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

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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
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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)

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01	P6	Initial submission to NNB HPC.	Cefas	29/06/2021
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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 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.

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, chromium 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. 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 $\mu g\ l^{-1}$ 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.

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 Revision 2) considers the combined construction and cold commissioning discharges and supersedes BEEMS Technical Report TR443. This report also considers two recent variations to the water discharge permits which modified 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 2017, as amended by the Conservation of Habitats and Species (Amendment) (EU Exit) Regulations 2019 (European Union (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 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.

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

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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

Groundwater associated with construction activities, containing metals and Dissolved Inorganic Nitrogen (DIN), 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.

Chromium, 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	7685	2520		Pass	2330	Yes
Cyanide	50	1	-	Pass	Below detection	Yes
Total cadmium	0.374	0.2	-	Pass	0.08	Yes
Total chromium	39.4	0.6	32	Fail	2.65	Yes
Total lead	3	1.3	14	Pass	0.85	Yes
Total copper	199.5	4.76	-	Fail	7.70	Yes
Total zinc	1620	6.8	-	Fail	342	Yes
Total mercury	1	-	0.07	Pass	0.04	Yes

[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

[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.

[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.

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 $\mu g\ l^{-1}$ of ammoniacal nitrogen (total ammonia) and MAC of 8000 $\mu g\ l^{-1}$. 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) is reviewed in Section 3.5.

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;

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

- 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.

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.

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[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.

- 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. 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 5.2.6)	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, chromium 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.

[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).

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

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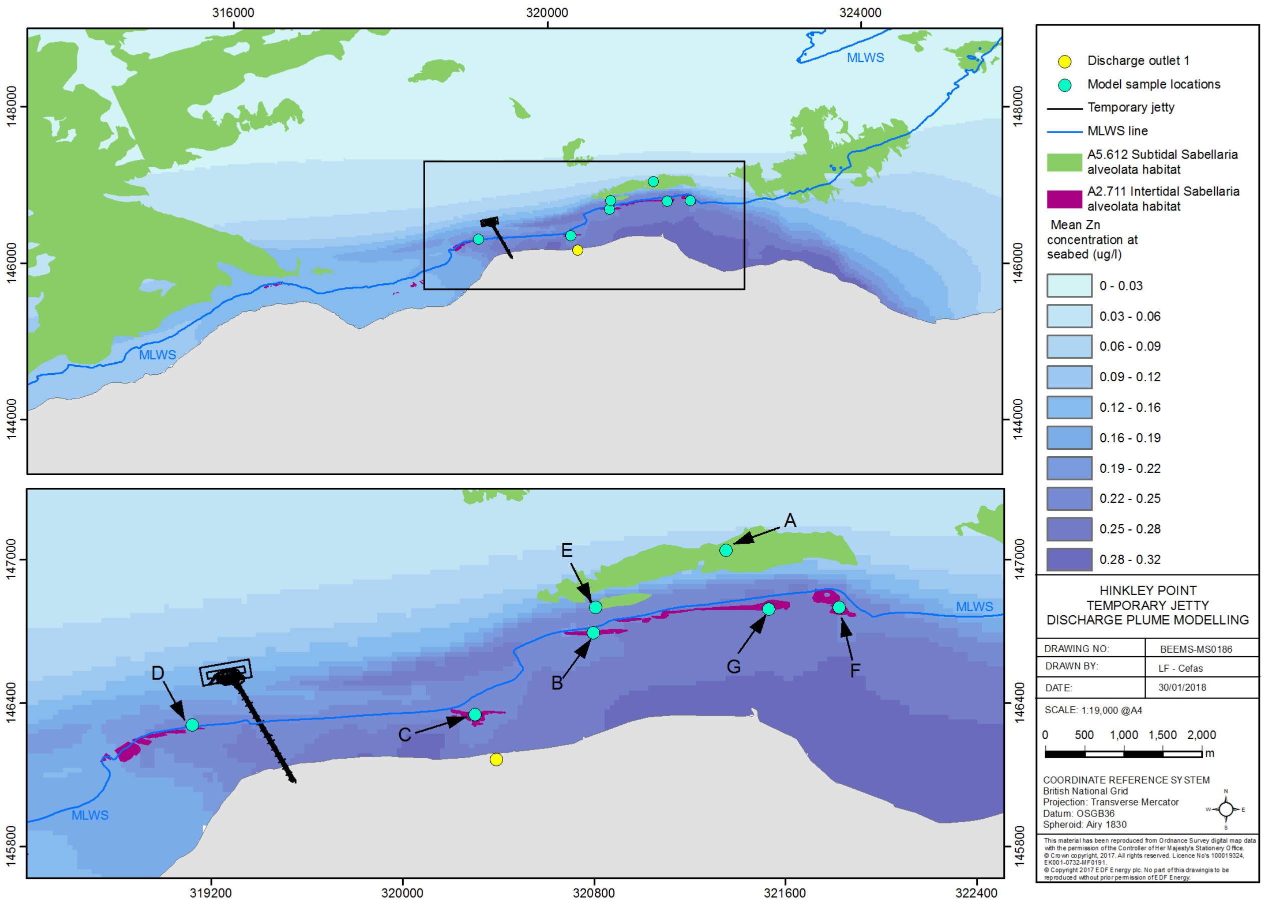

Figure 5.1: The spatial distribution of the discharge plume showing the mean seabed concentration of zinc (µg l^{-1}) during the maximum construction phase discharges, Case C (worst-case). The distribution of *Sabellaria* is delineated and the location of subtidal *Sabellaria* patch A and E, and intertidal *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.

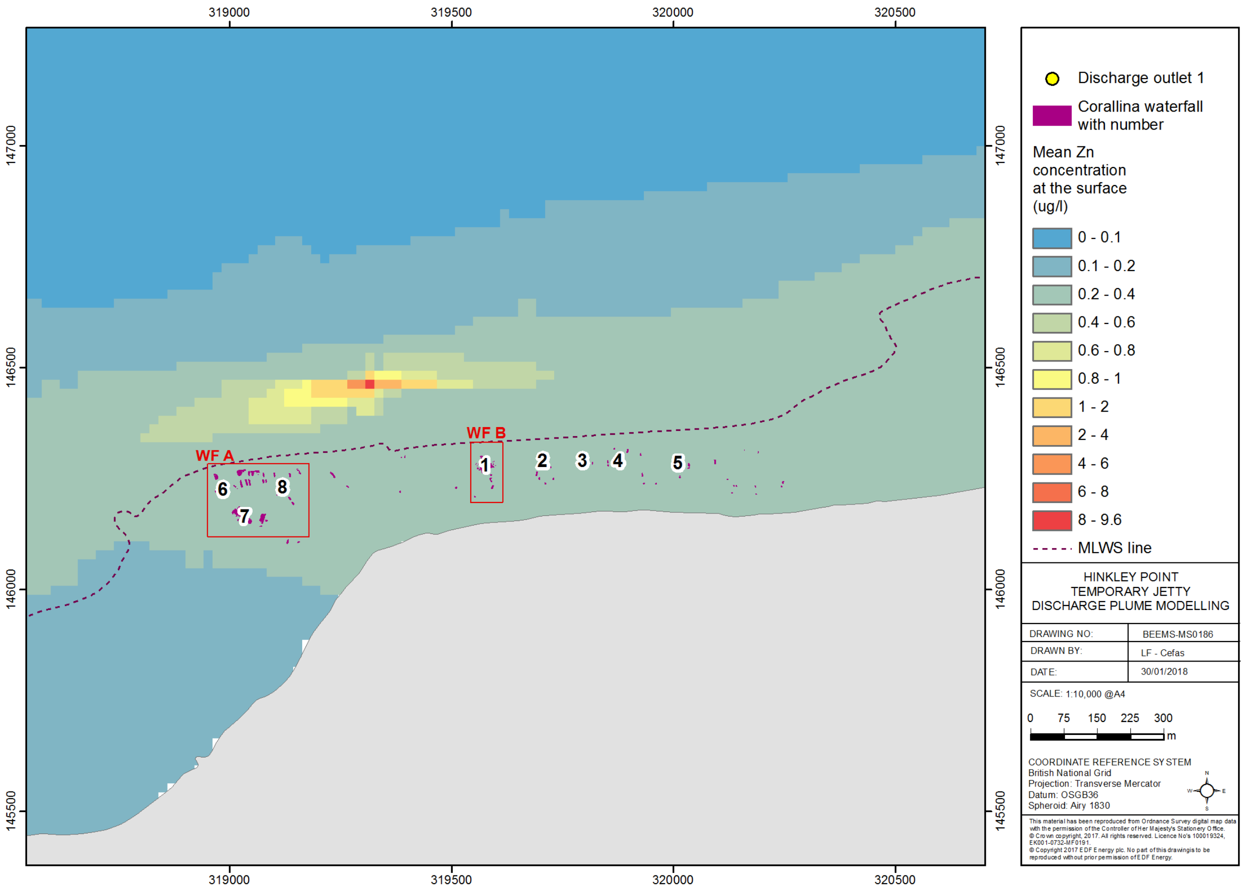

Figure 5.2: The spatial distribution of the discharge plume showing average surface concentrations of zinc for Case C in relation to the *Corallina* features. The plot shows concentrations above background levels, as such the EQS reference value is 3.77 μg l^{-1} and is exceed in a small area by the 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 5.2.6). 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

[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).

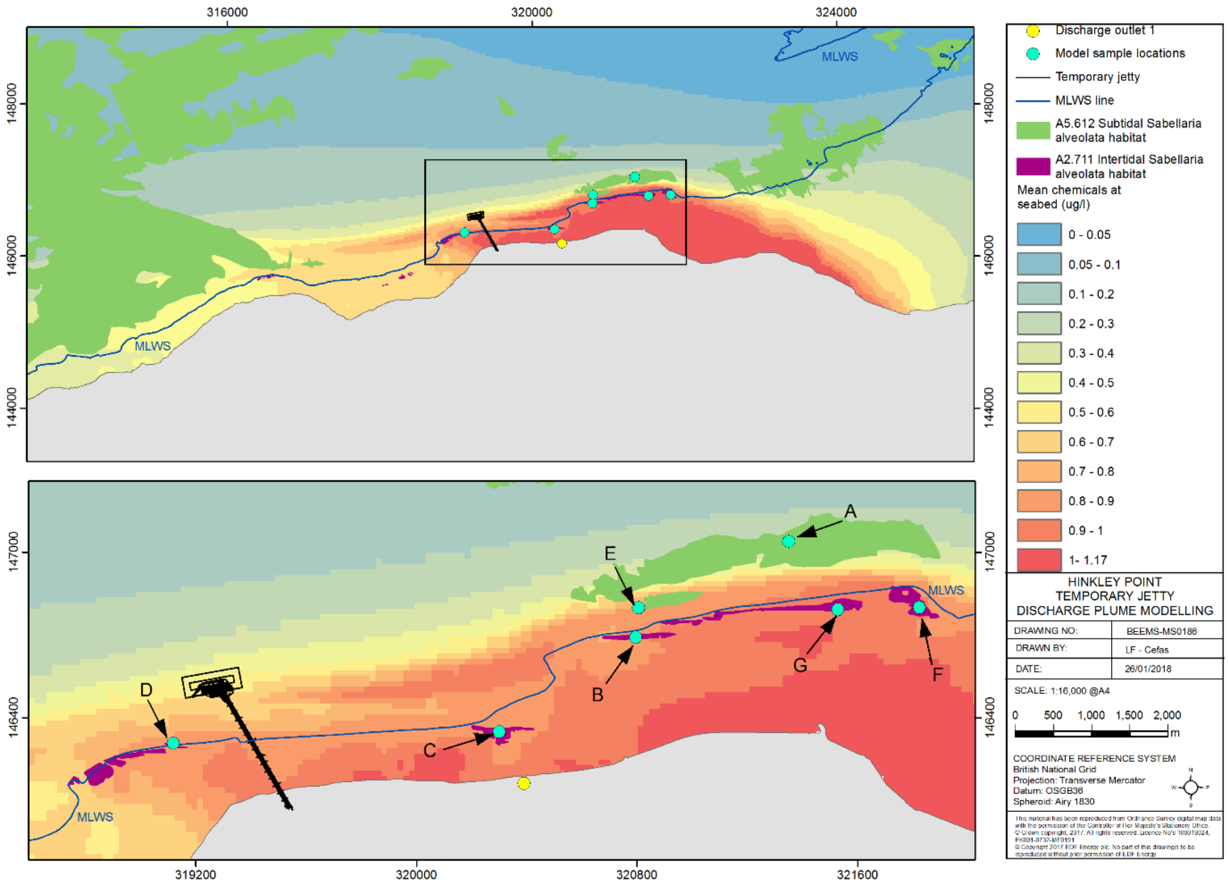

Figure 6.1: The spatial distribution of the discharge plume showing average (mean) seabed concentration of Condat CLB F5/M (µg l^{-1}) for Case D. The locations of *Sabellaria* features are delineated. Subtidal *Sabellaria* patches A and E and intertidal *Sabellaria* patch B, C, and D, F, and G are marked. 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

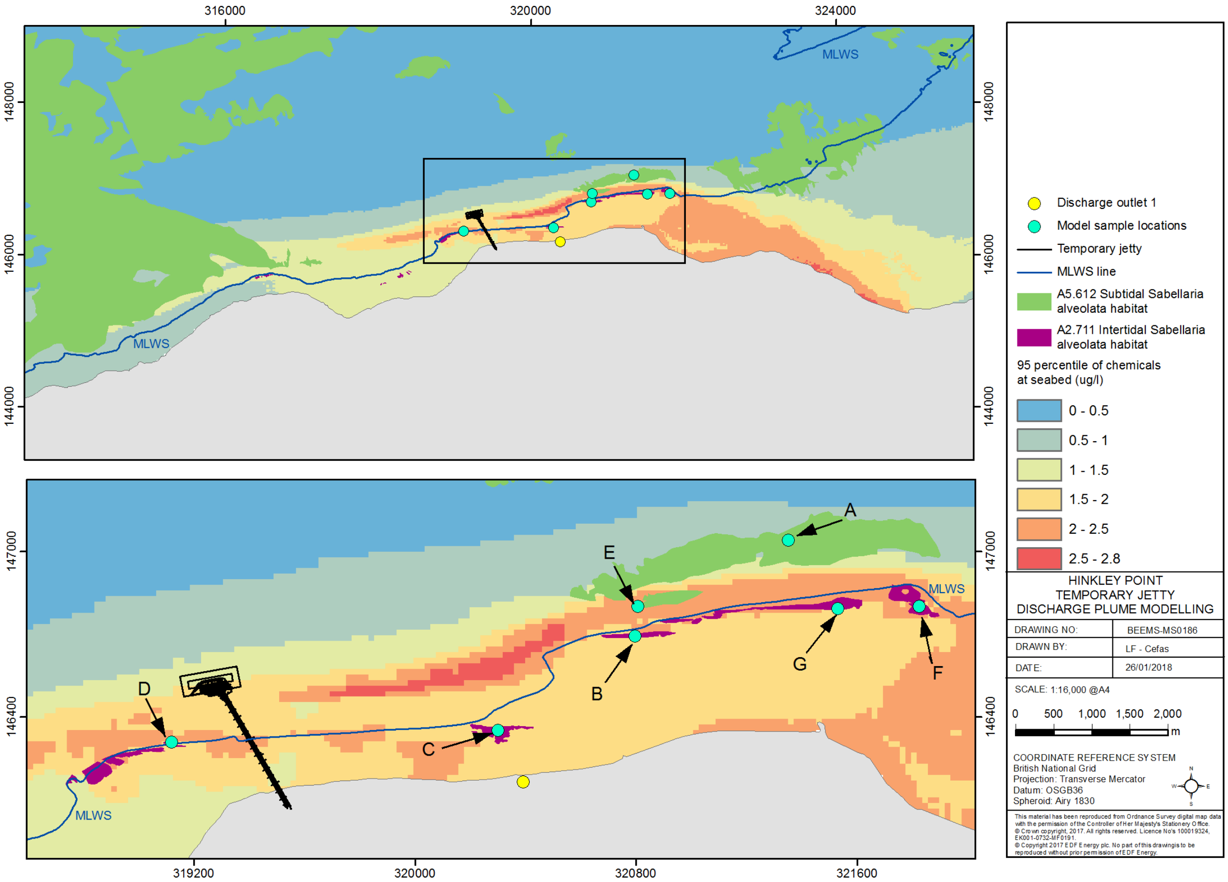

Figure 6.2: The 95%ile for seabed concentrations of Condat CLB F5/M (µg l^{-1}). The locations of *Sabellaria* features are delineated. Subtidal *Sabellaria* patches A and E and intertidal *Sabellaria* patch B, C, and D, F, and G are marked. The PNEC (proxy EQS) for Condat CLB F5/M is 4.5 µg l^{-1} and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

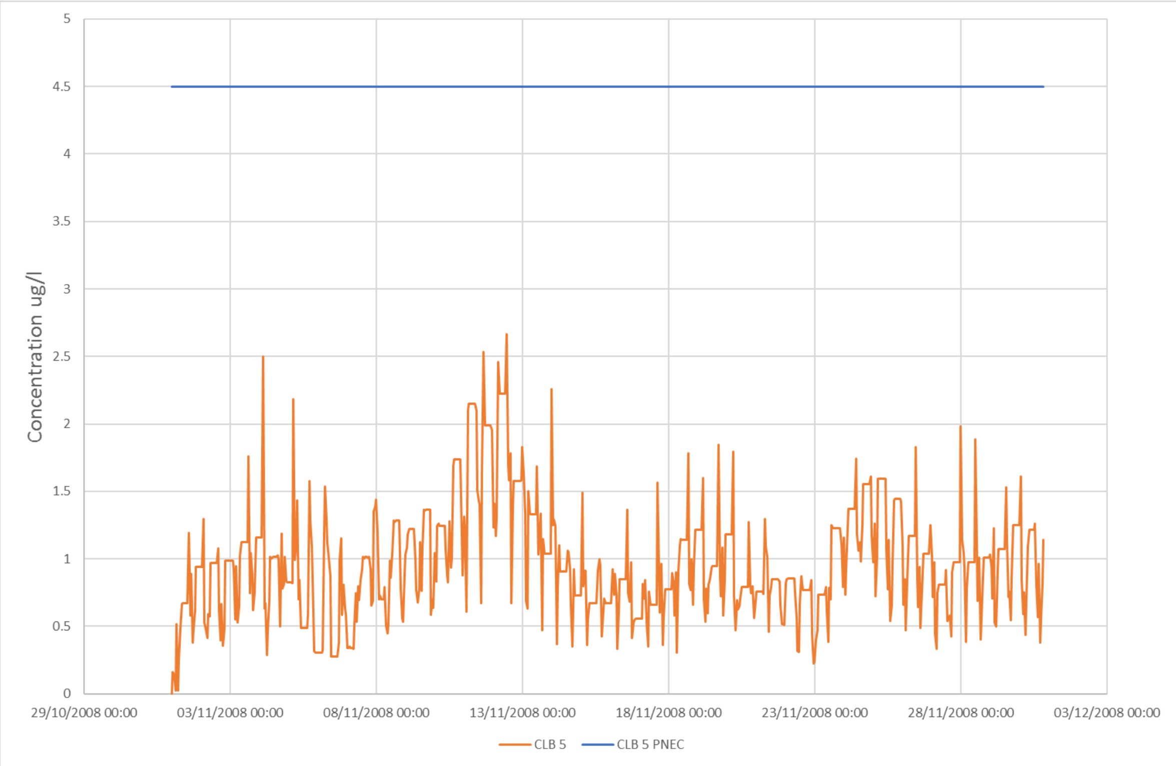

Figure 6.3: Concentration time series of Condat CLB F5/M at location G (µg l^{-1}) showing the proxy EQS of 4.5 µg l^{-1} (PNEC).

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.

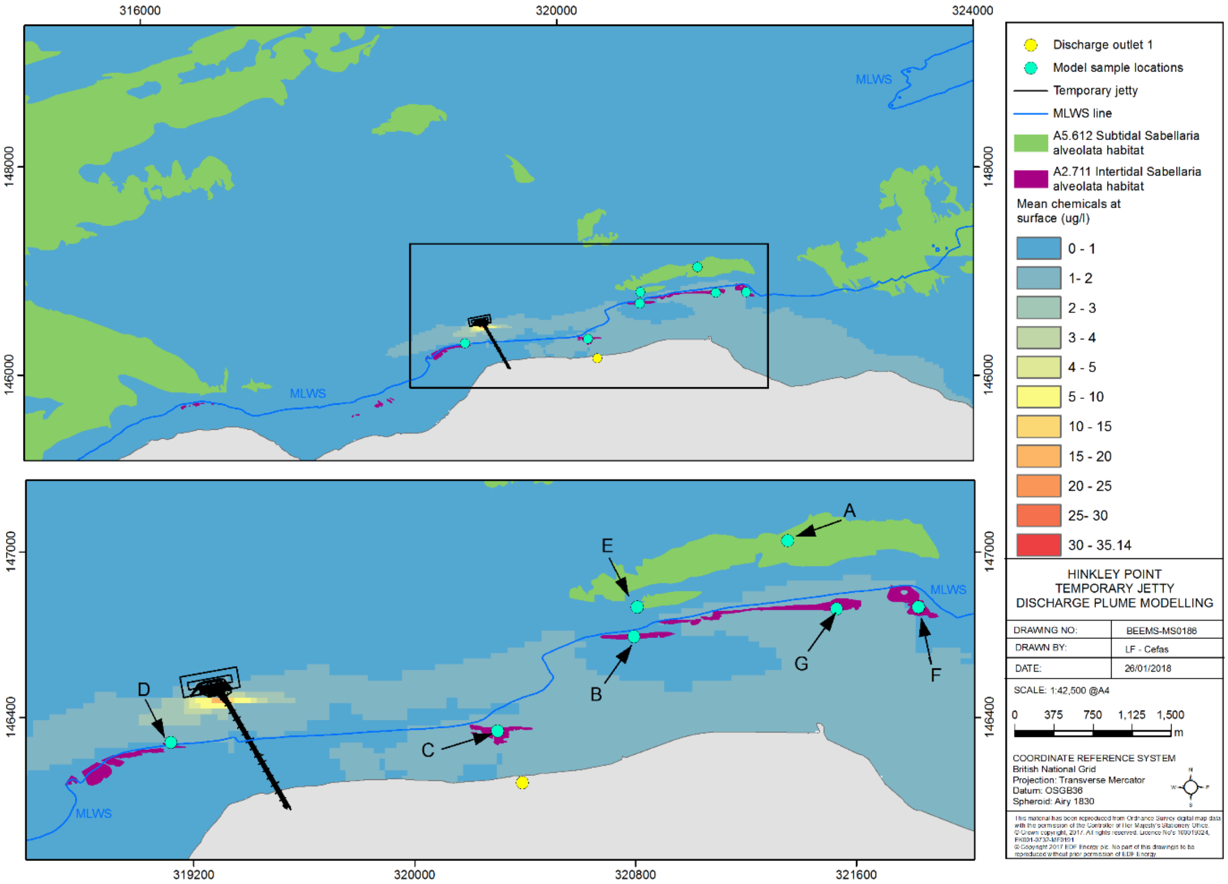

Figure 6.4: The spatial distribution of the discharge plume showing average sea surface concentration of Condat CLB F5/M (µg l^{-1}) during Case D. The EQS for Condat CLB F5/M is 4.5 µg l^{-1}.

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).

[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.

7.2.2 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.

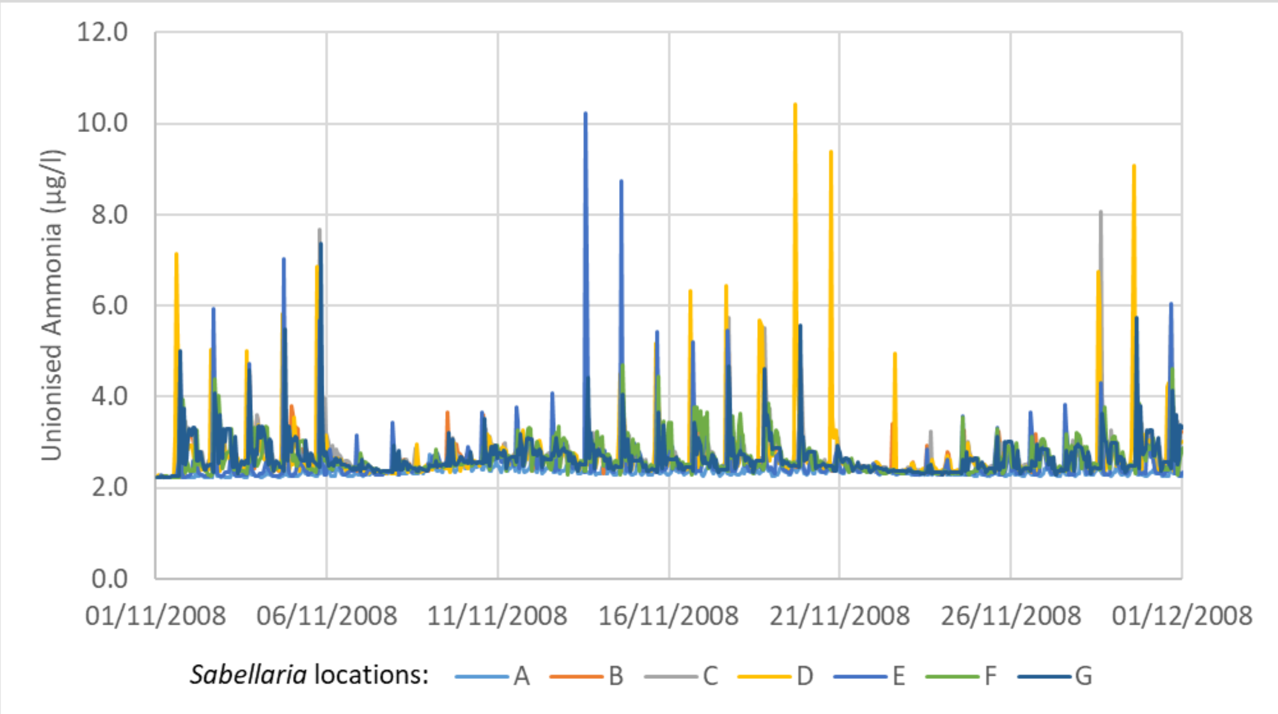

Figure 7.1: Time series of un-ionised ammonia at the locations of *Sabellaria* for the 38 l s^{-1} at 80 mg l^{-1}+70 l s^{-1} at 271 mg l^{-1} scenario using mean conditions of temperature, salinity, and pH. This plot represents an alternative sewage flow rate (described in TR581) but not implemented,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

7.2.6 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.

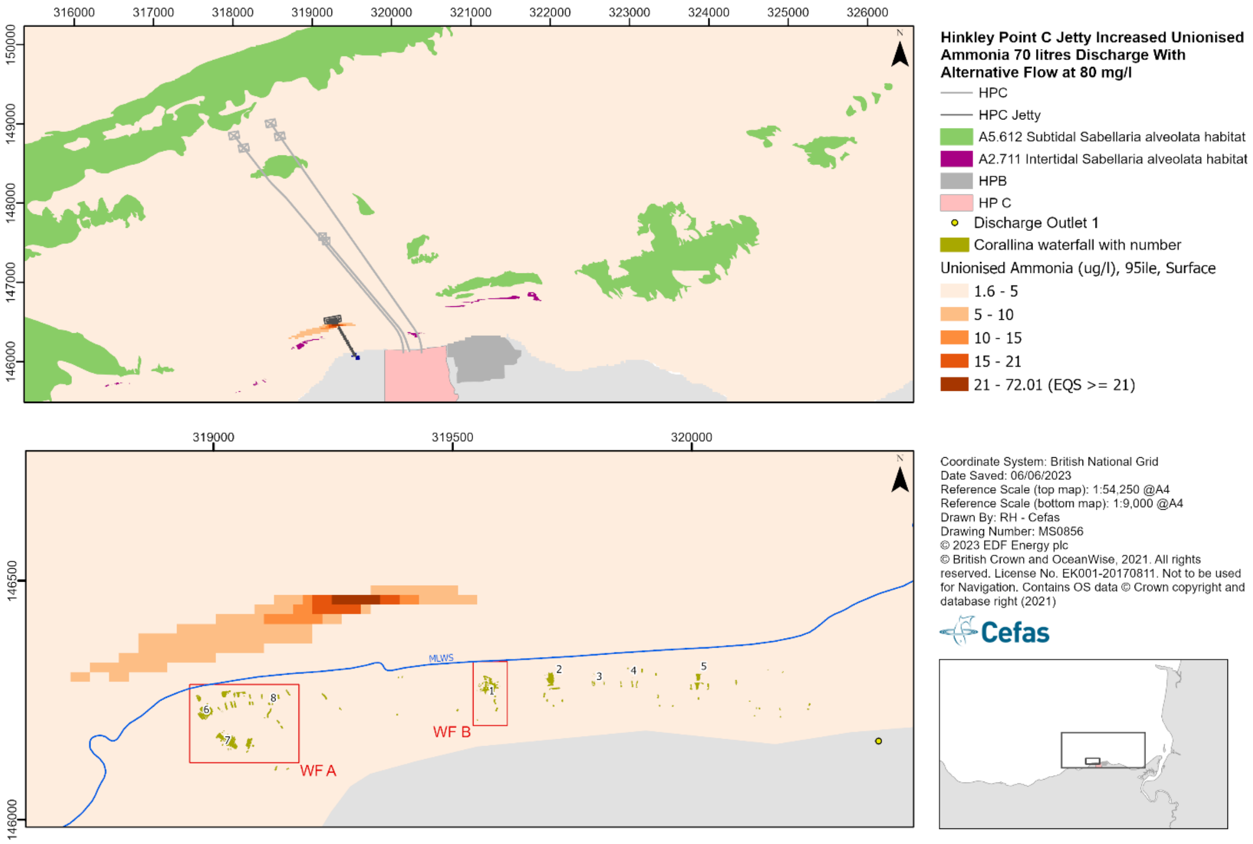

Figure 7.2: Un-ionised Ammonia Surface. 38 l s^{-1} at 80 mg l^{-1}+ 70 l s^{-1} at 271 mg l^{-1}) 95th Percentile. *Corallina* waterfalls are labelled 1 – 8, the two waterfall locations are boxed as Waterfall A and Waterfall B.

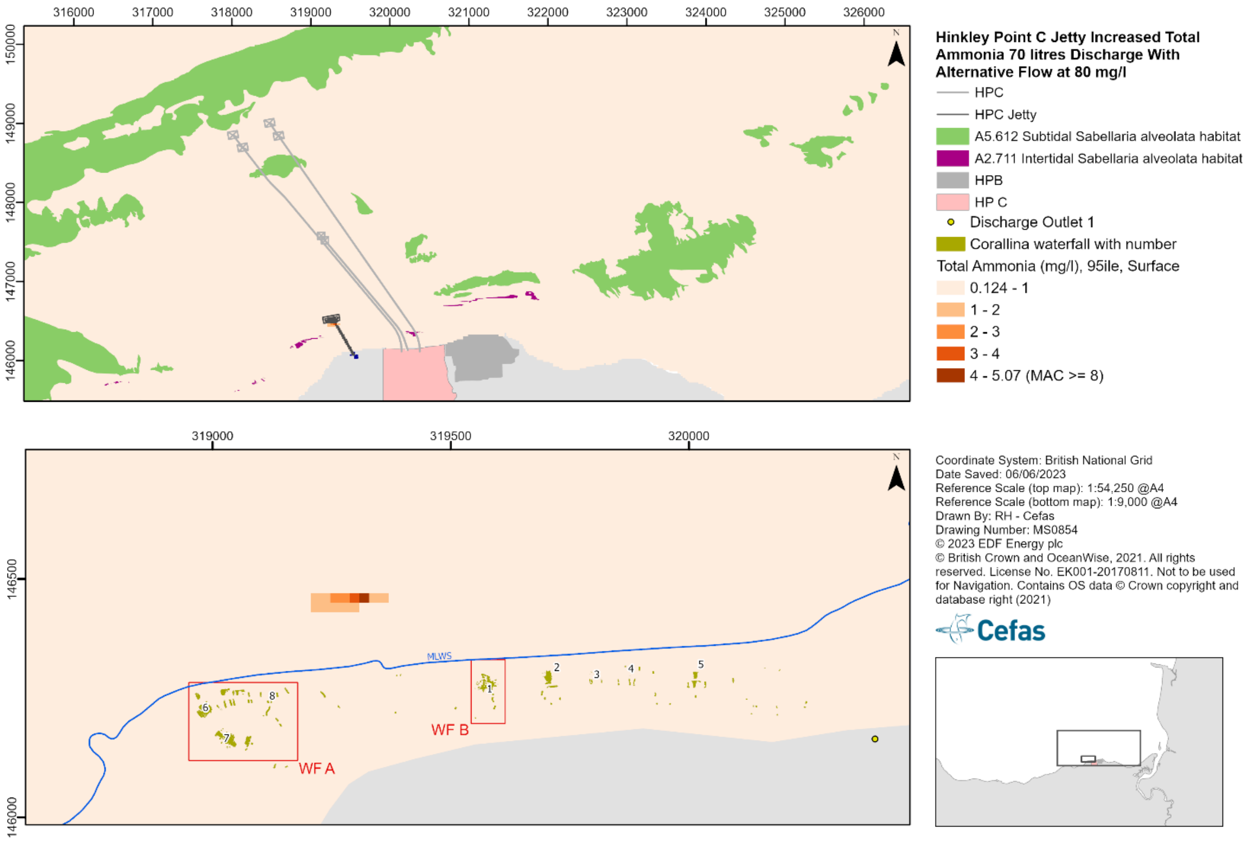

Figure 7.3: Total Ammonia Surface. (38 l s^{-1} at 80 mg l^{-1}+ 70 l s^{-1} at 271 mg l^{-1}) 95th Percentile. *Corallina* waterfalls are labelled 1 – 8, the two waterfall locations are boxed as Waterfall A and Waterfall B.

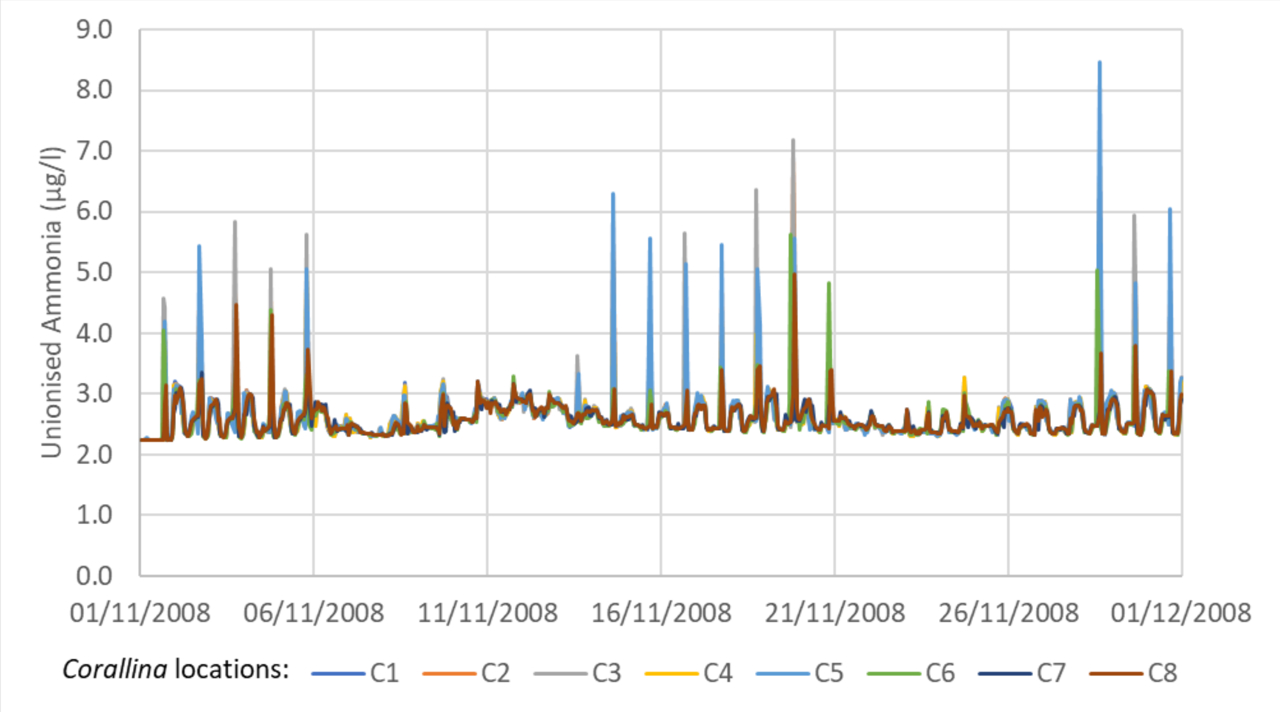

Figure 7.4: Time series of un-ionised ammonia at the locations of *Corallina* for the 38 l s^{-1} at 80 mg l^{-1}+70 l s^{-1} at 271 mg l^{-1}. This plot represents an alternative sewage flow rate (described in TR581) but not implemented, and therefore is conservative. The relevant EQS is 21 µg l^{-1}.

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.

7.2.7 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). 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[12].

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 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

[12] 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.

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 $\mu g\ l^{-1}$)	0.3 ha	within 5m	Loc 4 mean 0.12 $\mu g\ l^{-1}$ Loc 2 max 0.64 $\mu g\ l^{-1}$	Loc 4 mean 0.12 $\mu g\ l^{-1}$ Loc 2 max 0.64 $\mu g\ l^{-1}$	n/a	Loc G mean 0.11 $\mu g\ l^{-1}$ Loc E 95% 0.28 $\mu g\ l^{-1}$
Mean un-ionised ammonia based on 38l s^{-1} (Case D) + 37 l s^{-1} commissioning (EQS 21 $\mu g\ l^{-1}$ 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 $\mu g\ l^{-1}$ as mean)	no exceedance	no exceedance	Loc 5 Mean 2.34 $\mu g\ l^{-1}$	n/a	Loc C Mean 2.40 $\mu g\ l^{-1}$	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 $\mu g\ l^{-1}$	n/a	Loc G 95% 3.03 $\mu g\ l^{-1}$	
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 $\mu g\ l^{-1}$)	0.19 ha	no exceedance	n/a	n/a	n/a	loc G mean 2.90 $\mu g\ l^{-1}$ loc E 95% 7.12 $\mu g\ l^{-1}$
TBM CLB F5 (Case D) (EQS 4.5 $\mu g\ l^{-1}$)	1 ha	no exceedance	n/a	n/a	n/a	loc G mean 0.97 $\mu g\ l^{-1}$ loc E 95% 2.37 $\mu g\ l^{-1}$

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

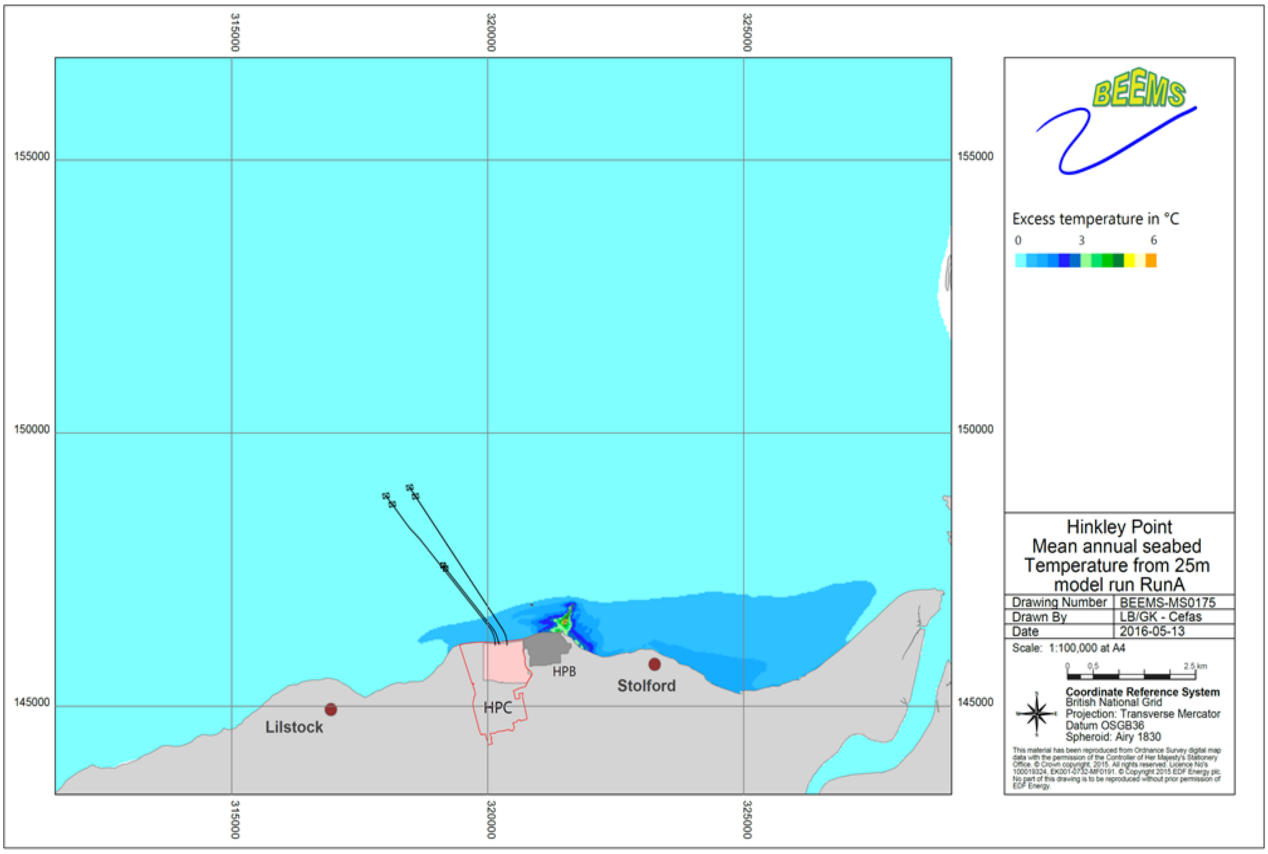

Figure 9.1: Mean excess temperature at the seabed due to HPB discharges from high resolution 25 m model, BEEMS Technical Report TR267.

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, chromium 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[13] 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 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. Non-toxic contamination effects, for example by nutrients, salinity or temperature were excluded following investigation of nutrient inputs with a phytoplankton model. 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

[13] 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.

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, 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 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

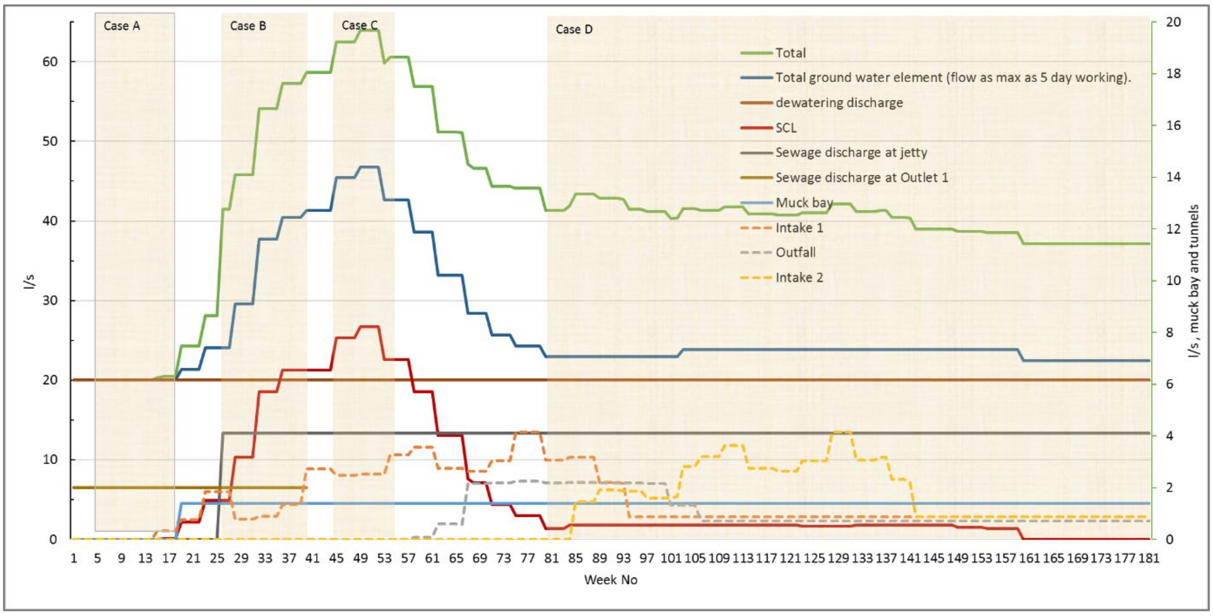

Figure 10.1: Likely flow volumes discharged at the jetty location from the start of tunnelling. Discharge volumes from 'Muck Bay' and TBM tunnelling for HPC intake 1, outfall and intake 2 are shown on the right-hand axis. Timing is according to August 2017 scheduling and selected scenarios for assessment 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 calculation 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

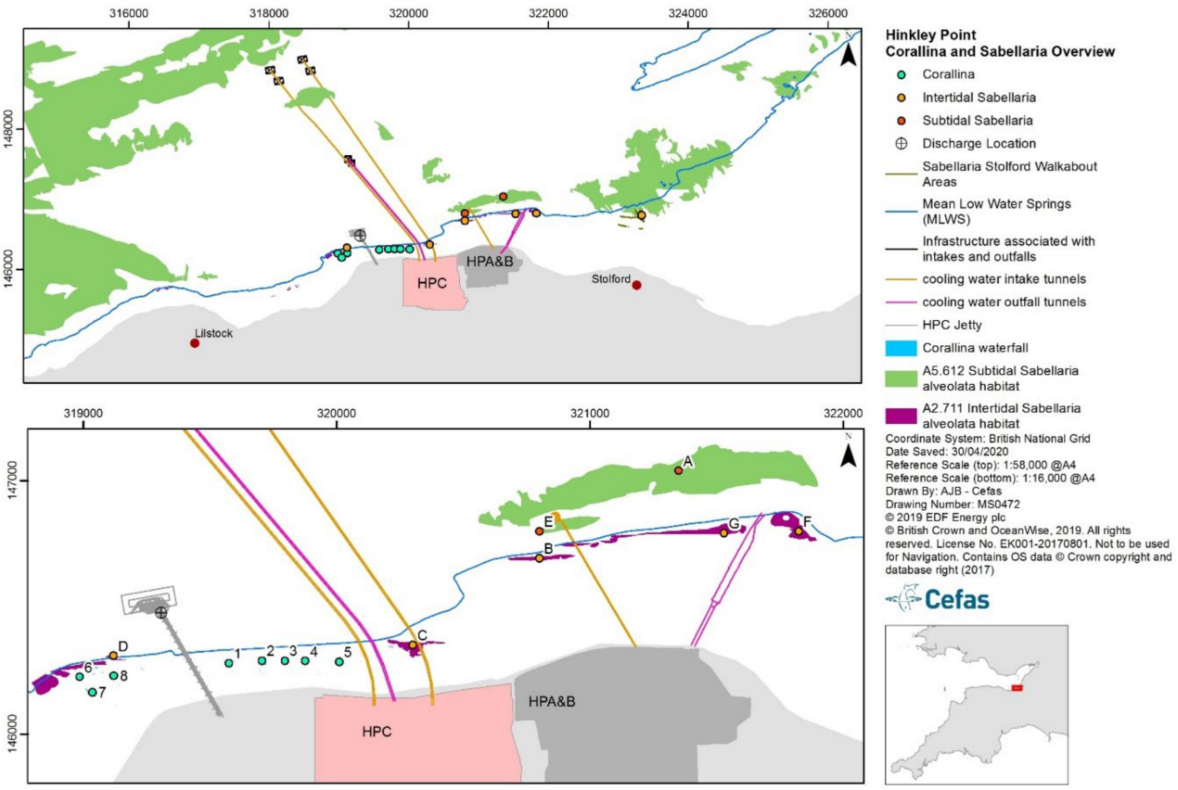

Figure 10.2: Location of subtidal and intertidal *Sabellaria alveolata* around Hinkley Point. Locations A and E are subtidal; locations B, C, D, F and G are intertidal) (BEEMS Technical Report TR445).