based on a 95th percentile assessment (i.e., 5% of the time) a maximum of 0.2 hectares at the surface could exceed the EQS for un-ionised ammonia, however there is no exceedance of the EQS at the seabed. For context the receiving water body (Bridgwater Bay Water Body ID GB670807410000) has a surface area of 9,224.5 ha, and therefore the area of exceedance represents 0.002% of the water body.

As total ammonia (NH_4^+ plus NH_3) has potential toxicological effects, the contributions from the cold commissioning discharge needs to be considered alongside contributions from the construction discharge of groundwater and sewage (Case D, Table 2.1). Modelling of total ammonia is described in BEEMS Technical Report TR428 updated to account for the variation to the treated sewage ammoniacal nitrogen limits in BEEMS Technical Report TR581.

Areas of exceedance were evaluated against an annual average guideline values (proxy EQS) of 1100 µg l^{-1} of ammoniacal nitrogen (total ammonia) and MAC of 8000 µg l^{-1}. Mixing results in the concentration exceeding the EQS being limited to the immediate vicinity of the discharge.

The model outputs show the MAC for total ammonia is not exceeded at the scale of the model (25 m). Exceedance of the annual average PNEC was limited to 0.04 ha (i.e., the immediate vicinity of the discharge).

3 HRA Designated Features

The proposed activities are located in Bridgwater Bay in the Bristol Channel. The description of the activities in Section 2 demonstrates that potential effects would be highly localised and therefore designated sites in the vicinity have been identified based on a highly precautionary 5 km search radius.

The activity is within The Severn Estuary SPA and Severn Estuary Ramsar Site, and the Severn Estuary/ Môr Hafren SAC. No other designated sites were identified which could plausibly be affected by the activity. Consideration of functionally linked habitat (in particular for migratory fish associated with the River Usk/ Afon Wysg SAC and River Wye/ Afon Gwy SAC) is reviewed in Section 3.5.

Consultation with the Environment Agency regarding recent proposed permit variations (described in Section 2) raised two further designated sites for consideration; the Bristol Channel Approaches SAC and the Somerset Levels and Moors SPA. The Bristol Channel Approaches SAC is approximately 100 km from the discharge point, it is inconceivable that effects would be apparent at such distances and therefore there is no pathway for direct effects, indirect effects on the qualifying feature (Harbour porpoise) are also considered inconceivable given the highly localised activities and effects described in Section 2. The Somerset Levels and Moors SPA is an inland SPA designated for bird features over 20 km from the discharge point, while it is feasible that bird features designed in Somerset Levels and Moors SPA may forage in Bridgwater Bay, as described Section 2 and detailed further in Section 5.2.7 there are no impacts predicted to benthic invertebrate communities and discharge plumes do not extend over the intertidal areas where birds may forage. Therefore, both sites are scoped out of the assessment.

Conservation Advice for these sites was obtained from the Regulation 33 package that was published in 2009 Natural England/Countryside Council for Wales (2009), which is summarised below in Sections 3.1 to 3.3.

SSSI are designated under the wildlife and countryside Act (1981), not the Habitats Regulations, and while not formally part of an HRA, the potential effects on species and habitats notified as part of the Bridgwater Bay SSSI are also considered in this report at the request of the Environment Agency.

3.1 Severn Estuary SPA

The Severn Estuary SPA is designated for the following features (the Natura 2000 Standard Data Form version 25/01/2016):

- Internationally important winter populations of regularly occurring species Bewick's swan (*Cygnus columbianus bewickii*) (Natural England/Countryside Council for Wales, 2009).
- Internationally important waterfowl assemblage during winter.
- Internationally important winter populations of regularly occurring migratory species; greater white-fronted goose (*Anser albifrons albifrons*), dunlin (*Calidris alpina alpina*), common redshank (*Tringa totanus*), common shelduck (*Tadorna tadorna*) and gadwall (*Anas strepera*).
- Nationally important winter populations of the following species; Eurasian wigeon (*Anas penelope*); ringed plover (*Charadrius hiaticula*); whimbrel (*Numenius phaeopus*); grey plover (*Pluvialis squatarola*); Eurasian teal (*Anas crecca*); Eurasian curlew (*Numenius arquata arquata*); northern pintail (*Anas acuta*); spotted redshank (*Tringa erythropus*); common pochard (*Aythya farina*); and tufted duck (*Aytha fuligula*).
- Nationally important numbers of the following species during passage periods: ringed plover (*Charadrius hiaticula*); dunlin (*Calidris alpina alpina*); whimbrel (*Numenius phaeopus*); and common redshank (*Tringa totanus*).

- Nationally important breeding population of the following migratory species: lesser black-backed gull (*Larus fuscus graellsii*).
- Supporting habitats for the over-wintering and migratory bird assemblages (saltmarshes, intertidal mud and sand, hard substrate habitats).

The Conservation Objectives of the 24,487.91 ha (marine area = 22,112.58 ha[5]) SPA site is to ensure that the integrity of the site is maintained or restored as appropriate, and ensure that the site contributes to achieving the aims of the Wild Birds Directive, by maintaining or restoring;

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

Species specific guidance is available in Natural England/Countryside Council for Wales (2009).

3.2 Severn Estuary / Môr Hafren SAC

The Severn Estuary / Môr Hafren SAC is designated for the following features (NE, 2009 and Natura 2000 Standard Data Form version 25/01/2016[6]):

- **Annex I Habitats** – 'Estuaries' (73,677.25 ha) (sub-features include 'Hard substrate habitats' (approx. 1,500 ha) and notable estuarine assemblages of fish[7], waterfowl[8] and vascular plants), 'Mudflats and sandflats not covered by seawater at low tide' (20,271.38 ha), 'Atlantic salt meadows (*Glauco-Puccinellietalia maritimae*)' (656.06 ha), 'Sandbanks which are slightly covered by sea water all the time' (11,779.51 ha) and 'Reefs' (1,474.28 ha).
- **Annex II species** –designated for three migratory fish species: sea lamprey (*Petromyzon marinus*), river lamprey (*Lampetra fluviatilis*), and twaite shad (*Alosa fallax*).

The Conservation Objectives of the SAC are to ensure that the integrity of the site is maintained or restored as appropriate, and ensure that the site contributes to achieving the Favourable Conservation Status of its Qualifying Features, by maintaining or restoring;

- the extent and distribution of qualifying natural habitats and habitats of qualifying species;
- the structure and function (including typical species) of qualifying natural habitats;
- the structure and function of the habitats of qualifying species;
- the supporting processes on which qualifying natural habitats and the habitats of qualifying species rely;
- the populations of qualifying species; and
- the distribution of qualifying species within the site.

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[5] From the Natura 2000 Standard Data Form version 25/01/2016

[6] The extents of each feature are taken from the Natura 2000 Standard Data Form version 25/01/2016, with the exception of hard substrate habitats. The Standard Data Form does not provide information on hard substrate habitat, so the extent of this feature is taken from the Natural England/Countryside Council for Wales (2009) Regulation Advice.

[7] Migratory fish (salmon, eel, sea trout and allis shad) and Assemblage of fish species (>100 species).

[8] Internationally important populations of migratory bird species; Internationally important populations of wintering bird species; and Assemblage of nationally important populations of waterfowl.

3.3 Severn Estuary Ramsar Site

The Severn Estuary Ramsar Site is designated for the following features (NE, 2009):

- Ramsar criterion 1 – Annex I Habitats also afforded protection under the SAC designation: Estuaries (*Sabellaria alveolata* reefs and hard substrates are sub-features of the estuary); Mudflats and sandflats not covered by seawater at low tide; Sandbanks which are slightly covered by sea water all the time and Atlantic salt meadows (*Glauco-Puccinellietalia maritimae*).
- Ramsar criterion 3 - Due to unusual estuarine communities, reduced diversity and high productivity.
- Ramsar criterion 4 - Run of migratory fish between sea and river via the estuary. Species include: salmon (*Salmo salar*); sea trout (*Salmo trutta*); sea lamprey (*Petromyzon marinus*)*; river lamprey (*L. fluviatilis*)*; allis shad (*Alosa alosa*); twaite shad (*A. fallax*)*; and European eel (*Anguilla Anguilla*).
- Ramsar criterion 8 – The estuarine fish assemblage, which is one of the most diverse in Britain with over 110 species recorded.
- Ramsar criterion 5 – Waterfowl assemblages of international importance with peak counts in the winter.
- Ramsar criterion 6 – Current and future species/populations occurring at levels of international importance: tundra swan (*Cygnus columbianus bewickii*)*; greater white-fronted goose (*A. albifrons albifrons*)*; common shelduck (*T. tadorna*)*; gadwall (*A. strepera*)*; dunlin (*C. alpina alpina*)*; common redshank (*T. totanus*)*; lesser black-backed gull (*Larus fuscus graellsii*)*; ringed plover (*Charadrius hiaticula*)*; Eurasian teal (*Anas crecca*)*; and northern pintail (*Anas acuta*)*.
- Noteworthy fauna (not mentioned above) – Bird species/populations occurring at levels of national importance: herring gull (*Larus argentatus argentatus*); little egret (*Egretta garzetta*); ruff (*Philomachus pugnax*); whimbrel (*Numenius phaeopus*)*; Eurasian curlew (*Numenius arquata arquata*)*; common greenshank (*Tringa nebularia*); Eurasian wigeon (*Anas penelope*)*; northern shoveler (*Anas clypeata*); common pochard (*Aythya farina*)*; Water rail (*Rallus aquaticus*); and spotted redshank (*Tringa erythropus*)*. Nationally important invertebrate species: lagoon sea slug (*Tenellia adspersa*, nationally rare); mud shrimp (*Corophium lacustre*, nationally scarce); and lagoon sand shrimp (*Gammarus insensibilis*, nationally scarce).

  * indicates species that are also afforded protection under the SAC/SPA designation

There are currently no conservation objectives for Ramsar sites. The SAC/SPA conservation objectives are used for features in common. In summary, the conservation objectives for migratory fish species requires that:

- alternations in water quality, water flows or physical barriers to not restrict migratory passage of adult or juvenile stages of fish species,
- no decline in the population size of fish in rivers in the catchment area and returning adults occurs,
- the abundance of prey resources in the estuary is maintained.

Details on the conservation objectives for the SAC, SPA and Ramsar sites are provided in Natural England/Countryside Council for Wales (2009).

3.4 Bridgwater Bay SSSI

The Bridgwater Bay SSSI has a total area of 6,237.47 ha (including non-marine components), the notified features with a marine component within include (Natural England, website accessed 26/05/2021):

- Notified bird features include aggregations of non-breeding Eurasian curlew (*Numenius arquata*), common redshank (*Tringa tetanus*), snipe (*Gallinago gallinago*), Eurasian teal (*Anas crecca*), dunlin (*C. alpina alpina*), common shelduck (*T. tadorna*), gadwall (*A. strepera*), black-tailed godwit (*Limosa limosa islandica*), whimbrel (*Numenius phaeopus*), and Eurasian wigeon (*Anas penelope*).

- Invertebrate assemblage.
- The marine habitats notified for management include intertidal mud and sand flats, which support a wide variety of marine invertebrates and represent an important food source for many fish and bird species. Coastal saltmarshes, which provide habitat for invertebrates and act as important nursery sites for several fish species, as well as refuge, feeding and breeding grounds for wading birds and wildfowl (English Nature, 2005).

The Conservation Objectives of the Bridgwater Bay SSSI, relevant to this report, are to maintain the sediment and water quality of the intertidal mud and sand flats and prevent disturbance to birds (English Nature, 2005).

3.5 Functionally linked habitat

Mobile species may rely on habitat outside of the designated site they are features of and there is a requirement for this to be considered within the HRA (Natural England, 2021). The description of activities detailed in Section 2 demonstrates that potential effects are constrained to the marine environment and highly localised around the discharge source. There will be no loss of habitat or physical disturbance associated with the activities. It is plausible that the water column could be impacted by discharges and therefore consideration should be given to migratory fish which may pass through the area.

There are two SACs up-stream of the Bridgwater Bay area which are designated for migratory fish; the River Usk/ Afon Wysg SAC and River Wye/ Afon Gwy SAC. Both are >40 km from the location of the activities. Both sites are designated for migratory fish including sea lamprey, river lamprey, twaite shad and Atlantic salmon. Given the highly localised effect areas described in Section 2, it is highly unlikely that migratory fish will encounter any effects associated with the discharges, and if they did, exposure would be limited to the brief period of passage. Furthermore, all the relevant species for the River Usk/ Afon Wysg SAC and River Wye/ Afon Gwy are considered within the assessments of the related local designated sites (i.e. sea lamprey, river lamprey, twaite shad and Atlantic salmon are assessed within the sections below, either in their own right, or as part of the wider typical fish assemblage). Therefore, it is not considered necessary to scope these distant designated sites into the HRA.

4 Likely Significant Effect (LSE) 'Alone' assessment

4.1 Pressures

In accordance with the HRA guidance (Defra, *et al.* 2021), the first stage of the HRA is to determine if there are any plausible LSE on the features of the designated sites as a result of the activities. LSE is a coarse filter intended to identify the proposed plans and projects which have the potential to significantly affect a designated feature or conservation objective and therefore require further investigation. For any identified LSE pathways an AA stage is a more detailed assessment to determine if adverse effects on site integrity can be ruled out beyond reasonable scientific doubt.

A proposal, alone or in combination with other proposals (see Section 9 for in-combination effects), could cause a significant effect on a European site if there's:

- a reduction in the amount or quality of designated habitats or the habitats that support designated species;
- a limit to the potential for restoring designated habitats in the future;
- a significant disturbance to the designated species;
- disruption to the natural processes that support the site's designated features; and/or
- only reduction or offset measures in place

Possible LSE from the discharge activities were assessed in relation to the effect categories (or pressures) stated by Natural England/Countryside Council for Wales in their Regulation 33(2a) advice for the Severn Estuary SPA, SAC and Ramsar Site (Natural England/Countryside Council for Wales, 2009).

The effect categories (pressures) are:

1. Physical loss
2. Physical damage
3. Non-physical disturbance
4. Toxic contamination
5. Non-toxic contamination
6. Biological disturbance

High level screening based on the nature of the activity (i.e., discharges of effluent to sea) can determine which of these categories/pressures are relevant and which can be screened out on the basis of no viable pathway (i.e. there is no mechanism for the pressure category to result for the proposed activity):

1. **Physical loss** – No physical removal of habitat or species is proposed. Neither is deposition of material proposed, which lead to smothering of habitats and species. No pathway exists between the activity and effect and the effect category is not considered further.

2. **Physical damage to habitat** – For example flow rates or changes to wave exposure suspended sediment levels or abrasion of habitats. No physical damage to estuarine habitats is predicted. No pathway exists between the activity and effect and the effect category is not considered further.

3. **Non-physical disturbance –** For example through noise or visual disturbance – No noise or visual disturbance is predicted from the jetty discharge. No pathway exists between the activity and effect and the effect category is not considered further.

4. **Toxic contamination –** For example by introduction of synthetic and/or non-synthetic compounds or radionuclides – Potentially toxic levels of metals from groundwater discharges, TBM chemicals, and commissioning chemicals may occur. This pressure cannot be screening out on the basis of pathway alone.

5. **Non-toxic contamination –** For example including nutrients, thermal regime, turbidity, salinity or oxygenation – Non-toxic inputs of DIN will occur and therefore this pressure cannot be screened out on the basis of pathway alone.

6. **Biological disturbance** – For example by selective extraction (e.g. selective extraction of species, introduction of pathogens or non-native species) – No biological disturbance is predicted. No pathway exists between the activity and effect and the effect category is not considered further.

Following initial screening of potential effects pathways, two categories; toxic contamination and non-toxic contamination are taken forward into the LSE assessment for some discharge elements. Other categories are excluded on the basis of no viable pathway. The following sections provide a summarised LSE screening with signposting to further details, where required.

4.2 LSE for groundwater and treated sewage discharges

Table 4.1 presents the LSE screening for the groundwater and treated sewage discharges as described in Section 2.2.1. Cross references in the table signpost to further evidence where necessary.

The assessment accounts for each of the effect categories outlined in Natural England/Countryside Council for Wales (2009) in relation to the designated features of the Severn Estuary/ Môr Hafren SAC/SPA/Ramsar Site and Bridgwater Bay SSSI.

Table 4.1: LSE assessment for Groundwater and Sewage Discharges.

Designated feature	Physical loss of habitat	Physical damage to habitat	Non-physical disturbance	Toxic contamination	Non-toxic contamination	Biological disturbance
SAC Annex I Habitats and supporting habitats for species listed under SPA, Ramsar and SSSI designations						
Estuaries	No pathway	No pathway	No pathway	No LSE (Section 5.2.1)	No LSE (Section 5.1)	No pathway
Estuaries sub-feature – Hard Substrate Habitats (including *Corallina*)	No pathway	No pathway	No pathway	No LSE (Section 0)	No LSE (Section 5.1)	No pathway
Mudflats and Sandflats not covered by seawater at low tide	No pathway	No pathway	No pathway	No pathway (Section 5.2.2)	No pathway (Section 5.1)	No pathway
Atlantic salt meadows (*Glauco-Puccinellietalia maritimae*)	No pathway	No pathway	No pathway	No pathway (Section 5.2.3)	No pathway (Section 5.1)	No pathway
Sandbanks which are slightly covered by seawater all the time	No pathway	No pathway	No pathway	No pathway (Section 5.2.4)	No pathway (Section 5.1)	No pathway
Reefs (including *Sabellaria*)	No pathway	No pathway	No pathway	No LSE (Section 5.2.5)	No LSE (Section 5.1)	No pathway
SAC Annex II Species and species listed under SPA, Ramsar and SSSI designations						
Migratory Fish and Fish Assemblage all species detailed in Section 3 unless otherwise stated	No pathway	No pathway	No pathway	No LSE (Section 5.2.8)	No LSE (Section 5.1)	No pathway
Birds: all species detailed in Section 3 unless otherwise stated (including indirect food-web effects):	No pathway	No pathway	No pathway	No LSE (Section 5.2.9)	No LSE (Section 5.1)	No pathway
Marine Invertebrate Assemblages as a food source for birds and fish (SSSI notification) including: Lagoon sea slug (*Tenellia adspersa*), Mud shrimp (*Corophium lacustre*), Lagoon sand shrimp (*Gammarus insensibilis*)	No pathway	No pathway	No pathway	No LSE (Section 5.2.7)	No LSE (Section 5.1)	No pathway

4.3 LSE for Tunnelling Discharges

Table 4.2 presents the LSE screening for the tunnelling discharges as described in Section 2.2.2. Cross references in the table signpost to the evidence base where necessary.

The assessment accounts for each of the effect categories outlined in Natural England/Countryside Council for Wales (2009) in relation to the designated features of the Severn Estuary/ Môr Hafren SAC/SPA/Ramsar Site and Bridgwater Bay SSSI.

Table 4.2: LSE assessment for Tunnelling Discharges

Designated feature	Physical loss of habitat	Physical damage to habitat	Non-physical disturbance	Toxic contamination	Non-toxic contamination	Biological disturbance
SAC Annex I Habitats and supporting habitats for species listed under SPA, Ramsar and SSSI designations						
Estuaries	No pathway	No pathway	No pathway	No LSE (Section 6.1.1)	No pathway	No pathway
Estuaries sub-feature – Hard Substrate Habitats (including *Corallina*)	No pathway	No pathway	No pathway	No LSE (Section 6.1.6)	No pathway	No pathway
Mudflats and Sandflats not covered by seawater at low tide	No pathway	No pathway	No pathway	No pathway (Section 6.1.2	No pathway	No pathway
Atlantic salt meadows (*Glauco-Puccinellietalia maritimae*)	No pathway	No pathway	No pathway	No pathway (Section (6.1.3)	No pathway	No pathway
Sandbanks which are slightly covered by seawater all the time	No pathway	No pathway	No pathway	No pathway (Section 6.1.4	No pathway	No pathway
Reefs (including *Sabellaria*)	No pathway	No pathway	No pathway	No LSE (Section 6.1.5)	No pathway	No pathway
SAC Annex II Species and species listed under SPA, Ramsar and SSSI designations						
Migratory Fish and Fish Assemblage all species detailed in Section 3 unless otherwise stated	No pathway	No pathway	No pathway	No LSE (Section 6.1.8)	No pathway	No pathway
Birds: all species detailed in Section 3 unless otherwise stated (including indirect food-web effects):	No pathway	No pathway	No pathway	No LSE (Section 6.1.9)	No pathway	No pathway
Marine Invertebrate Assemblages as a food source for birds and fish (SSSI notification) including: Lagoon sea slug (*Tenellia adspersa*), Mud shrimp (*Corophium lacustre*), Lagoon sand shrimp (*Gammarus insensibilis*)	No pathway	No pathway	No pathway	No LSE (Section 6.1.7)	No pathway	No pathway

4.4 LSE for Construction and Cold Commissioning Discharges

Table 4.3 presents the LSE screening for the cold commissioning discharges (including overlapping groundwater and treated sewage discharges) as described in Section 2.2.3. Cross references in the table signpost to the evidence base where necessary.

The assessment accounts for each of the effect categories outlined in Natural England/Countryside Council for Wales (2009) in relation to the designated features of the Severn Estuary/ Môr Hafren SAC/SPA/Ramsar Site and Bridgwater Bay SSSI.

Table 4.3: LSE assessment for Construction and Cold Commissioning Discharges.

Designated feature	**Physical loss of habitat**	**Physical damage to habitat**	**Non-physical disturbance**	**Toxic contamination**	**Non-toxic contamination**	**Biological disturbance**
SAC Annex I Habitats and supporting habitats for species listed under SPA, Ramsar and SSSI designations						
Estuaries	No pathway	No pathway	No pathway	No LSE (Section7.2.1)	No LSE (Section 7.1)	No pathway
Estuaries sub-feature – Hard Substrate Habitats (including *Corallina*)	No pathway	No pathway	No pathway	No LSE (Section 7.2.6)	No LSE (Section 7.1)	No pathway
Mudflats and Sandflats not covered by seawater at low tide	No pathway	No pathway	No pathway	No pathway (Section 7.2.2)	No pathway (Section 7.1)	No pathway
Atlantic salt meadows (*Glauco-Puccinellietalia maritimae*)	No pathway	No pathway	No pathway	No pathway (Section 7.2.3)	No pathway (Section 7.1)	No pathway
Sandbanks which are slightly covered by seawater all the time	No pathway	No pathway	No pathway	No pathway (Section 7.2.4)	No pathway (Section 7.1)	No pathway
Reefs (including *Sabellaria*)	No pathway	No pathway	No pathway	No LSE (Section 7.2.5)	No LSE (Section 7.1)	No pathway
SAC Annex II Species and species listed under SPA, Ramsar and SSSI designations						
Migratory Fish and Fish Assemblage all species detailed in Section 3 unless otherwise stated	No pathway	No pathway	No pathway	No LSE (Section 7.2.8)	No LSE (Section 7.1)	No pathway
Birds: all species detailed in Section 3 unless otherwise stated (including indirect food-web effects):	No pathway	No pathway	No pathway	No LSE (Section 7.2.9)	No LSE (Section 7.1)	No pathway
Marine Invertebrate Assemblages as a food source for birds and fish (SSSI notification) including: Lagoon sea slug (*Tenellia adspersa*), Mud shrimp (*Corophium lacustre*), Lagoon sand shrimp (*Gammarus insensibilis*)	No pathway	No pathway	No pathway	No LSE (Section 7.2.7)	No LSE (Section 7.1)	No pathway

5 Groundwater and treated sewage evidence base

5.1 Evidence base supporting LSE assessment for 'Non-Toxic Contamination'

Freshwater inputs have the potential to alter the salinity and thermal environment of the receiving waters. Discharges will be at ambient temperature thus no thermal effects are predicted. Continuous monitoring data collected off Hinkley Point between 16 December 2008 to 8 April 2009 showed a range of salinities from 22 to over 30 (BEEMS Technical Report TR186). The influence of a small volume of freshwater discharged within the transitional waters of the Severn Estuary is not predicted to have an effect the salinity regime. At slack water a localised buoyant plume of lower salinity water will occur in proximity to the jetty which will be rapidly mixed during the flood and ebb tide. No LSE on designated receptors is predicted.

The jetty discharge will release DIN into the estuary. Under the Water Framework Directive Standards, the Bridgwater Bay waterbody has 'Good' status for DIN. Discharges result in a very localised elevation in DIN in the receiving waterbody and the initial screening test was passed (Section 2.2.1). The average annual uplift from the jetty discharge during year 1 was estimated at 0.36 µmol l^{-1} relative to mean annual concentration of 75 µmol l^{-1} within Bridgwater Bay and so 'Good' status is maintained (BEEMS Technical Report TR428). Due to the high turbidity, productivity in the Severn is light-limited (Underwood, 2010) and therefore effects from DIN or phytoplankton growth are likely to be negligent. No LSE for DIN discharges are predicted on the designated Severn Estuary features.

5.2 Evidence base supporting LSE assessment for 'Toxic Contamination'

Screening and modelling of potential contaminants which may lead to toxic contamination pressures is described in Section 2.2.1. The characterisation of the discharge showed that while most contaminants could be screened out, zinc and copper required further investigation. Modelling was carried out for zinc as the metal with the greatest EQS exceedance. The sections below detail the results in relation to the features of the designated sites.

5.2.1 Estuaries

The total area defined as Annex I Estuary habitat within the Severn Estuary / Môr Hafren SAC is 73,677.25 ha and dominates the habitat type of the site. Estuary features are also included within the SPA as a supporting habitat for designated birds and under the Ramsar and SSSI notifications.

In the case of zinc, the total sea surface area exceeding the average EQS for the short-term period of maximum discharges during Case C equates to 0.0004 % of the Estuaries SAC feature (Table 5.1).

Longer-term discharges during Case D cause a sea surface area corresponding to 0.0002 % of the SAC estuary area to exceed the zinc EQS (0.1 ha).

Average concentrations of zinc and other contaminants in the buoyant discharge plume are not predicted to exceed the EQS at the seabed.

Due to the small spatial extent of the discharge plume no LSE is predicted for the conservation objectives of the estuary feature.

The spatial distribution of the average seabed and sea surface concentrations of zinc in the discharge plume can be viewed in Figure 5.1 and Figure 5.2, respectively.

Table 5.1: Total area (ha) of the discharge plume in exceedance of the zinc EQS, and the percentage of the designated estuary feature (73,677.25 ha). The EQS is an average annual concentration threshold, at the discharge site the threshold is set at 3.77 µg l^{-1} above background concentrations.

Construction Phase	Area of sea surface exceeding the EQS	% of the SAC estuary feature above the surface EQS threshold	Area of seabed exceeding the EQS
Case C	0.30 ha	0.0004 %	0 ha
Case D	0.125 ha	0.0002 %	0 ha

5.2.2 Mudflats and Sandflats not covered by seawater at low tide

The area of ‘mudflats and sandflats not covered by seawater at low tide’ is located to the east of Hinkley Point, several kilometres[9] away from the jetty discharge site in the shallow intertidal areas. This designated habitat feature is beyond the extent of the discharge plume, accordingly there is no effect pathway.

5.2.3 Atlantic salt meadows (*Glauco-Puccinellietalia maritimae*)

The area of ‘Atlantic salt meadows’ (*Glauco-Puccinellietalia maritimae*) are located to the east of Hinkley Point, several kilometres from the jetty discharge site. The discharge plume does not intersect this habitat and accordingly there is no effect pathway.

5.2.4 Sandbanks which are slightly covered by sea water all the time

The area of ‘sandbanks which are slightly covered by sea water all the time’ is located in the subtidal area, at the mouth of the River Parrett well beyond the extent of the discharge plume. The discharge plume does not intersect this habitat, no further assessment is made and accordingly there is no effect pathway.

5.2.5 Reefs

Intertidal and subtidal biogenic reefs formed by the honeycomb worm *Sabellaria alveolata* and subtidal *S. spinulosa* reefs have been identified in the area of the jetty discharge. Data collected from a number of surveys on the distribution of intertidal and subtidal *Sabellaria* is provided in BEEMS Technical Report TR414.

5.2.5.1 Sabellaria *and zinc discharges*

Subtidal and intertidal *Sabellaria* reef features are not predicted to interact with zinc concentrations exceeding the EQS during the long-term construction phase (Case D, Table 2.1), or during the maximum construction discharges in Case C (BEEMS Technical Report TR428). Table 5.2 summarises the modelling described in BEEMS Technical Report TR428 and shows that with both the mean average concentrations and 95th percentile concentrations there is no exceedance of the EQS predicted at any of the *Sabellaria* locations.

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[9] Magic Maps https://magic.defra.gov.uk/magicmap.aspx feature layer ‘Marine Protected Area Features’.

Table 5.2: Mean and 95%ile zinc concentrations at subtidal *Sabellaria* patches A and E, and intertidal patches B, C, D, F, and G for month-long model simulations for long-term operations during Case D and maximum discharges during Case C. The EQS for zinc is 6.8 µg $l^{-1}$and the background concentration is 3.03 µg l^{-1} resulting in an adjusted threshold of 3.77 µg l^{-1}. No exceedance of the EQS is predicted at any location.

Feature	**Seabed µg l^{-1} (Mean)**		**Seabed µg l^{-1} (95%ile)**	
	Case D	**Case C**	**Case D**	**Case C**
Subtidal *Sabellaria* A (Easting 321350 Northing 147040)	0.03	0.14	0.09	0.20
Intertidal *Sabellaria* B (Easting 320800 Northing 146694)	0.10	0.24	0.23	0.54
Intertidal *Sabellaria* C (Easting 320300 Northing146351)	0.10	0.24	0.20	0.47
Intertidal *Sabellaria* D (Easting 319118 Northing 16309)	0.10	0.23	0.22	0.53
Subtidal *Sabellaria* E (Easting 320800 Northing 146800)	0.10	0.22	0.28	0.65
Intertidal *Sabellaria* F (Easting 321824 Northing146800)	0.11	0.25	0.23	0.55
Intertidal *Sabellaria* G (Easting 321529 Northing146793)	0.11	0.27	0.24	0.56

Potential for bioaccumulation effects

Similar to many polychaetes, *Sabellaria* has been shown to be resilient to high zinc concentrations. Rubal *et al.* (2014) recorded the presence of *S. alveolata* as an important contributing taxon at two impacted sites, where zinc concentrations of ≤10 µg l^{-1} and over 40 µg l^{-1} were measured. Copper is present at lower concentrations than zinc in the groundwater and failed the initial screening by a smaller margin (Table 2.2), accordingly elevated concentrations of copper that *Sabellaria* will be exposed to will be considerably lower than that of zinc. Polychaetes have been shown to be relatively tolerant to copper contamination with No Observable effect concentration (NOEC) > 10 µg l^{-1} reported from several studies (WFD-UKTAG, 2012b). See Section 7.2.7 for further details on invertebrate tolerance to copper and zinc.

The modelling assesses the potential for the *Sabellaria* feature to interact with zinc in solution within the plume. However, zinc, and other contaminants, may also interact with benthic communities through adsorption of dissolved metals onto particulate material within the water column. Subsequent deposition during periods of low energy may result in contaminants becoming available for benthic biota, including *Sabellaria*. Zinc is known to accumulate in UK estuarine sediments including in the Severn Estuary and deposition of particulate metals forms an important part of sediment loading. However, the strong hydrodynamic nature of the Severn Estuary and high levels of turbidity mean that contaminated sediments are mixed and dispersed over large areas rather than concentrating near point source discharges (Langston *et al.,* 2003). Furthermore, the mean concentration of zinc in the discharge plume interacting with the seabed (Figure 5.1) and the overlying surface waters (Figure 5.2) at the position of the *Sabellaria* patches is orders of magnitude below the EQS. Polychaete species are relatively tolerant to sediment-bound zinc, with tissue concentrations either independent or weakly related to sediment concentrations, suggesting a regulatory ability (Bryan & Langston, 1992). As such, no LSE is predicted in relation to discharges of zinc (and by extension other metals).

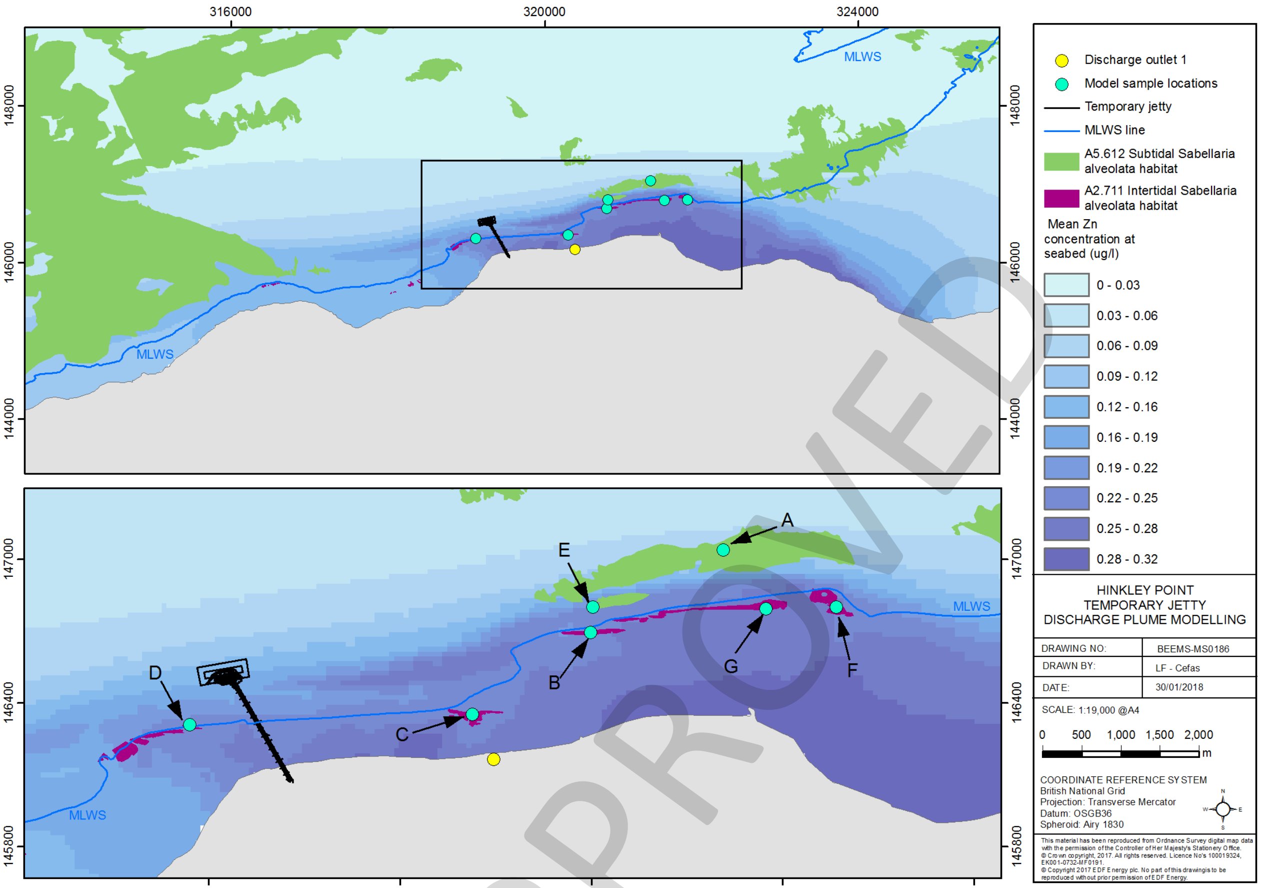

Figure 5.1: The spatial distribution of the discharge plume showing the mean seabed concentration of zinc (µg l^{-1}) during the maximum construction phase discharges, Case C (worst-case). The distribution of *Sabellaria* is delineated and the location of subtidal *Sabellaria* patch A and E, and intertidal *Sabellaria* patches B, C, and D, F and G are marked. The EQS reference value for zinc is 3.77 µg l^{-1} above background concentrations.

5.2.6 Hard Substrate Habitats

Modelling was completed to identify the potential for the discharge plume to interact with the hard substrate habitats on the rock platform where *Corallina officinalis* waterfalls and *Sabellaria alveolata* reefs occur.

Whilst the tide is the primary mode of transport and dilution of the plume, wind forcing from the north has the potential to push the plume in a southerly direction where it may have a greater probability of interacting with the hard substrate features. To account for this, modelling incorporated wind scenarios from the month of November 2008. The selected month had both the highest proportion of northerly winds, and the highest percentage of days with average wind speeds in exceedance of 5 – 15 m s^{-1} from N and NW directions. Therefore, results can be considered a worst-case scenario of real weather conditions.

5.2.6.1 *Corallina* waterfalls

Corallina waterfalls have been identified as features of interest on the rocky intertidal platform (BEEMS Technical Report TR256). Tidal transport results in the spatial extent of the plume extending further in an along-shore, east-west direction with limited north-south dispersion (Figure 5.2).

None of the *Corallina* waterfalls are predicted to be exposed to areas of the discharge plume that exceed the EQS (Figure 5.2). Indeed, during Case C (Table 2.1), the mean seabed concentration is estimated to increase by only approximately 1 % of the adjusted EQS threshold at each of the eight *Corallina* locations.

When the maximum seabed zinc concentration modelled (100%ile) is considered, the highest concentration of zinc is 1.50 µg l^{-1} at position 2 (refer to Appendix D for locations) are well below the 3.77 µg l^{-1} adjusted EQS threshold (see Table 7 in BEEMS Technical Report TR428). Therefore, no LSE are anticipated on the *Corallina* waterfalls.

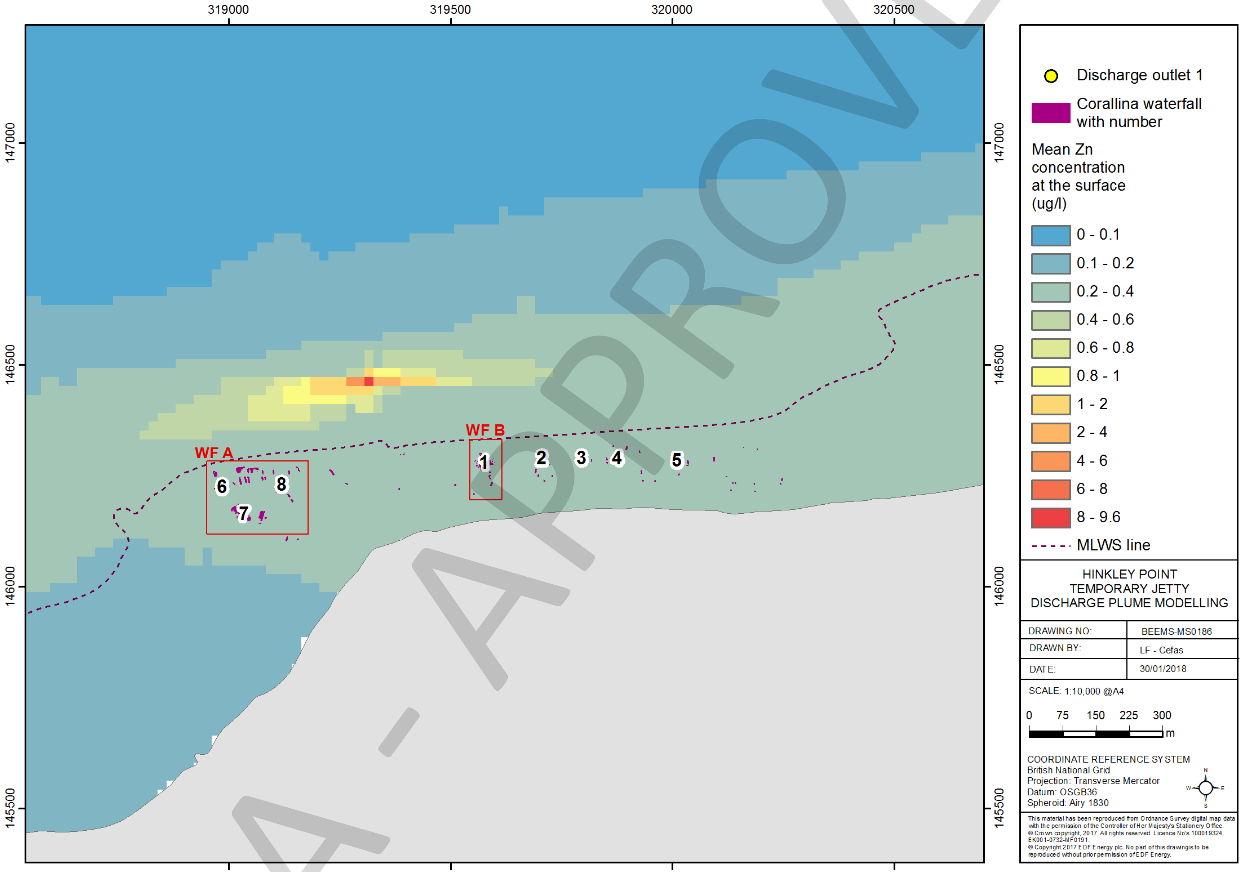

Figure 5.2: The spatial distribution of the discharge plume showing average surface concentrations of zinc for Case C in relation to the *Corallina* features. The plot shows concentrations above background levels, as such the EQS reference value is 3.77 µg l^{-1} and is exceed in a small area by the discharge itself. *Corallina* waterfalls positions are labelled 1 – 8, the two waterfall locations identified as being at risk from the jetty construction are boxed as Waterfall A and Waterfall B.

5.2.7 Marine Invertebrate Assemblages (as a food source for fish and birds)

Marine invertebrates form an important part of the diet of estuary fish and designated species of birds. Food web-effects have the potential to be mediated through reductions in prey availability resulting from toxicity or through bioaccumulation of contaminants within invertebrate prey tissues, which is subsequently biomagnified up the food web. Both impact pathways are considered in relation to fish and designated bird species.

5.2.7.1 Benthic Invertebrates

The effect of the plume on benthic invertebrates is the primary consideration for food-web effects for two reasons; firstly area-restricted benthic invertebrates are most likely to have the greatest exposure time to the discharges and, secondly, intertidal benthic invertebrates make up a major contributory component of the diet of designated bird species (Table 10.2). Designated fish species have the potential to be susceptible to indirect food-web effects should subtidal invertebrate prey be exposed to toxicological effects. Designated bird species, however, feed intertidally (and not subtidally), meaning there is no impact pathway between birds and subtidal invertebrates. The quality of intertidal areas as feeding habitats for birds and fish varies within the region of HPC (Section 5.2.9), however, all intertidal areas provide potential feeding habitats for designated fish and bird species and are therefore considered.

Direct Toxic Effects

The discharge plume is buoyant and the EQS for zinc is not predicted to be exceeded at the seabed. As such, there is no pathway for direct toxicological effects on benthic marine invertebrates and no predicted food-web LSE.

Bioaccumulation of Contaminants

There is the potential for contaminant-bound particles to settle out of suspension and enter benthic food-webs. Indeed, important bioavailable sources of zinc for benthic organisms include sediment-bound phases, zinc dissolved in interstitial water and in the overlying waterbody (Bryan and Langston, 1992). The extreme tidal range in the Severn Estuary results in dynamic mixing of contaminant-bound sediment particles (Langston *et al*., 2003).

Intertidal feeding habitats are not predicted to come into contact with waterborne concentrations of zinc, or indeed copper, above the EQS (Sections 5.2.5 and 0). Furthermore, many benthic invertebrates are able to regulate tissue zinc concentrations (Bryan and Langston, 1992), and bioaccumulation and biomagnification of zinc up the food chain is considered to be low level (WFD-UKTAG, 2012a). Given that discharge metal concentrations do not exceed the EQS on the seabed it is predicted that effects from metal discharges on benthic invertebrates will be negligible.

Fish feeding on benthic invertebrates along with intertidal feeding waterfowl are not predicted to incur significant food-web effects from accumulation of metal contaminants originating from the jetty discharge plume.

5.2.7.2 Epi-benthic crustaceans

Sampling of crustaceans during the Comprehensive Impingement Monitoring Programme (CIMP) at HPB between 2009 – 2010 and 2021 – 22 showed high abundances and biomass of shrimp species, particularly *Crangon crangon* and *Pasiphaea* spp. (BEEMS Technical Report TR129 and BEEMS Technical Report TR573). Epi-benthic species of shrimp such as *C. crangon, Pasiphaea* spp. and *Pandalus montagui* are important prey items for many species of fish and designated birds such as redshank (see section 7.2.9; and Table 10.2 Appendix C).

Direct Toxic Effects

C. crangon feeds on the intertidal mudflats at Bridgwater Bay at high water (Henderson *et al*., 2006). The discharge plume does not exceed the EQS on the seabed. The epi-benthic feeding mode of *C. crangon* and other shrimp species means that it is highly unlikely that the population of this important prey species will be directly affected by jetty discharges as they would not be exposed to direct toxic effects.

Bioaccumulation of Contaminants

As discussed above, important intertidal feeding habitats are not predicted to come into contact with metal concentrations above the EQS. Thus, there is no pathway for bioaccumulation resulting from metal discharges in mobile epi-benthic crustaceans.

5.2.7.3 Summary of food-web effects

The concentrations of metal contaminants coming into contact with important intertidal feeding areas is predicted to be low relative to background conditions and considerably below the EQS. No chronic toxicity is predicted preventing negative impacts on invertebrate populations. In addition, the dynamic sediment environment, coupled with the ability of many species to regulate zinc, and the lack of biomagnification up the food-chain, indicates that food-web effects will be minimal. It is therefore highly unlikely that the predicted discharges of zinc (and copper) will have food-web LSE on designated fish species or the assemblages as a whole or intertidal feeding birds within the estuary.

5.2.8 Migratory Fish and Wider Typical Fish Assemblage

Small areas of the sea surface are predicted to exceed the EQS for zinc during constructions phases Case C and longer-term Case D (Figure 5.1). The likelihood of the protected fishes (allis and twaite shad, river and sea lamprey, eel, salmon and sea trout) being exposed to the toxic contaminants in the discharge plume is considered to be extremely low. The worst-case discharge zone above the zinc EQS of 0.30 ha or 0.0004% of the SAC at the surface, forms either a narrow ribbon or a localised fan on the surface of the flood or ebb tide. Given that these migratory fishes are highly mobile animals, any individuals swimming locally to the discharge plume are unlikely to remain in the plume for any length of time and so potential exposure times are likely to be small.

Small numbers of adult eels migrate seawards past Hinkley Point in January and February and juveniles are present in low numbers in the vicinity of the HPB cooling water inlets to the east of the discharge site for virtually all of the year. Given the extreme tidal range and the high tidal velocities in the Severn, it is considered likely that the migratory adults and glass eels and the small number of resident juveniles would all transit past the discharge zone with the tide in a matter of minutes. Neither river nor sea lamprey appears to have a high abundance in the Hinkley Point area, being absent from the BEEMS fish characterisation surveys (BEEMS Technical Report TR-S200) and impinged only intermittently at HPB (BEEMS Technical Report TR573). Adult lampreys migrate up-estuary to spawn and juveniles down-estuary to feed. However, both species are parasitic, so their dispersion is controlled by the movements of their hosts, which are likely to be distributed widely through the estuary.

Of the designated species, twaite shad are present in the Severn catchment area and are observed during the 2009 – 2010 HPB CIMP (BEEMS Technical Report TR129) and in the 2021 – 22 HPB CIMP (BEEMS Technical Report TR573). Much as they are in the UK as a whole, allis shad are rare in the local area. Juveniles do use estuaries as nursery grounds, but (i) allis shad are extremely rare, (ii) there is no reason to suspect that either species would be concentrated in the area around the discharge zone, and, in any case, (iii) they are sufficiently mobile that they would not remain in the plume for any length of time.

Salmon are relatively rare in the Hinkley Point area and sea trout considered very rare in the locality. Moreover, both species use the estuary for migration only and, if they were to swim close to the shore, are likely to pass by the discharge zone in a very short period of time.

Of the wider fish assemblage, during the 2009 – 2010 HPB CIMP, 64 species were observed, seven species accounted for the top 95 % of annual impingement. These were sprat, whiting, Dover sole, Atlantic cod, thin-lipped grey mullet, European flounder, and five-beard rockling (BEEMS Scientific Position Paper SPP112). During the 2021 – 22 CIMP, 62 species were observed, ten species accounted for the top 95 % of annual impingement. These were sprat, Atlantic herring, whiting, sand gobies of the genus *Pomatoschistus* spp. Dover sole, poor cod, five-beard rockling, thin-lipped grey mullet, common sea snail and bib. Sprat was the most abundance species (BEEMS Technical Report TR573). The small spatial extent of the buoyant plume, coupled with the motility of the fish species indicates the proportion of the population exposed to areas in excess of the EQS is likely to minimal, and exposure times extremely brief. It is therefore considered highly unlikely that discharges of metal contaminants will have a LSE on the wider typical fish assemblage.

Potential for bioaccumulation

The chronic zinc NOEC for fish, used in combination with values for other species to determination of the saltwater EQS, is 25 µg l^{-1} indicating that fish are less susceptible to zinc than other species used in the assessment (WFD-UKTAG, 2012a). The situation is the same for copper, with normalised species mean NOEC concentrations for fish (~55 µg l^{-1}) higher than many invertebrate or algae values (WFD-UKTAG, 2012b). Both zinc and copper NOEC concentrations for fish are higher than those predicted at the point of discharge from the jetty and potential exposure times to fish migrating within the estuary are predicted to be very brief (Figure 5.2).

Chronic accumulation of metals in the organs of yellow perch transplanted from a reference site to a mining impacted lake (7.85 µg l^{-1} of bioavailable Zn^{2+}) showed zinc marginally increased in the gills and kidneys but not in the gut or liver despite 100-fold increases in background concentrations (Kraemer *et al*., 2005). Noël-Lambot (1981) showed that eels presented with high metals concentrations had the capability of excreting mucus corpuscles enriched with cadmium, zinc and copper and proposed the findings as a potential mechanism for protection against hazardous levels of contamination.

The limited spatial extent of the discharge plume means that fish using the estuary as a migratory pathway will have limited exposure probabilities. Should individual fish encounter the plume, exposure times are likely to be brief. Furthermore, fish have homeostatic capabilities to regulate essential metal concentrations, thus even in the worst-case scenario of some fish species being attracted by the jetty structure, significant toxicological effects are not anticipated. As such, no LSE are predicted.

5.2.9 Bird Assemblages

This section of the report builds on the assessment made in section 5.2.7 and considers the indirect effects of discharges on specific bird assemblages in the Severn Estuary, mediated through food-web interactions. Direct toxicological effects of exposure to contaminant metals are not predicted to have an impact pathway and are therefore not further assessed.

To establish the potential for discharges to affect the prey species of foraging birds, an understanding of their feeding modes, diet and distribution in relation to the discharge is a prerequisite. Table 10.2 in Appendix C, provides a summary of the dietary composition of species included in the SPA, Ramsar and SSSI designations and identifies the species that rely on intertidal feeding areas.

Analysis of winter Wetland Bird Survey (WeBS) data[10] (November 2002 to February 2003) by the Environment Agency showed that the intertidal foreshore on the HPC frontage is visited by wigeon, curlew and redshank. Whilst these species are observed at the HPC foreshore, densities were higher on intertidal habitats to the east of HPC (Environment Agency, 2012). An intertidal bird survey commissioned at the foreshore at Hinkley Point and to the mudflat habitats to the east also indicated that the most important local foraging resources are located on the Steart mudflats to the east of Hinkley Point B (Entec, 2011). Shelduck have been recorded on the foreshore in very low numbers, whilst large numbers of moulting birds have been

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[10] Wetland Bird Survey Data | BTO - British Trust for Ornithology.

observed in July rafting, typically 500 m offshore near the proposed temporary jetty site (Amec, 2011). The potential for disturbance of the jetty construction and operational phases on shelduck has been considered through the HRA process elsewhere (see MMO, 2010).

Accordingly, of the designated species that feed on intertidal invertebrates and algae, only shelduck, wigeon, and redshank may be susceptible to food-web effects arising from discharge contamination as low densities of these species occur in the intertidal areas close to the discharge. However, discharge modelling showed that intertidal areas are subject to only marginal increases in zinc concentration, and copper discharges are considerably smaller (Figure 5.1). Indeed, average seabed increases in zinc concentration at the eight *Corallina* locations on the HPC foreshore were very minor (1 % of EQS). Accumulation of metal contaminants from the jetty discharge plume is likely to be negligible across the important Steart mudflat foraging areas to the east of Hinkley Point. Furthermore, bioaccumulation and biomagnification of zinc (and by extension other metals) up the food chain is considered to be low level (WFD-UKTAG, 2012a).

No LSE are predicted on the food sources of designated bird assemblages in Bridgwater Bay.

6 Tunnelling (conditioning chemicals) discharges evidence base

6.1 Evidence base supporting LSE assessment for 'Toxic Contamination'

6.1.1 Estuaries

The discharge plume for BASF Rheosoil 143 and Condat CLB F5/M has the same buoyant, tidally forced behaviour as for zinc, as is described in Section 2.2.2.

For the sea surface concentration, in Case D (Table 2.1), modelling predicted that the mean concentration of BASF Rheosoil 143 at the sea surface will exceed the PNEC (EQS) (40 µg l^{-1}) for an area of 0.19 ha. This equates to 0.0003 % of the Estuaries SAC feature. The average sea surface concentrations of Condat CLB F5/M exceeded the PNEC (EQS) threshold (4.5 µg l^{-1}) for an area of 1.0 ha, or 0.0013 % of the Estuaries SAC feature (Table 6.1).

For the seabed concentration the average concentration of BASF Rheosoil 143 and Condat CLB F5/M is not predicted to exceed the PNEC (EQS) at the seabed.

Due to the small spatial extent of the discharge plume no LSE is predicted for the conservation objectives of the estuary feature.

Table 6.1: Total area of the discharge plume in exceedance of the PNEC (proxy EQS). The EQS is an average annual concentration threshold, at the discharge site the threshold is 40 µg l^{-1} for BASF Rheosoil 143 and 4.5 µg l^{-1} for Condat CLB F5/M.

Discharged chemical	Area of exceedance at surface	Area of exceedance at bed
BASF Rheosoil 143	1875 m^2 (0.19 ha)	0
Condat CLB F5/M	10,000 m^2 (1 ha)	0

6.1.2 Mudflats and Sandflats not covered by seawater at low tide

This designated habitat feature is beyond the extent of the discharge plume, accordingly there is no effect pathway and the receptor is not considered for further assessment.

6.1.3 Atlantic salt meadows (*Glauco-Puccinellietalia maritimae*)

The discharge plume does not intersect this habitat, there is therefore no pathway and no further assessment is made.

6.1.4 Sandbanks which are slightly covered by sea water all the time

The area of 'sandbanks which are slightly covered by sea water all the time' is located in the subtidal area, at the mouth of the River Parrett beyond the extent of the discharge plume. There is no pathway and no further assessment is made.

6.1.5 Reefs

Intertidal and subtidal biogenic reefs formed by the honeycomb worm *Sabellaria alveolata* and subtidal *S. spinulosa* reefs have been identified in the area of the jetty discharge (see Section 5.2.5).

6.1.5.1 Sabellaria and TBM discharges

The model simulation predicts the mean concentration of BASF Rheosoil 143 and Condat CLB F5/M to be well below the average EQS concentration at the seabed for all *Sabellaria* reef features (Table 6.1). Of the labelled features, intertidal *S. alveolata* located at position G will be exposed to the highest mean seabed concentrations of both Condat CLB F5/M (0.97 µg l^{-1}) and BASF Rheosoil 143 (2.90 µg l^{-1}), equating to 21 % and 7 % of the EQS thresholds respectively. Figure 6.1 shows the average seabed concentration of the Condat CLB F5/M plume as it is closer to the PNEC (proxy EQS) value than BASF Rheosoil 143.

Due to the strong tidal forcing at the site, transient concentration peaks were also investigated using model simulations to determine the potential for acute toxic effects. The 95%ile concentrations of the month-long simulation were below the EQS for both chemicals, at all the positions investigated (Figure 6.2). As with the mean concentration, the 95%ile values were all below the PNEC (proxy EQS) levels (Table 6.2).

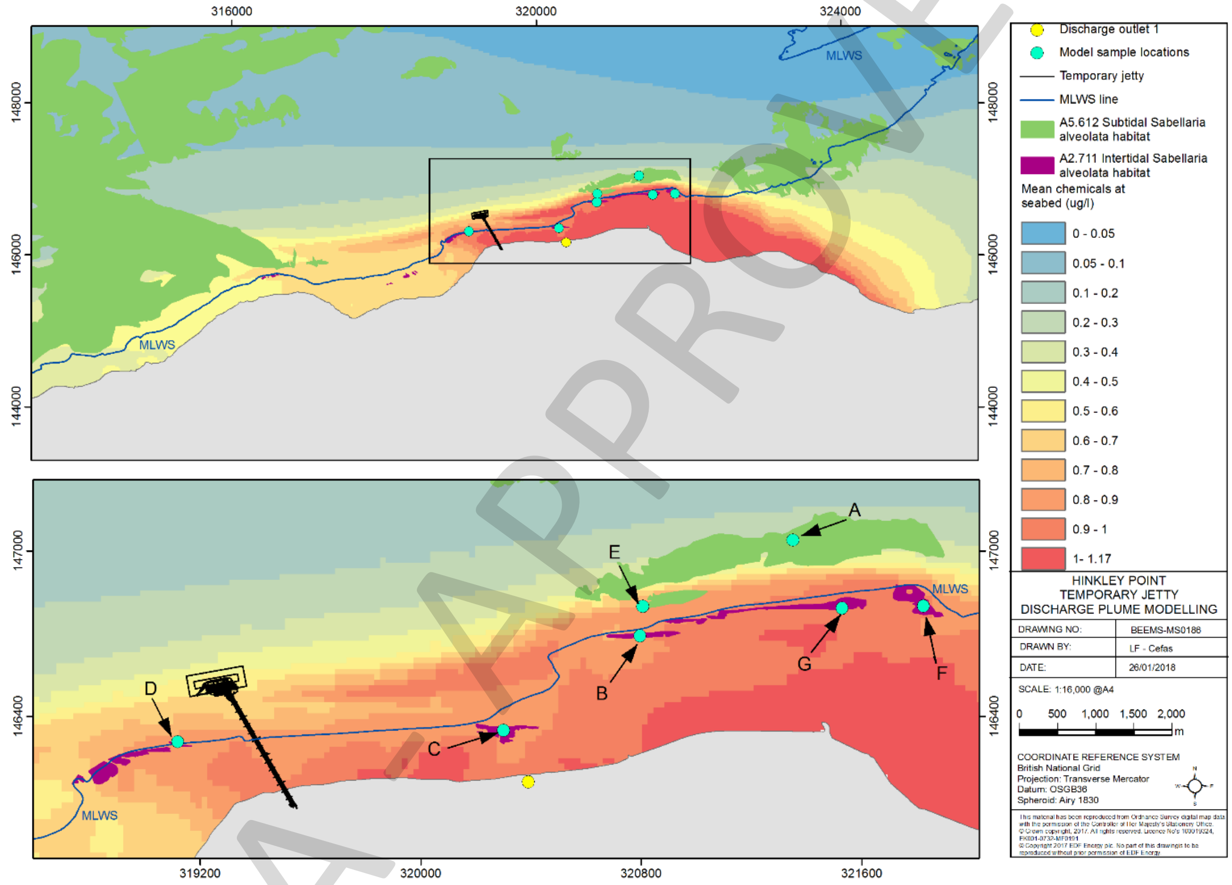

Figure 6.1: The spatial distribution of the discharge plume showing average (mean) seabed concentration of Condat CLB F5/M (µg l^{-1}) for Case D. The locations of *Sabellaria* features are delineated. Subtidal *Sabellaria* patches A and E and intertidal *Sabellaria* patch B, C, and D, F, and G are marked. The maximum scale of the plot is 1.7 µg l^{-1} whilst the PNEC (proxy EQS) for Condat CLB F5/M is 4.5 µg l^{-1} and therefore all contours are below the PNEC.

Table 6.2: Mean and 95%ile seabed concentrations of TBM ground conditioning chemicals, BASF Rheosoil 143 and Condat CLB F5/M, at subtidal *Sabellaria* patches A, E and intertidal *Sabellaria* patches B, C and D, F, and G. The coordinates of the *Corallina* feature with the greatest exposure is also displayed.

Feature	**Mean seabed concentration (µg l^{-1})**		**95%ile seabed concentration (µg l^{-1})**	
	Condat CLB F5/M (PNEC/EQS 4.5 µg l^{-1}).	BASF Rheosoil 143 (PNEC/EQS 40 µg l^{-1})	Condat CLB F5/M (PNEC/EQS 4.5 µg l^{-1}).	BASF Rheosoil 143 (PNEC/EQS 40 µg l^{-1})
Subtidal *Sabellaria* A Easting 321350 Northing 147040	0.53	1.58	0.74	2.21
Intertidal *Sabellaria* B Easting 320800 Northing 146694	0.87	2.60	1.96	5.87
Intertidal *Sabellaria* C Easting 320300 Northing146351	0.86	2.57	1.70	5.10
Intertidal *Sabellaria* D Easting 319118 Northing 16309	0.84	2.52	1.93	5.79
Subtidal Sabellaria E Easting 320800 Northing 146800	0.79	2.37	2.37	7.12
Intertidal *Sabellaria* F Easting 321824 Northing146800	0.91	2.73	1.99	5.96
Intertidal *Sabellaria* G Easting 321529 Northing146793	0.97	2.90	2.03	6.09
Corallina Position 5 Easting 320010 Northing 146285	0.94	2.84	2.01	6.01

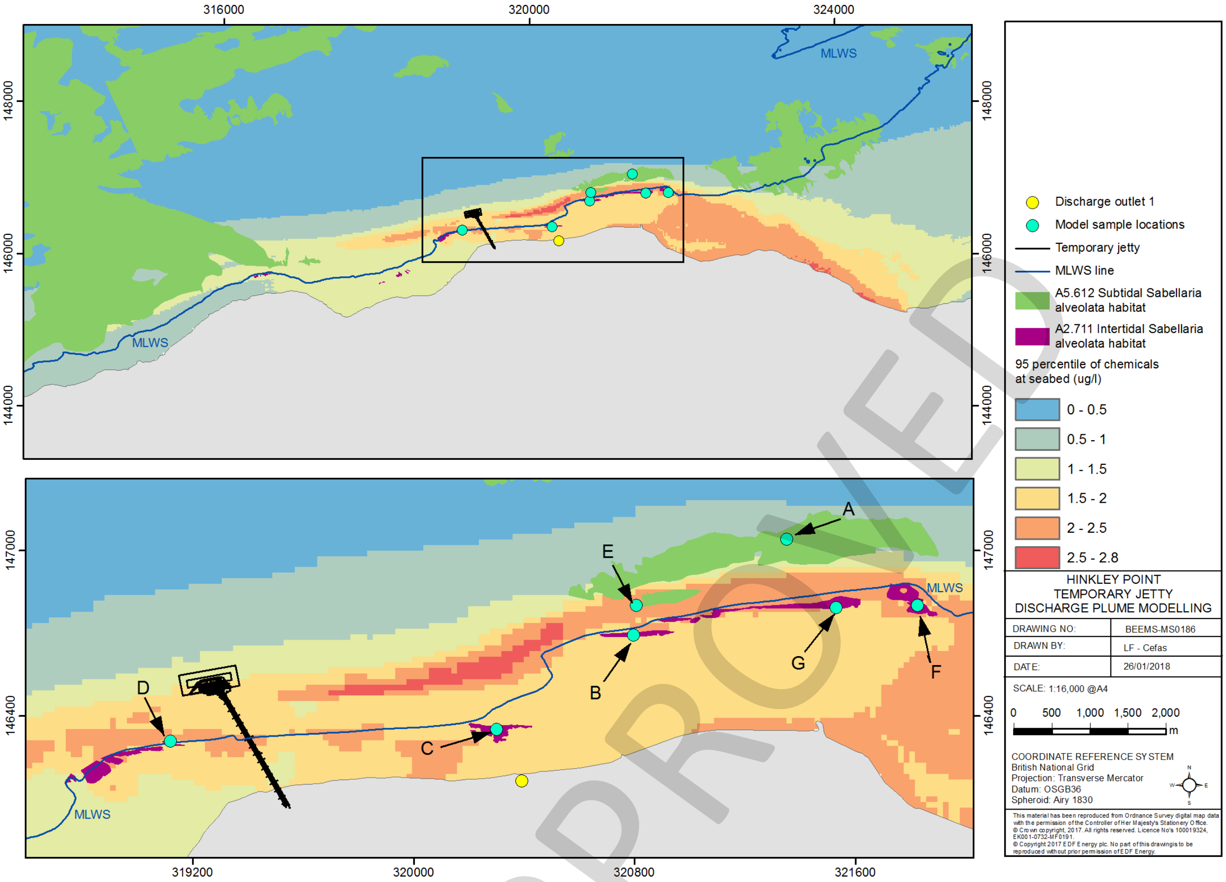

Figure 6.2: The 95%ile for seabed concentrations of Condat CLB F5/M (µg l^{-1}). The locations of *Sabellaria* features are delineated. Subtidal *Sabellaria* patches A and E and intertidal *Sabellaria* patch B, C, and D, F, and G are marked. The PNEC (proxy EQS) for Condat CLB F5/M is 4.5 µg l^{-1} and therefore all contours shown are below the PNEC.

As a further precautionary approach, the maximum (100%ile) concentration was considered for *Sabellaria* patch G, the location of the highest average exposure concentrations. A time-series of the data at patch G is shown in Figure 6.3 which shows no exceedance of the PNEC (proxy EQS) at any time.

Accordingly, no chronic or acute toxic effects to the *Sabellaria* features are predicted as a result of discharges of tunnelling compounds, therefore no LSE are considered to occur.

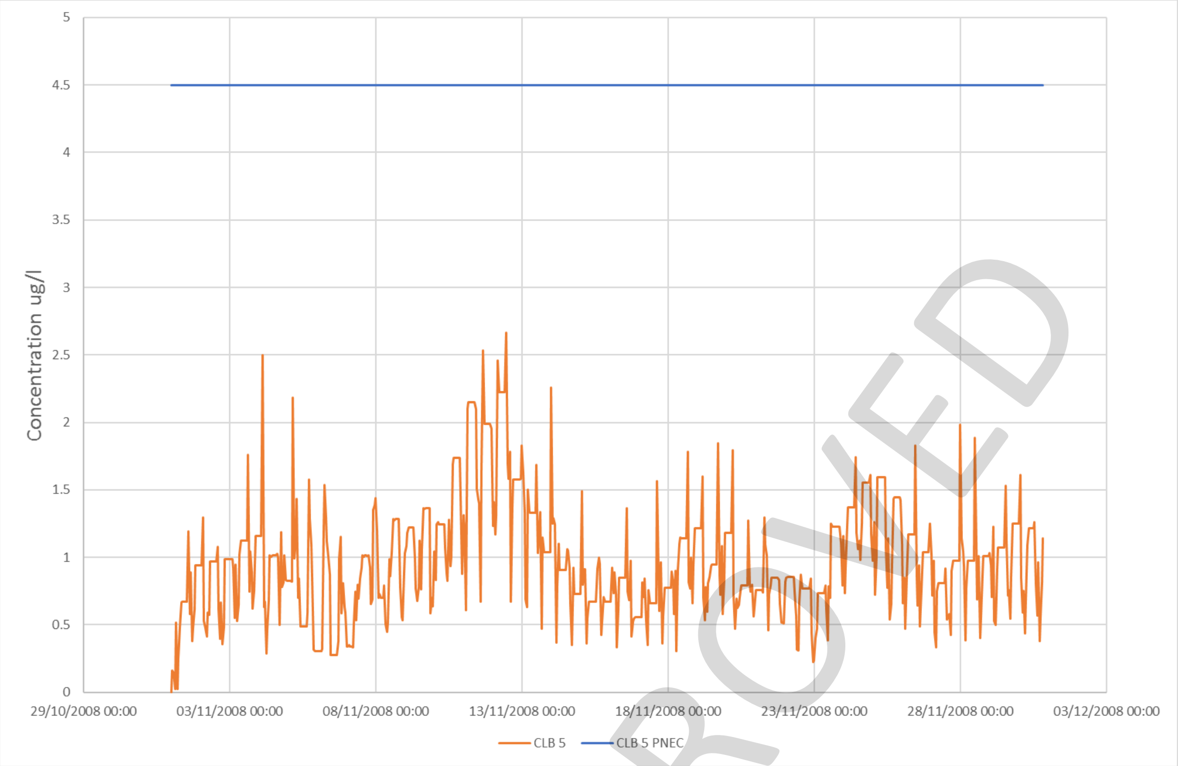

Figure 6.3: Concentration time series of Condat CLB F5/M at location G (µg l^{-1}) showing the proxy EQS of 4.5 µg l^{-1} (PNEC).

6.1.6 Hard Substrate Habitats

6.1.6.1 *Corallina* waterfalls

Similar to the *Sabellaria* results, modelling predicted no exceedance of the EQS value for average concentrations of either BASF Rheosoil 143 or Condat CLB F5/M at the *Corallina* features. The along-shore profile of the plume results in *Corallina* experiencing lower seabed concentrations of contaminants than *Sabellaria* patches to the east of the discharge. *Corallina* features at location 5 are exposed to the highest mean concentrations of both Condat CLB F5/M (0.94 µg l^{-1}) and BASF Rheosoil 143 (2.01 µg l^{-1}), equating to ~ 21 % and <~ 5 % of the EQS thresholds respectively (Table 6.2).

No LSE are predicted on the hard substrate habitats as a result of discharges of tunnelling compounds under the proposed discharge scenarios.

6.1.7 Marine Invertebrate Assemblages (as a food source)

6.1.7.1 Benthic Invertebrates

The buoyant plume is mixed downwards on the flood tide resulting in higher average seabed concentration areas occurring to the east of the jetty in intertidal areas above mean low water spring (MLWS) tides (Figure 6.2). Mean and 95%ile concentrations are not predicted to exceed the PNEC (proxy EQS) for BASF Rheosoil 143 and Condat CLB F5/M at the seabed and therefore no effects on benthic features are expected.

Given that the model predicts no excess of the PNEC (EQS) no effects on marine invertebrates are predicted. Therefore, no LSE on invertebrate food as a prey source for designated birds and fish are predicted in relation to the tunnelling discharges.

6.1.8 Migratory Fish and wider fish assemblages

The area of sea surface that exceeds the EQS is 1.0 ha and 0.19 ha for Condat CLB F5/M and BASF Rheosoil 143, respectively. As discussed in Section 5.2.8 above, twaite shad are present in the Severn catchment area and are observed during the 2009 – 2010 HPB CIMP (BEEMS Technical Report TR129) and in the 2021 – 22 HPB CIMP (BEEMS Technical Report TR573).

The small spatial area of the plume in exceedance of the EQS indicates very few designated fish would be exposed to toxic levels of contamination. The location of the discharge is not a bottleneck in the migration path and therefore fish will have the ability to avoid exposure. Furthermore, the motility of migratory fish means exposure time, should the plume be encountered, is likely to be very brief and exposure concentrations at source are below levels where acute toxicity occurs (Figure 6.4). As such, LSE due to direct toxicity can be excluded.

Of the wider fish assemblage, during the 2009 – 2010 HPB CIMP, 64 species were observed, seven species accounted for the top 95 % of annual impingement. These were sprat, whiting, Dover sole, Atlantic cod, thin-lipped grey mullet, European flounder, and five-beard rockling (BEEMS Scientific Position Paper SPP112). During the 2021 – 22 CIMP, 62 species were observed, ten species accounted for the top 95 % of annual impingement. These were sprat, Atlantic herring, whiting, sand gobies of the genus *Pomatoschistus* spp. Dover sole, poor cod, five-beard rockling, thin-lipped grey mullet, common sea snail and bib. Sprat was the most abundance species (BEEMS Technical Report TR573). The spatial extent of the buoyant plume is small and any potential exposure time is likely to be brief. It is therefore considered highly unlikely that discharges of TBM contaminants will have a significant effect on the wider fish assemblage.

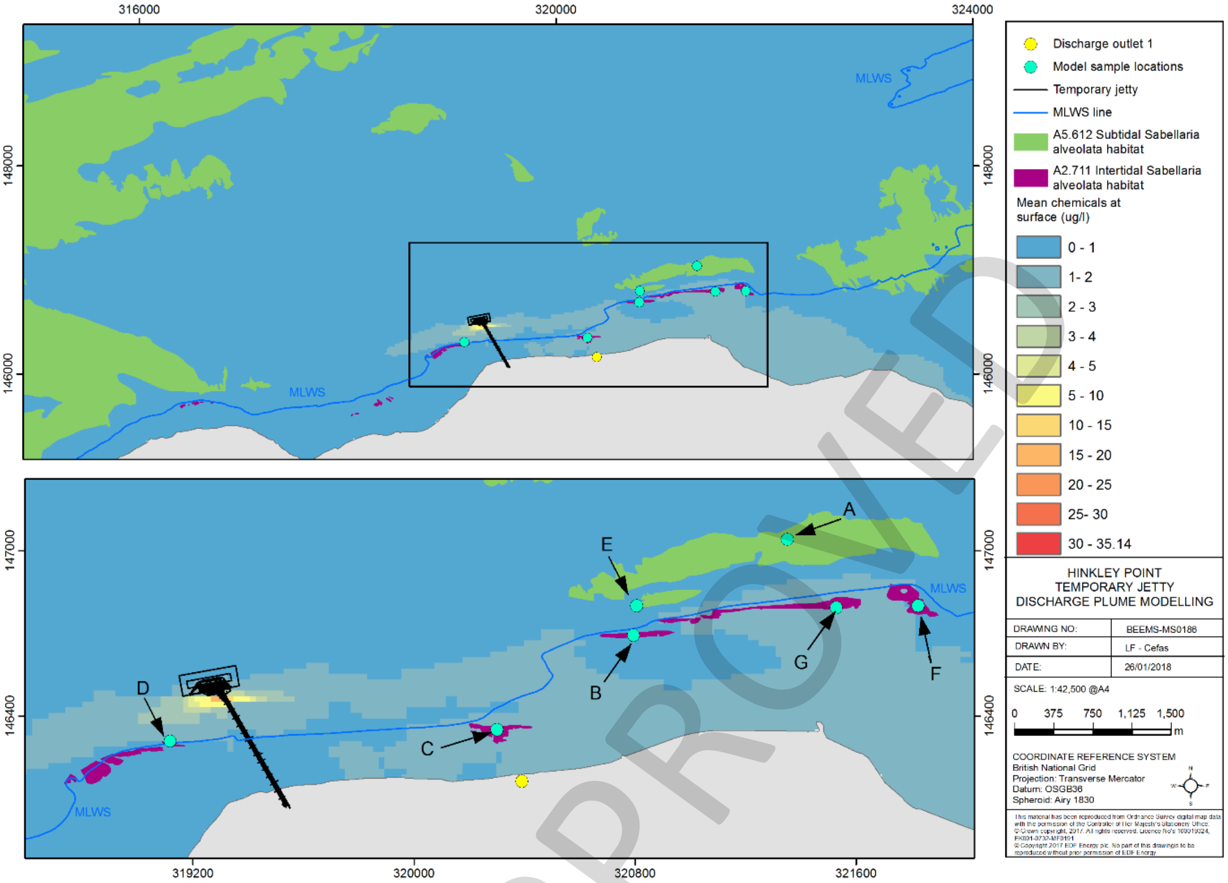

Figure 6.4: The spatial distribution of the discharge plume showing average sea surface concentration of Condat CLB F5/M (µg l^{-1}) during Case D. The EQS for Condat CLB F5/M is 4.5 µg l^{-1}.

As discussed in Section 6.1.7, no toxicological effects on invertebrate taxa inhabiting intertidal feeding areas are predicted. Accumulation of surfactants in the tissue of invertebrate prey has the potential to affect fish foraging in the exposed intertidal areas. However, bioaccumulation data for surfactants is sparse. Surfactant bioconcentration is influenced by water physico-chemistry and the structure of the compound, waterborne surfactants can be taken up across the gills and may be biotransformed or excreted (Tolls *et al*., 1994). Alkyl ether sulphates are readily taken up by fish, however metabolism and elimination are also rapid, leading Madsen *et al*. (2001) to conclude that bioconcentration does not occur.

As such, no LSE are predicted to occur in response to tunnelling discharges on the designated fish species in the estuary.

6.1.9 Bird Assemblages

Intertidal feeding bird species are not predicted to be exposed to direct toxicological impacts from surfactants as no effect pathway exists. Shelduck, present a potential exception, as moulting birds have been observed in July rafting 500 m offshore near the proposed temporary jetty site (Amec, 2011). The occurrence of birds near the discharge area presents a potential impact pathway as surfactants may impede the natural water repelling properties of their feathers. Evidence of the impact of surfactants on the waterproofing properties of feathers is primarily derived from studies of detergent use on oiled birds for which the effective concentrations of surfactant for oil removal are typically of the order of milligrams per litre. For example, Duerr *et al*., 2009 demonstrated that a concentration of 12 mg l^{-1} of dispersant containing anionic surfactants caused disruption of feather structure. Such concentrations are well above the model predictions at the immediate vicinity of the jetty discharge (Figure 6.4). Surface concentrations rapidly reduce falling to below the 4.5 µg l^{-1} EQS for Condat CLB F5/M within 1 ha and the 40 µg l^{-1} EQS for BASF Rheosoil within 0.19 ha. Accordingly, the concentration of surfactants present in the jetty discharge are considered insufficient for effective surfactant properties to operate and hence for significant removal of natural oil from feathers. Therefore, no direct LSE on shelduck are predicted.

The primary intertidal foraging areas for designated birds are located to the east of HPB on the Steart mudflats. These important foraging areas are not exposed to concentrations of surfactants that exceed the EQS at any time.

The potential for bioaccumulation of surfactants in invertebrates and subsequent biomagnification in birds is unknown. However, given the surfactants are not predicted to have an effect on invertebrate prey and the PNEC (proxy EQS) levels are not exceed at the seabed at any time, LSE are considered to be highly unlikely.

7 Cold Commissioning plus Construction discharges evidence base

7.1 Evidence base supporting LSE assessment for 'Non-Toxic Contamination'

Wastewater inputs have the potential to alter the salinity and thermal environment of the receiving waters. Discharges will be at ambient temperature thus no thermal effects are predicted. Continuous monitoring data collected off Hinkley Point between 16 December 2008 to 8 April 2009 showed a range of salinities from 22 to over 30 (BEEMS Technical Report TR186). The influence of a small volume of relatively lower conductivity wastewater discharged within the transitional waters of the Severn Estuary is not predicted to affect the salinity regime. At slack water, a localised buoyant plume of lower salinity water will occur in proximity to the jetty which will be rapidly mixed during the flood and ebb tide. No LSE on designated receptors are predicted.

The jetty discharge will release DIN and phosphorus into the estuary. Under the WFD Standards, the Bridgwater Bay waterbody has a 'Good' status for DIN (in 2022). Discharges result in a very localised elevation in DIN in the receiving waterbody, which passed the initial screening test (see Table 10.1 in Appendix B).

The total loading due to DIN and phosphorus was considered using a combined phytoplankton and macroalgal model. Results of the model output show that there is no difference between the Bridgwater Bay reference case or the HPC construction/cold commissioning run for either phytoplankton production or for macroalgae so 'Good' status is maintained (BEEMS Technical Report TR428). The DIN and ammoniacal nitrogen contributions from the CWW discharge (Case F, Table 2.1) are indicated[11] to be very small at around a half of that for the groundwater and so the concentration in the combined discharge is likely to be relatively unchanged or slightly lower than that already assessed (BEEMS Technical Report TR428).

Due to the high turbidity environment and productivity in the Severn is light-limited (Underwood, 2010), no LSE for minor DIN and phosphorus loading are predicted on the designated Severn Estuary features and no further assessment is made. In-combination effects of discharges from HPB/HPA and Outlet 12 are considered in Section 9.

7.2 Evidence base supporting LSE assessment for 'Toxic Contamination'

7.2.1 Estuaries

7.2.1.1 Un-ionised ammonia

The total area defined as Annex I Estuary habitat within the Severn Estuary / Môr Hafren SAC is 73,677.25 ha and is the dominant designated habitat type within the site. Estuary features are also included within the SPA as a supporting habitat for designated birds and under the Ramsar and SSSI notifications.

For un-ionised ammonia when considering the combined commissioning and construction/treated sewage discharges, there are no areas of EQS exceedance based on the average results. When considering the 95th percentile results there is no exceedance of the EQS at the seabed, and a very small area of exceedance of 0.2 hectares at the surface, which equates to 0.0003 % of the Estuaries SAC feature (BEEMS Technical Report TR428).

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[11] NNB HPC will provide a cementitious wash water characterisation report as per permit condition PO2 when the required information becomes available. NNB HPC recognise that no discharge can commence under Case F until a submission under PO2 is approved by the EA.

For total ammonia the model output does not show a failure of the MAC EQS for either the mean or the 95th percentile, for either model run and at either the surface or the bed. The annual average EQS was exceeded in the immediate vicinity of the discharge, within 0.04 ha.

Due to the small spatial extent of the discharge plume no LSE is predicted on the SAC Estuaries feature.

7.2.1.2 *Hydrazine*

For hydrazine during commissioning (Case J), there are no areas of EQS exceedance at the seabed for 10 and 15 µg l^{-1} release concentrations. The current permitted maximum hydrazine discharge is 15 µg l^{-1}; however the original modelling considers a higher concentration of 30 µg l^{-1}. For 30 µg l^{-1} at the seabed, the chronic and acute PNEC concentrations were exceeded over an area of 5.98 ha and 1.86 ha, respectively (BEEMS Technical Report TR445), which equates to 0.008% and 0.003% of the Estuaries SAC feature, respectively.

There are larger areas of EQS exceedances at the surface for the 10,15 and 30 µg l^{-1} release concentrations. For the 15 µg l^{-1} the plume for the acute PNEC (95th percentile) was 5.47 ha (0.007% of the Estuaries SAC feature), and for chronic effects (mean) 15.89 ha (0.02% of the Estuaries SAC feature).

For the worst case, 30 µg l^{-1} release concentration, chronic and acute PNEC concentrations were exceeded over an area of 36.63 ha and 14.55 ha, respectively (BEEMS Technical Report TR445), which equates to 0.05% and 0.02% of the Estuaries SAC feature, respectively.

In the context of the more recent Canadian Federal Water Quality Guidelines for hydrazine (Environment Canada, 2013), 200 ng l^{-1}, there is no exceedance in terms of 95th percentile concentrations at the surface or the seabed.

Due to the small spatial extent of the discharge plume no LSE is predicted on the SAC Estuaries feature.

7.2.1.3 *Demineralisation effluent*

Copper, zinc and free chlorine discharged in the demineralisation waste stream are lower relative to the relevant EQS than those modelled for zinc under the groundwater assessment (Section 5) as detailed in NNB GenCo (2024) and as such the zinc assessment in Section 5 represents a worst-case assessment for these substances. Other chemicals associated with cleaning processes were also screened out of further assessment. As such no LSE is predicted based on the assessment results in Section 5.

7.2.2 Mudflats and Sandflats not covered by seawater at low tide

The area of 'mudflats and sandflats not covered by seawater at low tide' is located to the east of Hinkley Point, several kilometres away from the jetty discharge site. This designated habitat feature is greatly beyond the extent of the discharge plume, accordingly there is no effect pathway and the receptor is not considered for further assessment.

7.2.3 Atlantic salt meadows (*Glauco-Puccinellietalia maritimae*)

The area of 'Atlantic salt meadows (*Glauco-Puccinellietalia maritimae*)' and the area of 'mudflats and sandflats not covered by seawater at low tide' are located to the east of Hinkley Point, several km from the jetty discharge site. The discharge plume does not intersect this habitat and no further assessment is made.

7.2.4 Sandbanks which are slightly covered by sea water all the time

The area of 'sandbanks which are slightly covered by sea water all the time' is located in the subtidal area, at the mouth of the River Parrett well beyond the extent of the discharge plume. The discharge plume does not intersect this habitat and no further assessment is made.

7.2.5 Reefs

Intertidal and subtidal biogenic reefs formed by the honeycomb worm *Sabellaria alveolata* and subtidal *S. spinulosa* reefs have been identified in the area of the jetty discharge. Data collected from a number of surveys on the distribution of intertidal and subtidal *Sabellaria* is provided in BEEMS Technical Report TR414.

7.2.5.1 Sabellaria and ammonia discharges

The EQS for un-ionised ammonia is not exceeded at any time at any of the *Sabellaria* locations. As demonstrated in Figure 7.1, the maximum unionised ammonia concentrations experienced at the *Sabellaria* locations is approximately 10 µg l^{-1}, which is less than half of the EQS.

The average and 95th percentile concentrations at each of the *Sabellaria* locations is shown in Table 7.1.

As there is no predicted exceedance of the EQS, LSE can be excluded.

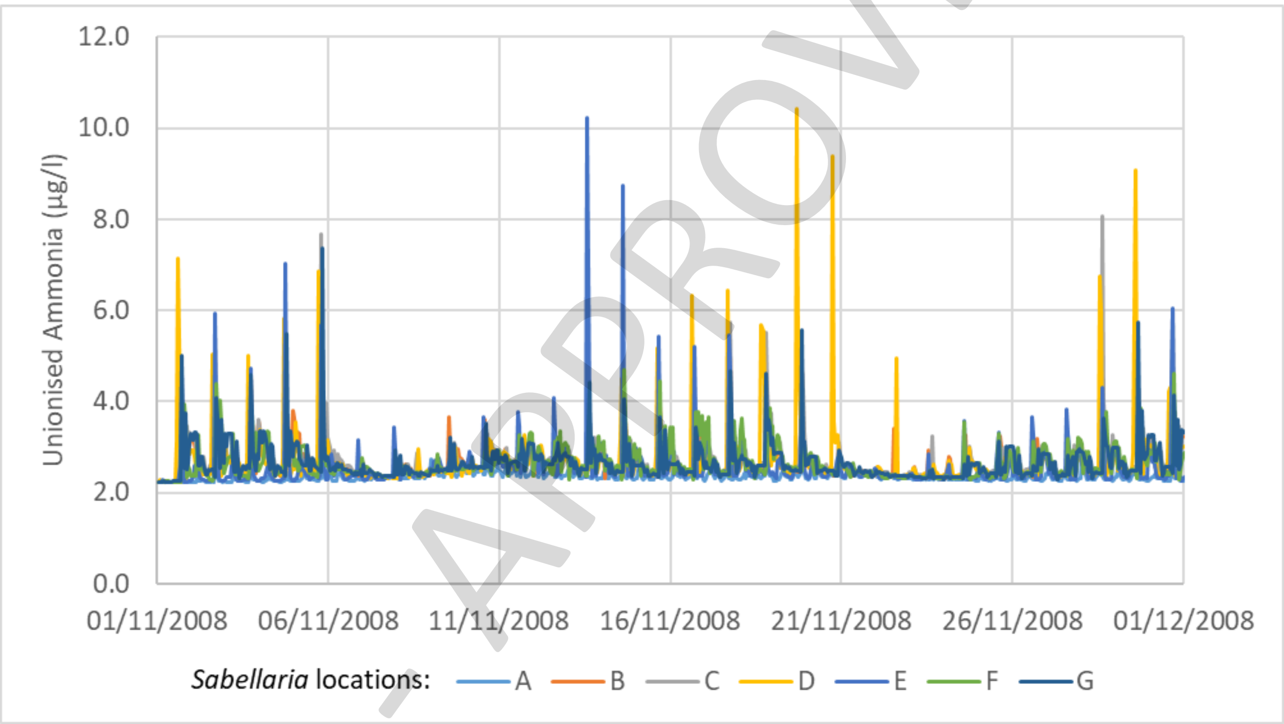

Figure 7.1: Time series of un-ionised ammonia at the locations of *Sabellaria* for the 38 l s^{-1} at 80 mg l^{-1}+70 l s^{-1} at 271 mg l^{-1} scenario using mean conditions of temperature, salinity, and pH. This plot represents an alternative sewage flow rate (described in TR581) but not implemented, and therefore is conservative. The relevant EQS is 21 µg l^{-1}.

Table 7.1: Summary of un-ionised ammonia (µg l^{-1}) at *Sabellaria* features (A – G) for the maximum ammonia scenario (80 mg l^{-1}). The letters correspond to the *Sabellaria* locations in Figure 6.1.

Feature	Mean seabed concentration (µg l^{-1})	95th percentile concentration (µg l^{-1})
Subtidal *Sabellaria* A	2.05	2.22
Intertidal *Sabellaria* B	2.32	2.91
Intertidal *Sabellaria* C	2.40	3.00
Intertidal *Sabellaria* D	2.38	2.88
Subtidal *Sabellaria* E	2.27	2.86
Intertidal *Sabellaria* F	2.34	3.03
Intertidal *Sabellaria* G	2.36	3.03

7.2.5.2 *Sabellaria and hydrazine discharges*

The model results presented in BEEMS Technical Report TR445, show that the discharge forms a thin elongated plume parallel to the shore with concentrations higher at the surface than at the bottom. As the plume is initially buoyant, due to the low salinity release, mixing and dilution mean that no subtidal *Sabellaria* reef was exposed to concentrations above the chronic or acute PNEC with a release concentration of 10 or 15 µg l^{-1}. For the 30 l^{-1} release concentration, at the seabed, the chronic and acute PNEC concentrations were exceeded over an area of 5.98 ha and 1.86 ha respectively (BEEMS Technical Report TR445). Therefore, the recommendation in BEEMS Technical Report TR445 was to reduce the maximum discharge concentration of hydrazine to 15 µg l^{-1} to avoid any interaction with the seabed in terms of chronic mean or acute 95th percentile concentrations and prevent any adverse environmental impacts to the protected *Sabellaria* features. The current permitted maximum hydrazine discharge is 15 µg l^{-1}.

Due to the buoyant nature of the plume, the hydrazine concentration was higher at the surface, for both the mean and 95th percentile. Table 7.2 provides a summary of the area of the plume that exceeds both concentration thresholds. For completeness, not only the chronic and acute PNEC values were included, but also other values between 0.1 and 0.5 ng l^{-1} for the chronic concentrations, and between 1 and 5 ng l^{-1} for the acute concentrations.

In addition to the two PNEC values considered in BEEMS Technical Report TR445, the area exceeding 200 ng l^{-1}, as set by the Canadian Federal Water Quality Guidelines for hydrazine (Environment Canada, 2013), as a maximum concentration and as a 95th percentile have been included.

Table 7.2: Area of the plume at different concentration levels of hydrazine, with a 10,15 and 30 µg l^{-1} release concentration in 5.0 h pulses. Values in bold exceed the respective PNEC concentrations.

Release Concentration	**Threshold**		**ng l^{-1}**	**95th percentile surface (ha)**	**95th percentile seabed (ha)**	**Mean surface (ha)**	**Mean seabed (ha)**
10 µg l^{-1}	Chronic PNEC	<PNEC	0.1			49.94	10.11
			0.2			22.49	2.17
			0.3			13.10	0.00
		>PNEC	**0.4**			**8.87**	**0.00**
			0.5			**6.60**	**0.00**
	Acute PNEC	<PNEC	1	20.33	2.99		
			2	8.67	0.00		
			3	5.06	0.00		
		>PNEC	**4**	**3.82**	**0.00**		
			5	**2.58**	**0.00**		
	Canadian Standard		**200**	**0.00 (95th)**	**0.00 (95th)**		
	Canadian Standard		**200**	**0.62 (max)**	**0.00 (max)**		
15 µg l^{-1}	Chronic PNEC	<PNEC	0.1			71.20	24.04
			0.2			36.63	5.98
			0.3			22.49	2.17
		>PNEC	**0.4**			**15.89**	**0.00**
			0.5			**11.25**	**0.00**
	Acute PNEC	<PNEC	1	31.47	6.71		
			2	14.65	1.96		
			3	8.67	0.00		
		>PNEC	**4**	**5.47**	**0.00**		
			5	**4.64**	**0.00**		
	Canadian Standard		**200**	**0.00 (95th)**	**0.00 (95th)**		
	Canadian Standard		**200**	**1.86 (max)**	**0.00 (max)**		
30 µg l^{-1}	Chronic PNEC	<PNEC	0.1			134.35	73.57
			0.2			71.20	24.04
			0.3			49.94	10.11
		>PNEC	**0.4**			**36.63**	**5.98**
			0.5			**27.65**	**3.61**
	Acute PNEC	<PNEC	1	53.66	20.84		
			2	31.37	6.60		
			3	20.22	2.99		
		>PNEC	**4**	**14.55**	**1.86**		
			5	**11.04**	**0.72**		
	Canadian Standard		**200**	**0.00 (95th)**	**0.00 (95th)**		
	Canadian Standard		**200**	**5.37 (max)**	**0.00 (max)**		

At the *Sabellaria* locations, instantaneous concentrations were predicted to exceed the acute PNEC at locations D and E for the 10 and 15 µg l^{-1} release concentrations (Figure 9 and Figure 15 of BEEMS Technical Report TR445). Exceedances were also predicted at locations B and C with a 30 µg l^{-1} release concentration (Figure 21 of BEEMS Technical Report TR445). At 10 µg l^{-1}, the maximum instantaneous concentration was 12.07 ng l^{-1} and 5.32 ng l^{-1}, at locations D and E respectively, with instantaneous concentrations exceeding the acute PNEC five times over the month at location D and once at location E. At 15 µg l^{-1}, the maximum instantaneous concentration was 18.11 ng l^{-1} and 7.98 ng l^{-1}, respectively at locations D and E, with instantaneous concentrations exceeding the acute PNEC eight times over the month at location D and twice at location E.

Whilst instantaneous concentrations exceeded the acute (4 ng l^{-1}) PNEC, the acute PNEC is normally assessed as the 95th percentile concentration value. Results shown in BEEMS Technical Report TR445, show that neither the chronic (mean monthly concentration) nor acute PNECs are exceeded (or even approached) at any *Sabellaria* locations with any of the three release concentrations, therefore no LSE are anticipated on the *Sabellaria* reef features.

7.2.5.3 Sabellaria and demineralisation discharges

Copper, zinc and free chlorine discharged in the demineralisation waste stream are lower relative to the relevant EQS than those modelled for zinc under the groundwater assessment (Section 5) as detailed in NNB GenCo (2024) and as such the zinc assessment in Section 5 represents a worst-case assessment for these substances. Other chemicals associated with cleaning processes were also screened out of further assessment. As such no LSE is predicted based on the assessment results in Section 5.

7.2.6 Hard Substrate Habitats

Modelling was completed to identify the potential for the discharge plume to interact with the hard substrate habitats on the rock platform where *Corallina officinalis* waterfalls and *Sabellaria alveolata* reefs occur.

Whilst the tide is the primary mode of transport and dilution of the plume, wind forcing from the north has the potential to push the plume in a southerly direction where it may have a greater probability of interacting with the hard substrate features. To account for this, modelling incorporated wind scenarios from the month of November 2008. The selected month had both the highest proportion of northerly winds, and the highest percentage of days with average wind speeds in exceedance of 5 – 15 m s^{-1} from north and northwest directions. Therefore, results can be considered a worst-case scenario of real weather conditions.

7.2.6.1 Corallina waterfalls and ammonia discharges

Corallina waterfalls have been identified as features of interest on the rocky intertidal platform (BEEMS Technical Report TR256). Tidal transport results in the spatial extent of the plume extending further in an along-shore, east-west direction with limited north-south dispersion (Figure 7.2).

Figure 7.2 and Figure 7.3 show the un-ionised and total ammonia discharge plume prediction in relation to the *Corallina* features from Case J.

A detailed time series for un-ionised *ammonia* were assessed for the *Corallina* features and shown in Figure 7.4 and Table 7.3. The values of un-ionised ammonia have been derived using mean temperature, salinity, and pH. No *Corallina* waterfall features are exposed to high level of un-ionised ammonia. Therefore, no LSE are anticipated on the *Corallina* waterfalls.

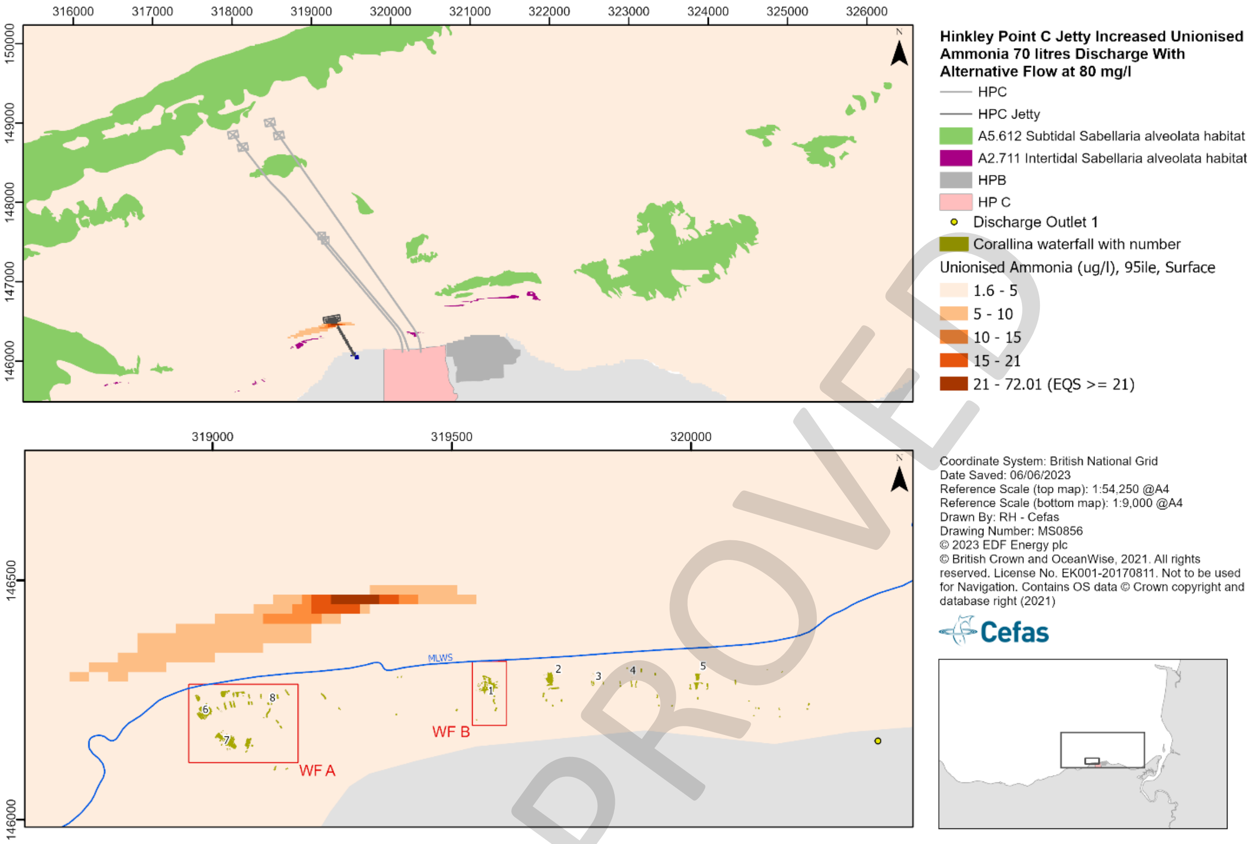

Figure 7.2: Un-ionised Ammonia Surface. 38 l s^{-1} at 80 mg l^{-1}+ 70 l s^{-1} at 271 mg l^{-1}) 95th Percentile. *Corallina* waterfalls are labelled 1 – 8, the two waterfall locations are boxed as Waterfall A and Waterfall B.

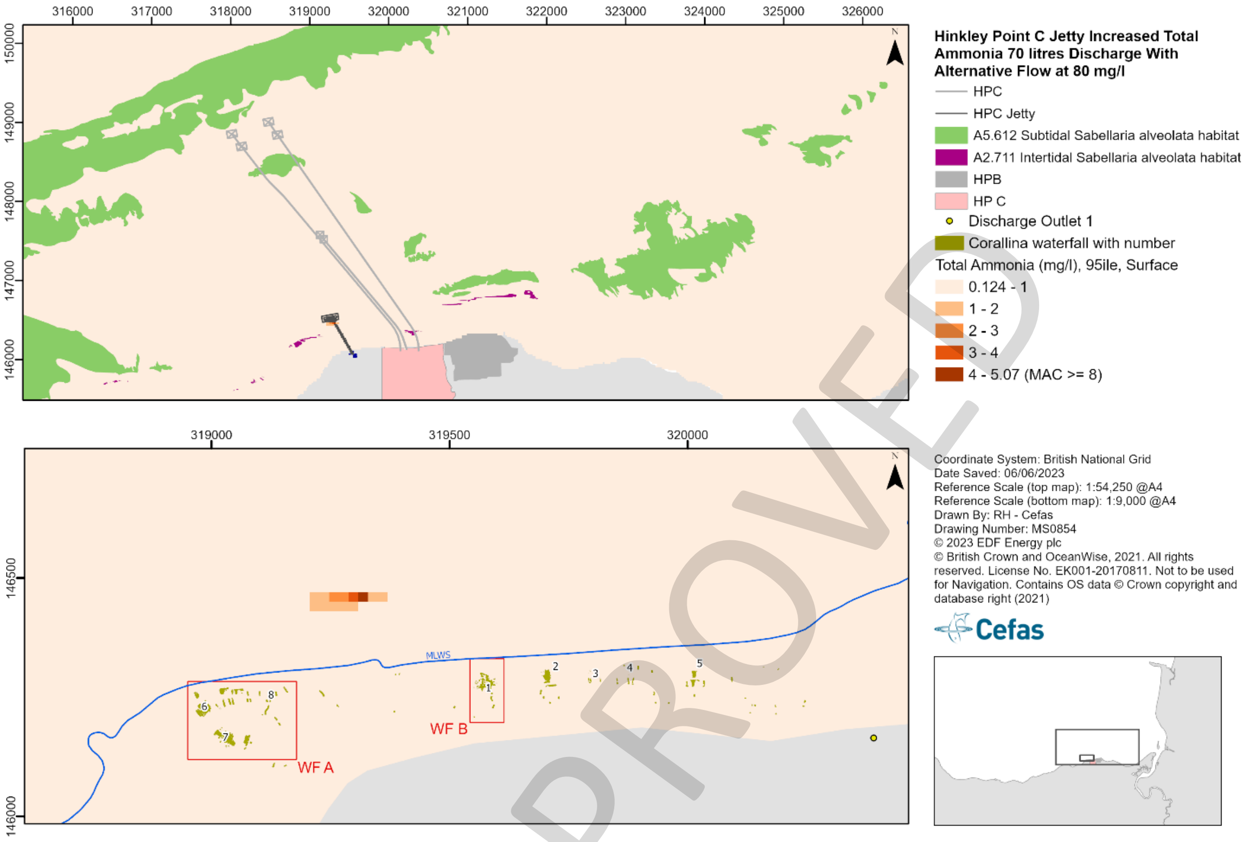

Figure 7.3: Total Ammonia Surface. (38 l s^{-1} at 80 mg l^{-1}+ 70 l s^{-1} at 271 mg l^{-1}) 95th Percentile. *Corallina* waterfalls are labelled 1 – 8, the two waterfall locations are boxed as Waterfall A and Waterfall B.

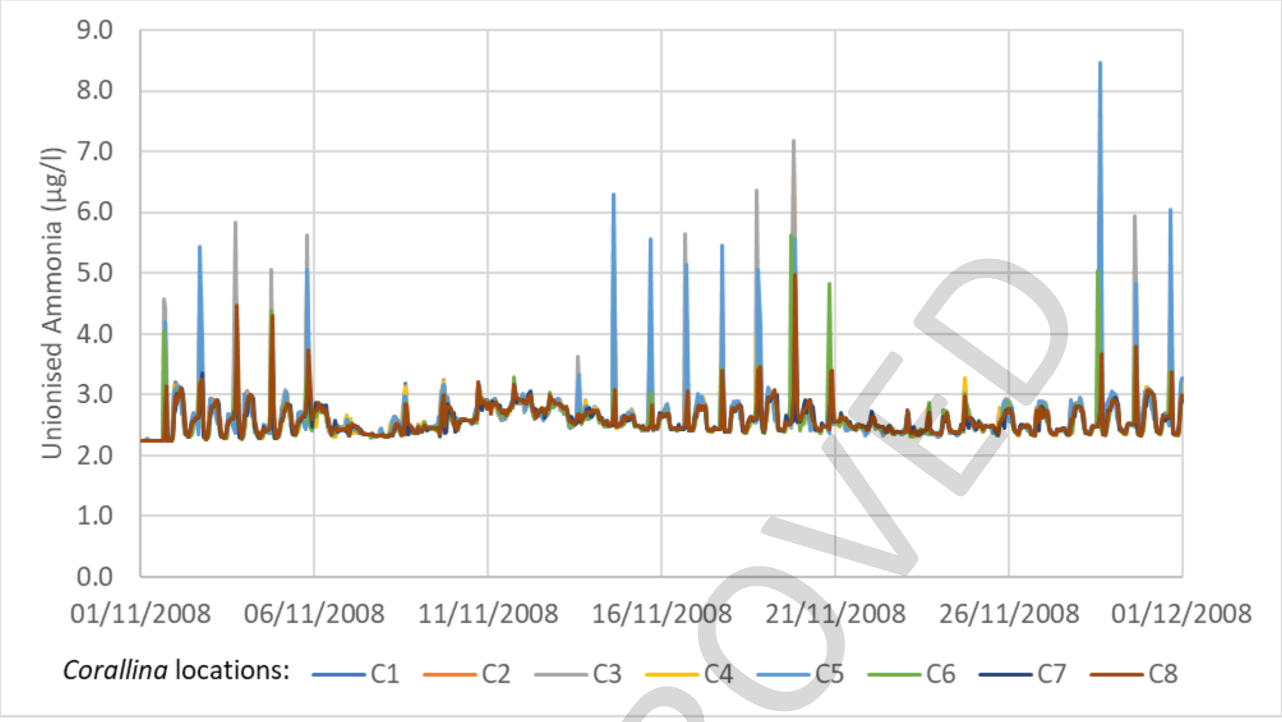

Figure 7.4: Time series of un-ionised ammonia at the locations of *Corallina* for the 38 l s^{-1} at 80 mg l^{-1}+70 l s^{-1} at 271 mg l^{-1}. This plot represents an alternative sewage flow rate (described in TR581) but not implemented, and therefore is conservative. The relevant EQS is 21 µg l^{-1}.

Table 7.3: Summary of un-ionised ammonia (µg l^{-1}) at *Corallina* features (C1 – C8) – numbers correspond to the locations in Figure 7.3. The relevant EQS is 21 µg l^{-1}.

Feature	Mean seabed concentration (µg l^{-1})	95th percentile concentration (µg l^{-1})
Corallina C1	2.28	2.73
Corallina C2	2.33	2.81
Corallina C3	2.33	2.79
Corallina C4	2.30	2.75
Corallina C5	2.34	2.79
Corallina C6	2.29	2.75
Corallina C7	2.27	2.64
Corallina C8	2.30	2.70

7.2.6.2 *Corallina waterfalls and hydrazine discharges*

According to the model results presented in BEEMS Technical Report TR445, the discharge forms a thin elongated plume parallel to the shore with concentrations higher at the surface than at the bottom. There were no areas at the seabed above the chronic or acute PNEC with a release concentration of 10 or 15 µg l^{-1}. For the 30 µg l^{-1} release concentration, at the seabed, the chronic and acute PNEC concentrations were exceeded over an area of 5.98 ha and 1.86 ha, respectively (BEEMS Technical Report TR445). Therefore, the recommendation in BEEMS Technical Report TR445 was to reduce the maximum discharge concentration of hydrazine to 15 µg l^{-1} to avoid any interaction with the seabed in terms of chronic mean or acute 95th percentile concentrations and prevent any adverse environmental impacts to the protected *Corallina* features (the current permitted maximum hydrazine discharge is 15 µg l^{-1}). Table 7.2 provides a summary of the area of the plume that exceeds both concentration thresholds.

The highest maximum instantaneous concentration was at *Corallina* location 6 with 2.49 ng l^{-1}, 3.73 ng l^{-1} and 7.46 ng l^{-1}, for the 10, 15 and 30 µg l^{-1} release concentrations, respectively (Figure 8, Figure 14 and Figure 20 in BEEMS Technical Report TR445). The instantaneous plume was consistently below 4 ng l^{-1} for release concentrations of 10 and 15 µg l^{-1}. At a release concentration of 30 µg l^{-1}, instantaneous concentrations were predicted to exceed 4 ng l^{-1} once at locations 2, 5 and 6 and four times at location 3. However, the duration of the plume above 4 ng l^{-1} was just 1 hour (a single model output time step). This is reflected in the 95th percentile concentrations which shows all concentrations were below the acute PNEC. The highest 95th percentile concentration was at Location 2 with 0.07 ng l^{-1}, 0.11 ng l^{-1} and 0.22 ng l^{-1}, for the three release concentrations, respectively (BEEMS Technical Report TR445).

Whilst instantaneous concentrations exceeded the acute (4 ng l^{-1}) PNEC, the acute PNEC is normally assessed as the 95th percentile concentration value. Results show that neither the chronic (mean monthly concentration) nor acute PNECs are exceeded (or even approached) at any *Corallina* locations with any of the three release concentrations, therefore no LSE are anticipated on the *Corallina* waterfalls.

7.2.6.3 *Corallina waterfalls and demineralisation discharges*

Copper, zinc and free chlorine discharged in the demineralisation waste stream are lower relative to the relevant EQS than those modelled for zinc under the groundwater assessment (Section 5) as detailed in NNB GenCo (2024) and as such the zinc assessment in Section 5 represents a worst-case assessment for these substances. Other chemicals associated with cleaning processes were also screened out of further assessment. As such no LSE is predicted based on the assessment results in Section 5.

7.2.7 Marine Invertebrate Assemblages (as a food source for fish and birds)

Marine invertebrates form an important part of the diet of estuary fish and designated species of birds. Food web-effects have the potential to be mediated through reductions in prey availability resulting from toxicity, and this impact pathway is considered in relation to fish and designated bird species.

7.2.7.1 *Benthic Invertebrates*

The effect of the construction and cold commissioning discharge on benthic invertebrates is the primary consideration for food-web effects for two reasons; firstly area-restricted benthic invertebrates are most likely to have the greatest exposure time and, secondly, intertidal benthic invertebrates make up a major contributory component of the diet of designated bird species (Table 10.2 Appendix C). Designated fish species have the potential to be susceptible to indirect food-web effects should subtidal invertebrate prey be exposed to toxicological effects. Designated bird species, however, feed intertidally (and not subtidally), meaning there is no impact pathway between birds and subtidal invertebrates. The quality of intertidal areas as feeding habitats for birds and fish varies within the region of HPC (Section 7.2.9), however, all intertidal areas provide potential feeding habitats for designated fish and bird species and are therefore considered.

The discharge plume is buoyant and the EQS for ammonia is not predicted to be exceeded at the seabed. There were no areas of exceedance at the bed above the hydrazine chronic or acute PNEC with a release concentration of 10 or 15 µg l^{-1}. For the 30 µg l^{-1} release concentration, at the seabed, the chronic and acute

PNEC concentrations were exceeded over an area of 5.98 ha and 1.86 ha, respectively (BEEMS Technical Report TR445). Therefore, the recommendation in BEEMS Technical Report TR445 was to reduce the maximum discharge concentration of hydrazine to 15 µg l^{-1} to avoid any interaction with the seabed in terms of chronic mean or acute 95th percentile concentrations (the current permitted maximum hydrazine discharge is 15 µg l^{-1}). As such, there is no predicted pathway for direct toxicological effects on benthic marine invertebrates (including the lagoon sea slug, mud shrimp and lagoon sand shrimp) and no significant effects are predicted on food-webs.

7.2.7.2 Epi-benthic crustaceans

Sampling of crustaceans during the CIMP at HPB between 2009 – 2010 and 2021 – 22 showed high abundances and biomass of shrimp species, particularly *C. crangon* and *Pasiphaea* spp. (BEEMS Technical Report TR129, and BEEMS Technical Report TR573). Epi-benthic species of shrimp such as *C. crangon, Pasiphaea* spp. and *P. montagui* are important prey items for many species of fish and designated birds such as redshank (Table 10.2, Appendix C).

C. crangon feeds on the intertidal mudflats at Bridgwater Bay at high water (Henderson *et al*., 2006). The discharge plume does not exceed the EQS or PNEC on the seabed for ammonia and hydrazine respectively and the epi-benthic feeding mode of *C. crangon* and other shrimp species suggests that it is highly unlikely that the population of this important prey species will be directly affected by the construction and cold commissioning discharges.

7.2.7.3 Summary of food-web effects

The concentrations of total ammonia, un-ionised ammonia and hydrazine coming into contact with important intertidal feeding areas is predicted to be low relative to background conditions and within the EQS. No chronic toxicity is predicted preventing negative impacts on invertebrate populations. No food-web LSE are therefore expected from the predicted construction and cold commissioning discharges on designated fish species, on the assemblages as a whole or on intertidal feeding birds within the estuary.

7.2.8 Migratory Fish and Wider Typical Fish Assemblage

There was a small area of exceedance at the surface of the un-ionised ammonia EQS of 0.2 hectares (0.0003 % of the SAC feature 'Estuaries'). The largest or worst case for hydrazine at the surface is for the 30 µg l^{-1} release concentration, where the chronic and acute PNEC concentrations were exceeded over an area of 36.63 ha and 14.55 ha, respectively (BEEMS Technical Report TR445), which equates to 0.05% and 0.02% of the Estuaries SAC feature, respectively (notable, the current permitted maximum hydrazine discharge is 15 µg l^{-1}, below the 30 µg l^{-1} worst case scenario). The likelihood of the protected fishes (allis and twaite shad, river and sea lamprey, eel, salmon and sea trout) being exposed to the toxic contaminants in the discharge plume is considered to be extremely low. The worst-case discharge zone above the EQS for un-ionised ammonia and hydrazine, forms either a narrow ribbon or a localised fan on the surface of the flood or ebb tide. Given that these migratory fishes are highly mobile animals, any individuals swimming locally to the discharge plume are unlikely to remain in the plume for any length of time and so potential exposure times are likely to be small.

Small numbers of adult eels migrate seawards past Hinkley in January and February and juveniles are present in low numbers in the vicinity of the HPB cooling water inlets to the east of the discharge site for virtually all of the year. Given the extreme tidal range and the high tidal velocities in the Severn, it is considered likely that the migratory adults and glass eels and the small number of resident juveniles would all transit past the discharge zone with the tide in a matter of minutes. Neither river nor sea lamprey appears to have a high abundance in the Hinkley Point area, being absent from the BEEMS fish characterisation surveys (BEEMS Technical Report TR-S200) and impinged only intermittently at HPB (BEEMS Technical Report TR573). Adult lampreys migrate up-estuary to spawn and juveniles down-estuary to feed. However, both species are parasitic, so their dispersion is controlled by the movements of their hosts, which are likely to be distributed widely through the estuary.

Of the designated species, twaite shad are present in the Severn catchment area and are observed during the 2009 – 2010 HPB CIMP (BEEMS Technical Report TR129) and in the 2021 – 22 HPB CIMP (BEEMS Technical Report TR573). Much as they are present in UK waters, allis shad are rare in the local area. Juveniles do use estuaries as nursery grounds, but (i) allis shad are extremely rare, (ii) there is no reason to suspect that either species would be concentrated in the area around the discharge zone, and, in any case, (iii) they are sufficiently mobile that they would not remain in the plume for any length of time.

Salmon and sea trout use the estuary for migration only and, if they were to swim close to the shore, are likely to pass by the discharge zone for a very short period of time.

Of the wider typical fish assemblage, during the 2009 – 2010 HPB CIMP, 64 species were observed, seven species accounted for the top 95 % of annual impingement. These were sprat, whiting, Dover sole, Atlantic cod, thin-lipped grey mullet, European flounder, and five-beard rockling (BEEMS Scientific Position Paper SPP112). During the 2021 – 22 CIMP, 62 species were observed, ten species accounted for the top 95 % of annual impingement. These were sprat, Atlantic herring, whiting, sand gobies of the genus *Pomatoschistus spp*. Dover sole, poor cod, five-beard rockling, thin-lipped grey mullet, common sea snail and bib. Sprat was the most abundance species (BEEMS Technical Report TR573). The small spatial extent of the buoyant plume, coupled with the motility of the fish in the assemblage, indicates that the proportion of the populations exposed to areas in excess of the EQS is likely to be minimal, and exposure times extremely brief. It is therefore considered highly unlikely that the construction and cold commissioning discharges will have a LSE on the wider typical fish assemblage.

7.2.9 Bird Assemblages

This section of the report builds on the assessment made in Section 7.2.7 and considers the indirect effects of discharges on specific bird assemblages in the Severn Estuary, mediated through food-web interactions. Direct toxicological effects of exposure to components of the construction and cold commissioning discharges are not predicted to have an impact pathway and are therefore not further assessed.

To establish the potential for discharges to affect the prey species of foraging birds, an understanding of their feeding modes, diet and distribution in relation to the discharge is a prerequisite. Table 10.2 (Appendix C), provides a summary of the dietary composition of species included in the SPA, Ramsar and SSSI designations and identifies the species that rely on intertidal feeding areas.

Analysis of winter Wetland Bird Survey (WeBS) data (November 2002 to February 2003) by the Environment Agency showed that the intertidal foreshore on the HPC frontage is visited by Eurasian wigeon, Eurasian curlew and common redshank. Whilst these species are observed at the HPC foreshore, densities were higher on intertidal habitats to the east of HPC (Environment Agency, 2013). An intertidal bird survey commissioned at the foreshore at Hinkley Point and to the mudflat habitats to the east also indicated that the most important local foraging resources are located on the Steart mudflats to the east of HPB (Entec, 2011). Common shelduck have been recorded on the foreshore in very low numbers, whilst large numbers of moulting birds have been observed in July rafting, typically 500 m offshore near the proposed jetty site (Amec, 2011). The potential for disturbance of the jetty construction and operational phases on common shelduck has been considered through the HRA process elsewhere (see MMO, 2010).

Accordingly, of the designated species that feed on intertidal invertebrates and algae, only common shelduck, Eurasian wigeon, Eurasian curlew and common redshank may be susceptible to food-web effects arising from discharge contamination as low densities of these species occur in the intertidal areas close to the discharge. However, discharge modelling showed that intertidal areas are subject to only marginal increases in un-ionised ammonia and hydrazine concentrations, which are below the EQS (or proxy PNEC as a proxy EQS) levels. Therefore, contamination effects are likely to be negligible across the important Steart mudflat areas foraging areas to the east.

No LSE are predicted on the food sources of designated bird assemblages in Bridgwater Bay.

8 Combined effects

Cold commissioning chemical discharges will overlap (spatially and temporally) with construction discharges modelled in Case J (BEEMS Technical Report TR428)[12]. This section considers the potential for the interaction of toxic effects of discharged substances.

A range of TBM chemicals will be used at the TBM cutting face, a small proportion of which will be discharged via the jetty into the receiving waterbody. The individual active compounds with the greatest EVF have been assessed in relation to designated receptors in section 6. Here, the potential for the combined effects of TBM chemicals, groundwater metals, ammoniacal nitrogen and hydrazine are considered[13].

Several active surfactant substances are present in the TBM chemicals with the potential for combined effects (see Section 2.2.2). The rapid degradation of surfactants into a range of isomers and homologues makes the exact nature of toxicity assessments challenging when attempting to compare laboratory toxicity trials to the field (Madsen *et al.,* 2001). However, it should be noted that as a precaution the assessment for Condat CLB F5/M (TBM soil conditioner) was based on the PNEC for the most toxic chain length compound (C14) within the mono-C10-16-alkyl sodium sulphate group. Table 6.2 illustrates that mean and 95th percentile concentrations of both Condat CLB F5/M and BASF Rheosoil 143 are predicted to be well below PNEC at the locations of the most sensitive receptors in the area, allowing a margin for combined effects.

Maximal TBM discharge rates occur during Case D, at which point groundwater contributions are slightly reduced relative to earlier phases of the construction period and an area of 0.3 ha at the surface exceeds the EQS for zinc (Table 8.1) and is likely to overlap with the tunnelling chemical discharge which has a potential footprint of up to 1 ha. Limited data exists on the toxicity of metals and surfactants combined. One such study, however, examined the acute toxicity of copper and mercury combined with the anionic surfactant linear alkylbenzene sulphonate (LAS) on freshwater rainbow trout (Calamari and Marchetti, 1973). In trials, LAS and copper was mixed at half the 24-hour LC_{50} concentrations (approximately 1 mg l^{-1} and 0.62 mg l^{-1}, respectively) and survival times were approximately halved, indicating a greater than additive lethal effect induced by mixing. In the context of this report, it is challenging to determine if such synergistic effects may occur given that a freshwater fish was used as a model organism and the experiment tested acute concentrations, with orders of magnitude higher than those likely to occur beyond the initial mixing zone of the discharge. Indeed, the authors note that despite the greater than additive effect between LAS and metals the safety margins placed on permitted discharges suggests that the increase in toxicity above simple addition is very small (Calamari and Marchetti, 1973).

Ammoniacal nitrogen is also present in the combined discharges during construction and cold commissioning with no areas of exceedance at mean concentrations but an area of 0.2 ha as a 95th percentile (Table 8.1). Recent studies of juvenile freshwater mussel (Salerno *et al*., 2020) have shown combined ammonia and copper solutions exert effects levels indicative of additive toxicity.

Hydrazine would be discharged during the cold commissioning phase and results in the largest predicted areas of exceedance relative to the precautionary acute and chronic PNEC values derived for hydrazine (BEEMS Technical Report TR445) (Table 8.1). Except for the 30 µg l^{-1} hydrazine

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[12] Demineralisation effluent includes metals from concentrated potable water, however at a lower concentration than the groundwater case investigated. Therefore, the groundwater discharge overlap with the other discharges is the worst-case assessment (refer to NNB GenCo (2024) for details of the demineralisation discharge assessment)

[13] This assessment was originally completed prior to construction (Rev1) and is retained to show the history of the assessments; however as of 2023, tunnelling has completed and therefore there is no possibility that TMB chemical discharges will coincide with cold commissioning.

discharge scenario no area at the seabed is affected at concentrations that exceed either the acute or chronic hydrazine PNECs. No information could be sourced regarding the toxicity of hydrazine in combination with other chemicals although interaction with copper has been shown to facilitate more rapid degradation of hydrazine (Moliner and Street, 1989; Ou and Street, 1987).

At a maximum modelled hydrazine concentration of 30 µg l^{-1} (noting that the permitted maximum is currently 15 µg l^{-1}) concentrations are predicted to exceed the chronic PNEC over an area of 37 ha at the surface and 6 ha at the seabed but the acute PNEC concentrations would be exceeded for no more than 1 – 2 hours (not more often than every 24 hours). Within the hydrazine discharge footprint there would be a maximum area of 0.2 ha, which could be exposed to overlapping discharge inputs of zinc, un-ionised ammonia, TBM surfactant and hydrazine at or above the respective EQS/PNEC.

Based on highest mean concentrations of discharged substances at selected locations of designated sensitivities (Table 8.1) the percentage of each substance relative to their respective EQS or PNEC can be calculated (Table 8.2). The total of the percentage contribution of predicted concentrations relative to EQS /PNEC for zinc, un-ionised ammonia, TBM CLB F5 (the most toxic TBM chemical assessed) results in a percentage of 42.5. Considering the mean hydrazine concentrations derived from the current discharge scenario (15 µg l^{-1}) the total percental of the combined EQS/PNEC is 80 % at selected locations for *Sabellaria* or *Corallina*. While this approach is purely additive and does not account for synergistic effects, as noted above there is in built margin in EQS thresholds to account for unknown variables in particular.

There is mixed evidence in the literature of the types of toxic interaction observed between chemical combinations from different chemical groups. There are a wide range of studies reporting greater than additive effects of some chemical mixtures, but the current view is that there is insufficient comparative toxicity data to provide a compelling case for more than additive effects of mixtures (Martin *et al*., 2021). For the combined construction and cold commissioning inputs described, an area of ca., 0.2 ha is likely to be affected by a combined toxic effect at or above individual EQS/PNEC level. Beyond this immediate mixing zone, based on an additive approach of combining the proportion of the EQS for each substance (Table 8.2) the combined chemical plumes contribution at the locations of the *Corallina* or *Sabellaria* receptors may be equivalent to a mean combined concentration of around 80 % of the PNEC/EQS level for any individual substance.

Overall, the areas that have the potential to experience combined chemical toxicity are very limited and are not considered to make a significant additional contribution to toxic effects relative to that predicted for individual substances. Therefore LSE can be excluded from combined effects of cold commissioning chemical discharges overlapping with construction discharges.

Table 8.1: Predicted concentration of contaminants of concern in construction and cold commissioning discharges with potential to interact at the location of *Corallina* or *Sabellaria* features. Loc refers to locations as shown in Figure 10.2 in Appendix D.

Contaminant of concern	**EQS/PNEC exceedance – Surface**	**EQS/PNEC exceedance – Bed**	***Corallina* surface**	***Corallina* bed**	***Sabellaria* surface**	***Sabellaria* bed**
Zinc (Case D) (mean EQS 3.77 μg l^{-1})	0.3 ha	within 5m	Loc 4 mean 0.12 μg l^{-1} Loc 2 max 0.64 μg l^{-1}	Loc 4 mean 0.12 μg l^{-1} Loc 2 max 0.64 μg l^{-1}	n/a	Loc G mean 0.11 μg l^{-1} Loc E 95% 0.28 μg l^{-1}
Mean un-ionised ammonia based on 38l s^{-1} (Case D) + 37 l s^{-1} commissioning (EQS 21 μg l^{-1} as mean)	no exceedance	no exceedance	n/a	n/a	n/a	n/a
95th percentile un-ionised ammonia based on 38 l s^{-1} (Case D) + 37l s^{-1} commissioning	0.12 ha	no exceedance	n/a	n/a	n/a	n/a
Mean un-ionised ammonia based on 38l s^{-1} (Case D) + 70 l s^{-1} commissioning (EQS 21 μg l^{-1} as mean)	no exceedance	no exceedance	Loc 5 Mean 2.34 μg l^{-1}	n/a	Loc C Mean 2.40 μg l^{-1}	n/a
95th percentile un-ionised ammonia based on 38 l s^{-1} (Case D) + 70 l s^{-1} commissioning	0.2 ha	no exceedance	Loc 2 95% 2.81 μg l^{-1}	n/a	Loc G 95% 3.03 μg l^{-1}	
Total ammonia (mean)	<25 m	<25 m	n/a	n/a	n/a	n/a
Total ammonia (95th percentile)	<25 m	<25 m	n/a	n/a	n/a	
TBM Rheosoil 143 (Case D) (EQS 40 μg l^{-1})	0.19 ha	no exceedance	n/a	n/a	n/a	loc G mean 2.90 μg l^{-1} loc E 95% 7.12 μg l^{-1}
TBM CLB F5 (Case D) (EQS 4.5 μg l^{-1})	1 ha	no exceedance	n/a	n/a	n/a	loc G mean 0.97 μg l^{-1} loc E 95% 2.37 μg l^{-1}

Contaminant of concern	**EQS/PNEC exceedance – Surface**	**EQS/PNEC exceedance – Bed**	***Corallina* surface**	***Corallina* bed**	***Sabellaria* surface**	***Sabellaria* bed**
hydrazine commissioning 10 µg l^{-1} (chronic PNEC 0.4 ng l^{-1}) (Mean)	8.87 ha	no exceedance	loc 3 mean 0.028 ng l^{-1}l (exceed chronic 1 hour)	n/a	loc D mean 0.103 ng l^{-1} (exceed chronic 1 hour)	n/a
hydrazine commissioning 10 µg l^{-1} (acute PNEC 4 ng l^{-1})	3.82 ha	no exceedance	loc 2 95% 0.072 ng l^{-1} Loc 6 Max 2.49 ng l^{-1}	n/a	loc E 95% 0.282 ng l^{-1}, Loc D Max 12.07 ng l^{-1}	n/a
hydrazine commissioning 15 µg l^{-1} (chronic PNEC 0.4 ng l^{-1}) (Mean)	15.89 ha	no exceedance	loc 3 Mean 0.041 ng l^{-1} (exceed chronic 1 hour)	n/a	loc D mean 0.15 ng l^{-1} (exceed chronic 1 hour)	n/a
hydrazine commissioning 15 µg l^{-1} (acute PNEC 4 ng l^{-1})	5.47 ha	no exceedance	loc 2 95% 0.108 ng l^{-1} Loc 6 Max 3.73 ng l^{-1}	n/a	loc E 95% 0.424 ng l^{-1}, Max 18.1 ng l^{-1}	n/a
hydrazine commissioning 30 µg l^{-1} (chronic PNEC 0.4 ng l^{-1}) (Mean)	36.63 ha	5.98 ha	loc 3 mean 0.083 ng l^{-1} (exceed chronic 1 hour)	n/a	loc D, mean 0.3 ng l^{-1}, (exceed chronic 1 hour)	n/a
hydrazine commissioning 30 µg l^{-1} (acute PNEC 4 ng l^{-1})	14.55 ha	1.86 ha	loc 2 95% 0.215 ng l^{-1}, Loc 6 Max 7.46 ng l^{-1}	n/a	loc E 95% 0.85 ng l^{-1}, Loc D Max 36.2 ng l^{-1}	n/a

Table 8.2: Percentage of each substance in the construction and cold commissioning discharge relative to their respective EQS or PNEC for the most exposed sensitive receptors as detailed in Table 8.1.

Contaminant of concern	Chronic EQS/PNEC	Highest mean concentration predicted	Percentage of EQS/PNEC
Zinc	3.77 ug l^{-1}	0.12 ug l^{-1}	3
Un-ionised ammonia	21 ug l^{-1}	2.4 ug l^{-1}	11
TBM Rheosoil 143 (Case D)	40 ug l^{-1}	2.90 ug l^{-1}	7
TBM CLB F5 (Case D)	4.5 ug l^{-1}	0.97 ug l^{-1}	21.5
Hydrazine 15 ug l^{-1}	0.4 ng l^{-1}	0.15 ng l^{-1}	37.5

9 In-Combination effects

This section considers the in-combination effects of the construction and cold commissioning discharges in relation to the plans, projects and permissions (PPP) outlined in the original HPC HRA (Environment Agency, 2013), and updated in 2020 (Environment Agency, 2020) which include:

- HPC jetty
- HPA discharge
- HPB discharge
- Environment Agency Steart coastal management project
- Bristol Port container terminal
- Compensation habitat creation for Bristol Port container terminal
- Swansea Bay Tidal Lagoon (planning succeeded to the original HRA but was considered in BEEMS Technical Report TR414)

The toxicity of contaminants is further considered in relation to thermal discharges from HPB and seasonal temperature variations.

The jetty discharges will only persist during the construction and cold commissioning phase. Therefore, there are no in-combination effects with operational phases of HPC. However, Unit 1 will be operational while Unit 2 is being commissioned, therefore discharges from the jetty will overlap (temporally) with discharges from the permanent outfall (see Section 9.1). BEEMS Technical Report TR414 completed an assessment of the in-combination effects of construction dewatering discharge for HPC with the PPP outlined in the original HPC HRA (Environment Agency, 2013) and updated in 2020 (Environment Agency, 2020), and the Swansea Bay Tidal Lagoon (BEEMS Technical Report TR414). In support of the original HRA, it was concluded that no in-combination effects of the discharges with these PPP on the estuary features was anticipated due to the restricted extent of the discharge plume and the short duration of exposure.

NNB HPC will be dredging as part of the development of HPC nuclear power station. Dredging is proposed at the cooling water intakes, outfall and flotation pocket, Fish Recovery and Return (FRR) outfall, with the dredged material being taken to a designated disposal site, if deemed suitable for disposal to sea. Evidence of the sediment quality with regards to potential contaminants has been provided as part of the Marine Management Organisation Marine Licence requirements to determine that the material is suitable for disposal to sea, therefore no significant in-combination effects are predicted on designated features. Furthermore, dredging is temporary, lasting only a few days, given the very limited likely temporal overlap, and the restricted extent of the discharge plume and the short duration of exposure, no significant in-combination effects are predicted.

No further PPP, since the original HPC HRA (BEEMS Technical Report TR414) and 2020 updates (Rev 1 of this report), were identified. Therefore, the conclusions remain unchanged. No in-combination effects of the proposed construction and cold commissioning discharges from the jetty and the PPP on designated features are predicted.

9.1 In-combination effects with operational discharges from HPC, HPB and HPA wastewater discharges

The HPC power station will include two reactors, Unit 1 & Unit 2. Progress on the construction of Unit 1 is approximately one year ahead of Unit 2. This will mean that Unit 1 will reach HFT (Hot Functional Testing) stage approximately one year ahead of Unit 2. From HFT onwards, the resulting effluent will be managed under the Operational WDA (OWDA) permit. On this basis for a period of approximately one year, effluent from Unit 2 will be discharging under the CWDA permit at the jetty and effluent from Unit 1 under the OWDA permit at the HPC permanent power station outfall.

9.1.1 Ammonia and Nutrients

The un-ionised ammonia CWDA discharge at the jetty that includes the scenario of Units 1 and 2 undergoing simultaneous cold commissioning is predicted to have limited influence on *Corallina* and *Sabellaria* features, and any influence would be reduced at the jetty location once the first permanent outfall is operational. The permanent outfall discharge would occur further offshore, and dilution and dispersion of this un-ionised ammonia loading is expected to influence a very limited mixing zone around the discharge point, and to have negligible impact.

The nutrient assessment was conducted using a 'box model' so the location of the discharge would not, in this case, change the input parameters or final predictions (because a particularly conservative suspended particulate matter level of 10 mg l^{-1} was used in the model, see BEEMS Technical report TR428 Appendix F).

There is an east-west separation of approximately 2.4 km between the jetty discharge and HPB/HPA outlet channel, which is therefore considered sufficient to ensure there is no interaction between these discharges (BEEMS Technical Report TR428).

Discharges from HPB and HPC enter two waterbodies: the River Parrett and the Bridgwater Bay. The effects of the discharge from the jetty are expected to uplift DIN by 2.52 µmol l^{-1} and 0.58 µmol l^{-1}, in each waterbody respectively (BEEMS Technical Report TR428). The combined discharges do not impact on the 'Good' status of either waterbody and therefore no LSE are predicted.

9.1.2 Coliforms from HPB

Cormix dilution rates have been used to determine the maximum distance from the discharge at which bathing water standards could be exceeded (see BEEMS Technical Report TR428).

It is not known what the actual microbiological discharge concentration is from HPB, however assuming the same standard of secondary treatment as HPC would imply a maximum potential extent of exceedance for *Escherichia coli* of approximately 1.8 km (BEEMS Technical Report TR428). This theoretical exceedance could only occur in very calm conditions. Under such calm conditions the plume would be long and thin and would not interact with the jetty discharge, as the tidal stream lines are separate. In practice most of the time, wave mixing will mix the discharge rapidly so that no interaction could occur. No LSE are predicted.

9.2 In-combination thermal effects with HPB

HPB stopped generating in August 2022, however the previous assessment detailed below is retained here as a record of the assessment which covered the initial groundwater discharges which overlapped with the operation HPB.

Temperature is considered one of the most important factors influencing chemical toxicity (Heugens *et al*., 2001). Most aquatic organisms are ectothermic, leading to changes in the metabolic rates following changes in environmental temperature. This metabolic change, also known as Q10, can be two-fold change with a 10˚C temperature variation. Thus, an aquatic organism is generally more susceptible to contamination due to increased diffusion and uptake rates (Cairns Jr, 1975). However, such effects are not universal, and Lee *et al*. (1997) showed no correlation between seasonal temperatures (0 – 28 °C) and periphyton sensitivity to alcohol ethoxysulphates (AES) and alcohol sulphate (AS) surfactants.

Temperatures at the site range from 6.6 °C in February to 19.4 °C in August, with typical inter annual variation in monthly mean temperatures of 1.1 °C (BEEMS Technical Report TR187). Thermal discharges from HPB are predicted to cause an average annual increase in sea surface temperature at the jetty site of 1.02 °C, within the range of interannual monthly variation.

Average EQS values are only exceeded in the immediate vicinity of the jetty location with Condat CLB F5/M (TBM tunnelling soil conditioner) having the greatest exceedance area of 0.96 ha at the sea surface. None of the chemicals assessed exceed the EQS at the seabed. Seasonality will be the driving factor responsible for temperature dependent toxicity with toxicity greatest during the warm summer months. However, the in-combination effects of a small temperature uplift from the HPB thermal discharges at the jetty site and the restricted spatial area of EQS exceedance for contaminant metals and TBM surfactants is not considered to have a significant effect on the designated estuarine features. As such, no in-combination effects between construction discharges and the HPB thermal plume are predicted at the point of discharge.

Mixing down of the discharge plume results in the highest seabed concentration of chemicals, relevant to the designated features, occurring to the east of the jetty in the intertidal areas adjacent to HPB. To estimate the temperature uplift from HPB in relation to the *Sabellaria* features results from high resolution thermal modelling (BEEMS Technical Report TR267) were applied (Figure 9.1 and Table 9.1). *Sabellaria* locations A – F experience modest annual average temperature uplifts of < 1.3 °C from HPB thermal discharges. *Sabellaria* patch G is exposed to the highest concentrations of contaminants and experiences the largest average annual temperature uplift (4.17 °C). However, as discussed in Sections 7.2.5, neither component of the construction and cold commissioning discharges exceed the applied EQS/PNEC at any of the *Sabellaria* features. Only transitory concentration peaks occur above EQS levels for TBM compounds. Accordingly, LSE are predicted resulting from the in-combination effects of increased temperature-dependent toxicity of construction contaminants due to thermal discharges from HPB.

Table 9.1: Mean temperature uplift due to HPB at *Sabellaria* locations at the seabed.

***Sabellaria* location**	**Mean temperature uplift (°C)**
Subtidal *Sabellaria* A	0.41
Intertidal *Sabellaria* B	1.18
Intertidal *Sabellaria* C	0.78
Intertidal *Sabellaria* D	0.68
Subtidal Sabellaria E	0.94
Intertidal *Sabellaria* F	1.27
Intertidal *Sabellaria* G	4.17

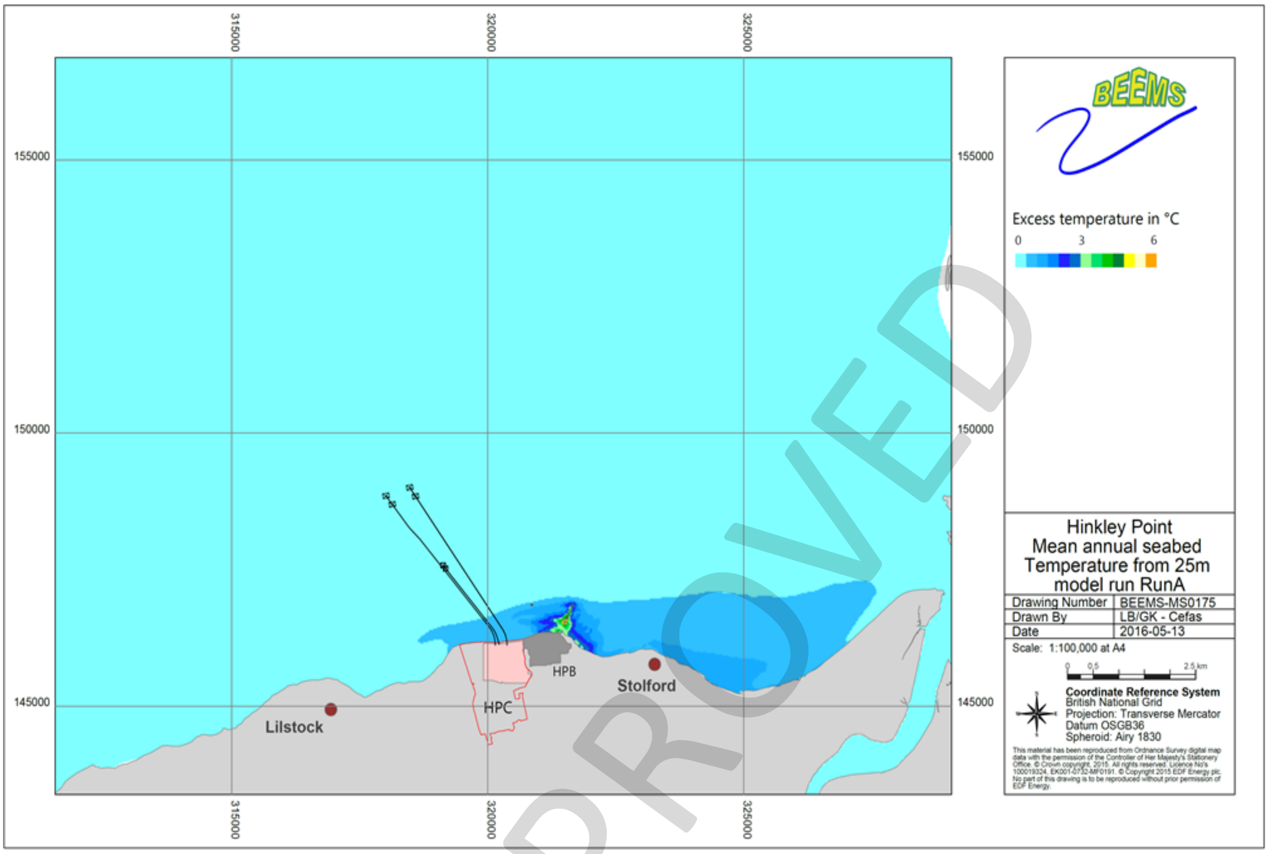

Figure 9.1: Mean excess temperature at the seabed due to HPB discharges from high resolution 25 m model, BEEMS Technical Report TR267.

10 Conclusions

The evidence presented in this report is to inform a HRA assessment of the HPC construction and cold commissioning discharges from the jetty (known as 'Outlet 12') on the designated features of the Severn Estuary/ Môr Hafren SAC, SPA, Ramsar site and Bridgwater Bay SSSI. This report includes evidence for the construction phase and the commissioning phase.

The construction phase discharges vary in composition, however the worst-case scenario for each substance of interest has been assessed. Two cases are described, Case C (the maximum dewatering phase) and Case D (the long-term typical case including groundwater, treated sewage and TMB chemicals).

Screening of the construction discharge showed potential toxic contamination effects from zinc and copper, could not be screened out. Zinc exceeded the EQS by the largest margin and was modelled to show maximum plumes sizes to represent all metals. Potentially toxic contaminants TBM chemicals BASF Rheosoil 143 and Condat CLB F5/M failed the screening tests and were subject to further modelling. Ammonia, from treated sewage discharges, passed the screening tests, however due to the complex partitioning of ammonia and un-ionised ammonia, was considered in further detail to demonstrate the size of plumes of un-ionised ammonia.

Modelling of the construction discharges showed very small plumes for all contaminants which do not exceed their respective EQS levels at the locations of any sensitive receptors (such as *Sabellaria* or *Corallina*). Modelling also showed there would be no areas in exceedance of the relevant EQS levels at the seabed for any substances. Maximum surface plumes above the EQS levels were 1 ha for TBM chemicals (Condat CLB F5/M), and 0.3 ha for zinc. The modelling results were considered in relation to designated features, considering both possible direct and indirect impacts. It was concluded that LSE could be excluded on the basis that the very small and localised plumes in excess of the EQS levels would not lead to a reduction in the amount or quality of any designated habitat or species.

For the CWW (Case F), preliminary characterisation[14] of untreated CWW indicates the presence of retarder and accelerator chemicals but also trace contaminant metals. As the combined discharge rate of e.g., groundwater and CWW would still be very low ca. 26 l s^{-1}, an increase of a few percent above that of the original groundwater metal concentrations would have negligible influence on the small mixing zone where the EQS might be exceeded (BEEMS Technical Report TR428). Also, the DIN and ammoniacal nitrogen contributions from the CWW discharge are indicated to be very small, at around a half of that for the groundwater, and so the concentration in the combined discharge is likely to be relatively unchanged or slightly lower than that already assessed (BEEMS Technical Report TR428). Therefore, the conclusion is that no significant effects are predicted from the CWW discharge.

The combined cold commissioning, including demineralisation effluent, and construction phase discharges assessment focused on a particular phase of the discharge schedule, Case J, as representative of the worst-case combination of discharges. The screening processed identified hydrazine and ammonia as potential substances of concern during the commissioning phase, which were modelled to show the size and shape of discharge plumes. Demineralisation effluent is lower than groundwater alone discharges and therefore the groundwater assessment is considered as the worst-case assessment for metals. Non-toxic contamination effects, for example by nutrients, salinity or temperature were excluded following investigation of nutrient inputs with a phytoplankton model.

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[14] NNB HPC will provide a cementitious wash water characterisation report as per permit condition PO2 when the required information becomes available. NNB HPC recognise that no discharge can commence under Case F until a submission under PO2 is approved by the EA.

Results of the model output show that there is no difference between the Bridgwater Bay reference model and the HPC construction/ cold commissioning model run for either phytoplankton production or for macroalgae. This is due to the high turbidity environment in the Severn, which means productivity is light-limited (Underwood, 2010).

The potential for toxic contamination effects from hydrazine and un-ionised ammonia were investigated with modelling of both discharges. Plume extents for both were very small, and neither showed any excess of the EQS at the seabed (for the currently permitted 15 µg l^{-1} hydrazine limit). Surface plumes in excess of the EQS (or PNEC as a proxy EQS) were shown to be small and did not overlap with any sensitive features (e.g., *Sabellaria* or *Corallina*). As the current permitted discharge concentration of hydrazine (15 µg l^{-1}) does not interact with the bed, there is no predicted pathway for direct toxicological effects on benthic marine invertebrates and epi-benthic crustaceans; and no predicted food-web significant effects. In regard to fish species, both migratory fish of conservation status and the wider fish assemblage, the small spatial extent of the buoyant plume for hydrazine and un-ionised ammonia, coupled with the motility of the fish species indicates the proportion of the population exposed to areas in excess of the EQS/PNEC is likely to be minimal, and exposure times extremely brief. It is therefore considered highly unlikely that the construction and cold commissioning discharges could have an LSE.

Discharge modelling showed that intertidal areas are subject to only marginal increases in un-ionised ammonia and hydrazine concentrations, and are below the EQS/PNEC levels, therefore, no contamination effects are predicted across the important bird foraging areas to the east of the Steart mudflat and no significant effects are predicted on the food sources of designated bird assemblages in Bridgwater Bay.

The modelling results were considered in relation to designated features, considering both possible direct and indirect impacts from commissioning discharges. It was concluded that LSE could be excluded on the basis that the very small and localised plumes in excess of the EQS (or PNEC as a proxy EQS) levels would not lead to a reduction in the amount or quality of any designated habitat or species.

The potential for the combined effects of TBM chemicals, groundwater metals[15], ammoniacal nitrogen and hydrazine were considered and overall, the areas that have the potential to experience combined exposure are very limited. The combined exposure is not considered to make a significant additional contribution to toxic effects relative to that predicted for individual substances. Therefore, consideration of the combined effects did not change the conclusions that LSE could be excluded.

The potential for in-combination effects with other PPP was assessed. In-combination effects with HPB were considered and it was concluded that LSE from combined effects could be excluded due the small scale of the effects and limited interaction or spatial/temporal overlap.

In summary potential pathways for effects of the construction and commissioning discharges were identified as: non-toxic contamination and toxic contamination. Screening of nutrient discharges and modelling of potential effects on primary production (non-toxic contamination) showed no LSE. Screening of potential toxic chemicals identified several which required modelling to characterise the extent of plumes. The plume modelling and interpretation showed small, localised excesses of relevant EQS thresholds at the surface only with no plumes apparent at the seabed. Sensitive receptors are not predicted to be exposed to contaminants in excess of relevant EQS (or PNEC as a proxy EQS) levels. Combined effects of low-level expose to multiple chemicals was shown to be minimal and unlikely to lead to significant effects. LSE, both alone and in-combination with other plans, projects or permissions was be excluded on the basis that the very small and localised plumes

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[15] Demineralisation effluent includes metals from concentrated potable water, however at a lower concentration than the groundwater case investigated. Therefore, the groundwater discharge overlap with the other discharges is the worst-case assessment.

in excess of the EQS levels would not lead to a reduction in the amount or quality of any designated habitat or species.

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Appendix A Discharge schedule

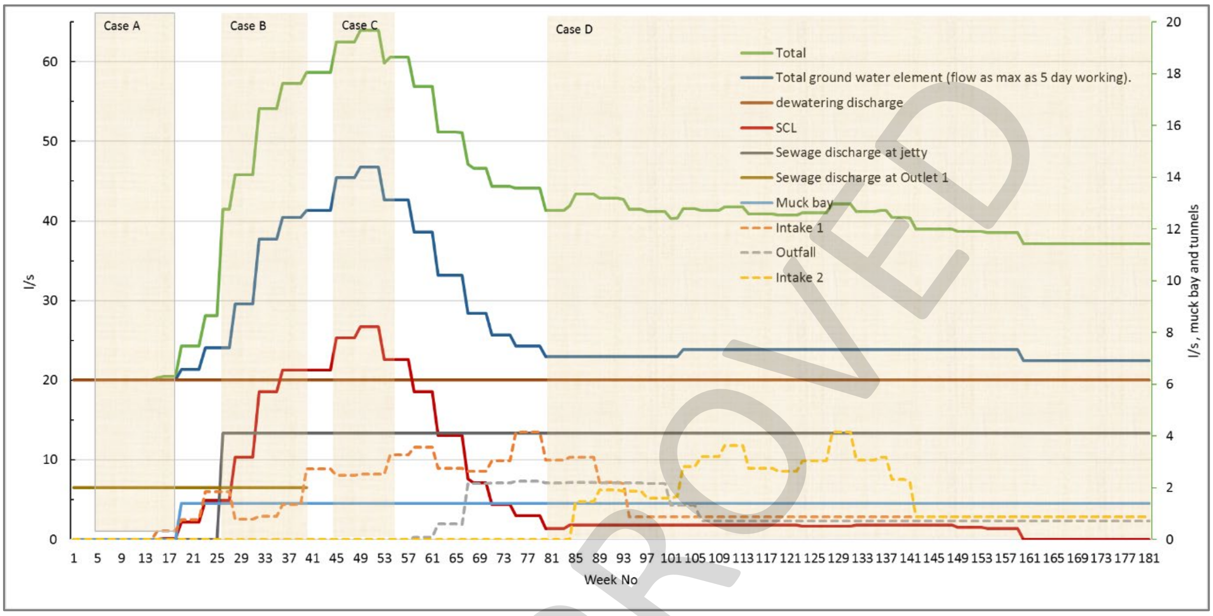

Figure 10.1: Likely flow volumes discharged at the jetty location from the start of tunnelling. Discharge volumes from ‘Muck Bay’ and TBM tunnelling for HPC intake 1, outfall and intake 2 are shown on the right-hand axis. Timing is according to August 2017 scheduling and selected scenarios for assessment represent the most conservative based on the assumed overlap of activities contributing to various contaminant sources (BEEMS Technical Report TR428).

Appendix B Screening of priority and hazardous substances

Table 10.1: Groundwater contaminants and concentrations likely to be present in the construction dewatering discharge and comparison to EQS for three cases. AA refers annual average concentration and MAC refers to the maximum allowable concentration. EVF ($m^3 s^{-1}$) has been derived using 95th percentile discharge concentrations and the AA EQS (except for mercury where the MAC EQS has been used). The shaded values indicate those used in the screening test assessment. These data are based on Environment Agency (Environment Agency, 2017) calculations from NNB HPC data sources (BEEMS Technical Report TR428). Underlined updated values had non-significant increases relative to original Cefas calculations.

Contaminant	**Assessed discharged concentration µg l^{-1}**		**Saltwater AA EQS µg l^{-1}**	**Saltwater MAC EQS (as 95%ile) (µg l^{-1})**	**Back-ground concentration (µg l^{-1})**	**(EVF) Case A and Case D**	**EVF Case C**	**TraC Water test 5 EVF< 3.0 Pass/Fail**
	Mean	**95%ile (used in EA Screening test)**						
Un-ionised ammonia (N)	258.75	123.5	21	-	**4.6**	**0.15**	**0.352**	**Pass**
DIN groundwater	1860.92	4073	2520[1]		1050	0.06	0.129	Pass
Cyanide	0.025	50	1	-	0	1.00	2.34	Pass
Total cadmium	0.09	0.460	0.2	-	**0**	**0.05**	**0.12**	**Pass**
Total chromium	4.58	24	0.6[2]	32	0.02	0.83	1.93	Pass
Total lead	0.85	3	1.3	14	0.02	0.05	0.11	Pass
Total copper	31.7	221	4.76	-	3.95	**5.46**	**12.17**	**Fail**
Total zinc	427.2	1642.15	6.8	-	3.035	**8.72**	**20.37**	**Fail**
Total mercury	0.2	0.49	-	0.07[3]	0.02	0.2	0.46	Pass
DIN Sewage sources		20,000[4]	2520		1050	0.19	0.41	Pass

[1] 99th percentile (180 µmol) standard for period 1st November – 28th February for dissolved inorganic nitrogen for Good status, Appendix B, Table 17 BEEMS Technical Report TR428.
[2] The EQS in seawater is set for dissolved hexavalent chromium only but this is dissolved total chromium (all species).
[3] The EQS for mercury is only set as a 95th percentile.
[4] A max value not 95th percentile, ammoniacal nitrogen as a proxy for total nitrogen from sewage treatment (µg l^{-1}) as other contributions e.g. NO_2, NO_3 are expected to be small.

The EVF of the discharge is defined as:

EVF = (EFR x RC) / (EQS – BC) $m^3 s^{-1}$

Where:

EFR = the effluent discharge rate ($m^3 s^{-1}$)

RC = release concentration of the priority substance of concern (µg l^{-1})

EQS = EQS (AA) of the substance of concern (µg l^{-1})

BC = mean background concentration at the discharge location (µg l^{-1})

Appendix C Dietary composition and foraging areas of designated bird species

Table 10.2: Dietary composition and foraging areas for the designated bird species in the Severn Estuary. Data from BEEMS Technical Report TR184 and Environment Agency (2013). Species in bold feed on intertidal prey and therefore are susceptible to potential indirect food-web effect pathways. Underlined species have been observed near the jetty.

Common name	Species	Potential prey
Gadwall	***Anas strepera***	Gadwall feed predominantly away from intertidal areas, their diet comprises seeds, leaves, roots and stems of aquatic plants grasses and stoneworts.
Greater white-fronted goose	*Anser albifrons albifrons*	Greater white-fronted geese feed on grass, clover, grain, winter wheat and potatoes.
Dunlin	***Calidris alpina alpina***	Dunlin feed on benthic invertebrates at low tide and on fields adjacent to the Severn Estuary. Dietary items include small *Scrobicularia plana*, small *Macoma balthica*, *Hydrobia ulvae*, *Corophium volutator, Hediste diversicolor, Talitrus* spp, *Carcinus* spp
Bewick's swan	*Cygnus columbianus bewickii*	Bewick's swans feed on seed, fruits, leaves, roots, rhizomes and stems of aquatic plants grasses sedges, reeds.
Common redshank	***Tringa totanus***	Common redshank feed in intertidal and freshwater wetland habitats. Overwinter common redshank feed predominantly on benthic invertebrates when exposed by the tide and in fields adjacent to the Severn Estuary. Dietary items include *Mya* spp, *Scrobicularia plana, Macoma balthica, Hydrobia ulvae, Corophium volutator, Hediste diversicolor, Nephtys* spp, small *Carcinus maenas, Crangon crangon, Talitrus* spp
Common shelduck	***Tadorna tadorna***	Common shelduck feed on benthic exposed at low tide and in shallow water. Their diet includes: *Hydrobia ulvae, Corophium volutator*, young *Macoma balthica*, young *Mytilus edulis*, young *Cerastoderma edule*, *Hediste diversicolor*, Nematoda, Polychaeta, Nereididae, Copepoda, Ostracoda, Amphipoda, Mollusca, Tellinacea, Platyhelminthes, Coleoptera, Tipulidae
Whimbrel	*Numenius phaeopus*	During their spring passage, whimbrel congregate on the Somerset and Gwent Levels where they feed on a terrestrial diet consisting mainly of wireworms and caterpillars.
Eurasian wigeon	***Anas penelope***	Eurasian wigeon feed on algae and grasses gathered on mudflats and on land.
Black-tailed godwit	***Limosa limosa islandica***	Black-tailed godwit feed intertidally on *Scrobicularia plana, Macoma balthica, Hediste diversicolor*. Potential food items also include *Skenea* spp, *Corophium* spp, Nematoda, *Hydrobia ulvae.*
Eurasian curlew	***Numenius arquata***	Eurasian curlew feed on a range of intertidal prey including: *Mya* spp, *Cerastoderma edule, Scrobicularia plana, Macoma balthica, Hediste diversicolor, Arenicola marina, Carcinus maenas, Skenea*

Common name	Species	Potential prey
		spp, *Corophium volutator,* Nematoda*, Hydrobia ulvae.* Earthworms also form a significant part of their diet.
Ringed plover	***Charadrius hiaticula***	Ringed plover in the summer feed on invertebrates and in the winter primarily marine worms (*Hediste diversicolor*), crustaceans (*Corophium volutator*) and molluscs (*Hydrobia ulvae*),
Grey plover	***Pluvialis squatarola***	Grey plover feed mainly on worms (*Hediste diversicolor* and *Arenicola marina*), crustaceans and molluscs (*Scrobicularia spp*, *Macoma balthica* and *Hydrobia ulvae*).
Eurasian teal	***Anas crecca***	Eurasian teal has a broad diet consisting of seeds of sedges, grasses, and aquatic vegetation; aquatic insects and larvae, molluscs, crustaceans.
Northern pintail	***Anas acuta***	Northern pintail has a broad diet consisting of Algae, seeds, tubers, vegetative parts of aquatic plants, sedges, grasses, aquatic invertebrates (insects, molluscs and crustaceans), amphibians and small fish.
Spotted redshank	***Tringa erythropus***	Spotted redshank feed mainly on insect larvae, shrimps, small fish and worms.
Common pochard	***Aythya farina***	Commo pochard feed mainly on aquatic plants with some molluscs, aquatic insects and small fish.
Tufted duck	***Aytha fuligula***	Tufted ducks are omnivores that feed on molluscs, aquatic insects and some plants.
Lesser black-backed gull	***Larus fuscus graellsii***	Lesser black-backed gull diet includes a wide variety of fish, insects, molluscs, crustaceans, marine worms, small birds, nestlings, eggs, rodents; also eats berries, seeds, seaweed.
Herring gull	***Larus argentatus argentatus***	Herring gulls have a varied diet of fish, earthworms, crabs, molluscs, echinoderms or marine worms, adult birds, bird eggs and young, rodents, insects, berries and tubers.
Little egret	***Egretta garzetta***	Little egret feed mainly on small fish, aquatic and terrestrial insects (e.g. beetles, dragonfly larvae, mole crickets and crickets), crustaceans (e.g. *Palaemonetes spp*., amphipods), amphibians, molluscs (e.g. snails and bivalves), spiders, worms, reptiles and small birds.
Ruff	***Philomachus pugnax***	Ruff mainly feed on insects and other invertebrates and during migration and winter, they may also eat seeds.
Common greenshank	***Tringa nebularia***	Common greenshank primarily feed on insects, worms, molluscs, small fish and crustaceans.
Northern shoveler	***Anas clypeata***	In the winter, northern shoveler feed mostly on seeds and other parts of aquatic plants, such as sedges, pondweeds, grasses, and others. In summer they feed on molluscs, insects, crustaceans and sometimes small fish.
Water rail	***Rallus aquaticus***	Water rail mainly feed on small fish, snails and insects.
Snipe	***Gallinago gallinago***	Snipe feed mainly on insect larva. Other invertebrate prey include snails, crustacea, and worms.

Appendix D Locations of sensitive receptors

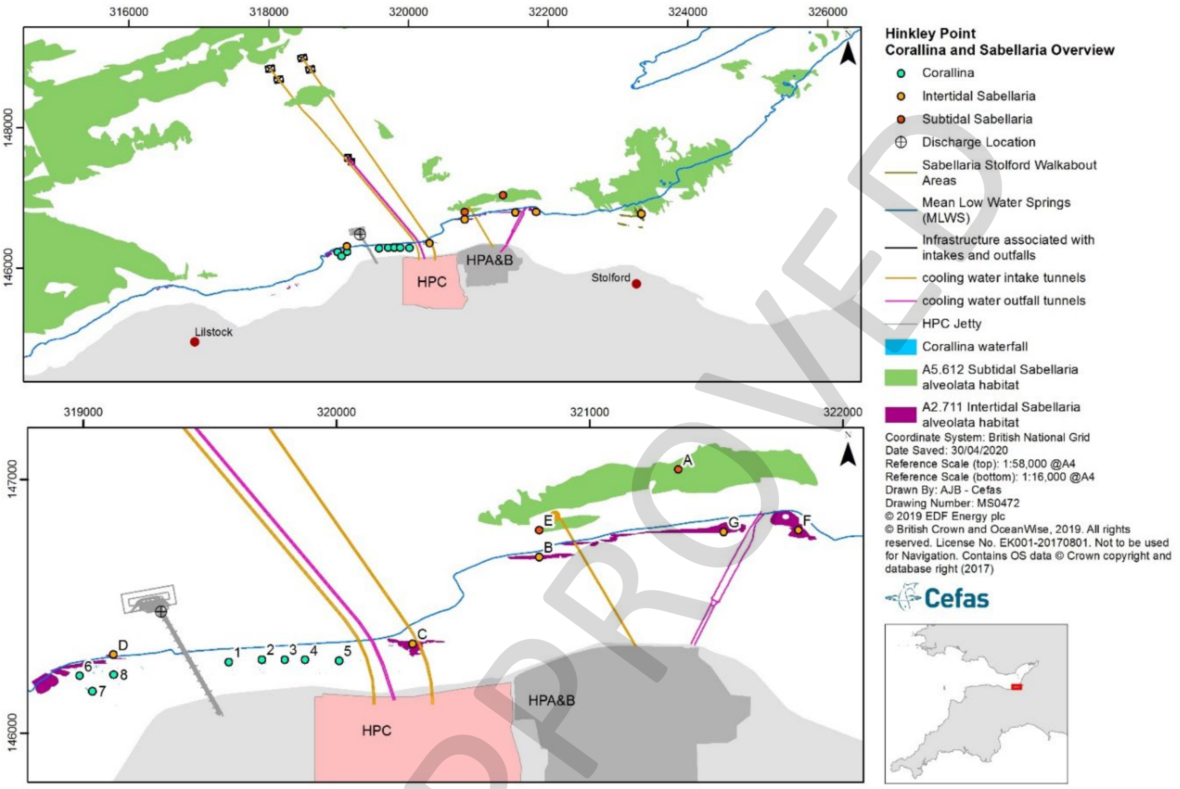

Figure 10.2: Location of subtidal and intertidal *Sabellaria alveolata* around Hinkley Point. Locations A and E are subtidal; locations B, C, D, F and G are intertidal) (BEEMS Technical Report TR445).