Thurrock Flexible Generation Plant

Environmental Statement Volume 6
Appendix 17.1: Phase 1 Intertidal Survey Report and Benthic Ecology Desktop Review

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Environmental Impact Assessment

Environmental Statement

Volume 6

Appendix 17.1

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Summary

This document reports the findings of an intertidal habitat survey of the proposed causeway location and the physical and chemical analysis of sediment samples taken at this location. It also provides a characterisation of benthic subtidal and intertidal ecology and sediment chemistry in the wider area, based on historic datasets from this part of the Thames Estuary.

Qualifications

This document has been prepared by Samantha Tuddenham, a marine consultant at RPS who has two years' experience of marine ecology and environmental impact assessment.

It has been checked by Kevin Linnane who is a Principal Marine Ecologist at RPS, with a doctorate in intertidal ecology and over 10 years' experience in marine consultancy offering specialist marine environmental services to a wide variety of sectors.

1. Introduction

1.1 Background

1.1.1 Thurrock Power Ltd ('Thurrock Power') has instructed RPS to undertake a Phase 1 intertidal walkover survey and Phase 2 sediment sampling in support of a Development Consent Order (DCO) application, and associated deemed marine licence (DML), for the Thurrock Flexible Generation Plant in Thurrock, Essex.

1.1.2 Thurrock Power is proposing to develop a new Flexible Generation Plant near Tilbury, Essex. The proposal includes the construction of a new causeway within the Thames Estuary, which will be used alongside a new haul road for barges delivering construction materials on site. The causeway will pass down the intertidal zone towards the low tide mark and will involve works below Mean High Water Springs (MHWS). The survey area is shown in Figure 1.1.

1.2 Survey Objectives

1.2.1 The Phase 1 intertidal walkover survey was carried out in order to characterise the marine ecology baseline from mean low water springs (MLWS) to MHWS in the vicinity of the proposed causeway and to identify any sensitive ecological receptors. In addition, Phase 2 sediment sampling has been undertaken in order to characterise the sediment composition, including sediment bound contaminants, within the footprint of the causeway. The purpose of the survey was to inform an impact assessment in support of DCO application, and associated DML.

1.2.2 This report also provides a characterisation of benthic subtidal and intertidal ecology and sediment chemistry in the wider area, based on historic datasets from this part of the Thames Estuary. These desktop data sources provide additional context for the site-specific survey data as discussed in Section 6.

Figure 1.1: Thurrock phase 1 intertidal walkover and phase 2 sediment sampling survey area.

2. Methodology

2.1 Intertidal Survey

2.1.1 A Phase 1 intertidal survey was undertaken on 16 August 2019 at the proposed causeway location for the Thurrock Flexible Generation Plant (1.1). Access to the foreshore for the survey was via a public footpath running along the seawall to the west of the site.

2.1.2 The survey was undertaken according to standard intertidal survey methodologies as outlined in the Joint Nature Conservation Committee (JNCC) Marine Monitoring Handbook (Davies et al., 2001) within Procedural Guidance No 3-1 In situ intertidal biotope recording (Wyn and Brazier, 2001; Hiscock, 2001) and The Handbook for Marine Intertidal Phase 1 Biotope Mapping Survey (Wyn et al., 2006). The survey was carried out by two suitably qualified ecologists experienced in habitat mapping in intertidal, coastal and terrestrial environments, approximately two hours either side of low water to ensure as much of the intertidal zone was sampled as possible.

2.1.3 The intertidal survey comprised both a general walkover noting changes in ecological and physical characteristics and dig-over macrofauna sampling. All conspicuous macrofauna species present were identified and enumerated on site. Field notes were also taken on the physical characteristics, including sediment type and presence of anoxic layers beneath the sediment surface. During the walkover survey, notes were made on the shore type, wave exposure, sediments/substrates present and descriptions of species/biotopes present. The spatial relationships between these features were observed and waypoints were recorded by a hand-held global positioning system (GPS) device, in conjunction with hand-written descriptions and photographs. All biotopes present were identified and their extents mapped with the aid of aerial photography and the hand-held GPS recorder. Any other features within the intertidal zone were also noted including man-made structures and any habitats/species of conservation importance.

2.1.4 Phase 2 sediment core sampling was also undertaken in order to characterise the sediment type and contaminant loads in vicinity of the proposed causeway. In line with consultation on the intertidal method statement with the Marine Management Organisation (MMO) and Port of London Authority (PLA) three sediment cores were collected and analysed along the proposed causeway footprint. These are shown in Figure 2.1 and were analysed at RPS labs for the determinants outlined in Section 2.2.

2.1.5 Sample locations were selected from within the survey area, ensuring they are representative of the sediments present, while also taking into account the accessibility of the intertidal mudflats present. Samples were taken using a sediment corer, transferred into appropriate sample containers, labelled and sent to a suitably qualified laboratory for analysis.

Figure 2.1: Location of samples taken for sediment chemistry

2.2 Sediment chemistry analysis

2.2.1 Phase 2 sediment core sampling will be transferred to RPS laboratory services for analysis. Samples will then be analysed for the following contaminants:

- Metals;
- Polychlorinated biphenyl (PCB) congeners and International Council for the Exploration of the Sea 7 (ICES7);
- Organotins;
- Physical parameters;
- Particle Size Analysis;
- Total Hydrogen Content (THC) by fluorescence spectrometry
- Polycyclic aromatic hydrocarbons (PAH); and
- Organochlorine pesticides.

2.2.2 The RPS laboratory has United Kingdom Accreditation Service (UKAS) accreditation to carry out the tests for all the contaminants listed and is accredited by the MMO for the all listed contaminant groups except for PCBs, THC, PAHs and organochlorine pesticides. The list of contaminants above is also in line with the sediment chemistry analysis requirements of the PLA for dredging operations in the Thames.

2.3 Timing

2.3.1 The fieldwork was undertaken during the optimal survey period for intertidal biotope mapping surveys of April to October to allow for macroalgal spring growth (Wyn et al., 2006). The intertidal survey was conducted approximately two hours either side of the morning low water spring tide on the 16 August 2019 (low tide times and heights are presented in Table 2.1).

Table 2.1: Low tide times survey the intertidal survey

Date	Daylight House		Time Local	Height (m)
Friday 16 August 2019	Sunrise 05.47	HW	02:22	6.37
		LW	08:34	1.01

2.4 Health and Safety

2.4.1 The survey staff adhered to the Risk Assessment and Method Statement. A site-specific risk assessment was performed on arrival at the survey location, prior to any work being carried out. All survey staff were experienced field scientists and were aware of tidal constraints at the site. The staff wore or carried the required personal protective equipment, as necessary. No accidents, incidents or near-misses occurred during the intertidal survey.

2.5 Habitats of Importance

2.5.1 The middle Thames Estuary, in which the Thurrock development is situated, is heavily industrialised for national and international trade and development. It is a dynamic environment with a strong tidal influence and large seasonal freshwater input. Generally, the habitats found there are estuarine habitats, including mudflats, sandflats, intertidal creeks, saline lagoons and saltmarsh.

2.5.2 There are no Marine Conservation Zones (MCZ) or Special Areas of Conservation (SAC) in the vicinity of the proposed development site. There are no marine Sites of Special Scientific Interest (SSSI) overlapping with the survey area, however the Mucking Flats and Marshes SSSI is approximately 3 km downstream (east) from the Thurrock site and is designated for its uncommon saltmarsh habitat and large intertidal feeding area for wintering wildfowl. The West Thurrock Lagoon & Marshes SSSI is approximately 7.5 km upstream (west) which is designated for its saltmarsh habitat. There are no Special Protection Areas overlapping with the survey area however the Thames Estuary and Marshes Special Protection Area (SPA) is approximately 3 km downstream and is designated for its overwintering bird assemblage as a wetland of international importance.

3. Survey Results

3.1 Summary

3.1.1 The intertidal survey area is located in a very sheltered area on the north bank of the Thames Estuary to the east of Tilbury Docks. The intertidal zone was characterised by extensive mud flats with discrete areas of mixed and hard substrates. Saltmarsh habitats were present at the upper shore with mixed sediments, artificially placed boulders and fucoid seaweed habitats characterising a narrow strip in the mid shore and mud flats dominating in the mid to lower shore. Zonation was clearly evident down the shore, with distinct boundaries of the saltmarsh and mudflats.

3.1.2 The following sections describe the intertidal survey area, including a description of the biotopes which are classified by the sediment composition and faunal communities. The MNCR SACFOR scale has been used to give a comparable, ecologically based estimate of species abundance in each biotope (JNCC, 2004). The extents of biotopes identified have been mapped and are shown in Figure 3.10, with a summary of the biotopes identified presented in Table 3.1.

3.2 Upper Shore

3.2.1 A concrete seawall (approx. 2.4 m in height) was present at the northern boundary of the survey site with a concrete access path on the seaward side. The northernmost section of the survey area was recorded as a band of established saltmarsh (LS.LMp.Sm; Figure 3.1). This area was dominated by saltmarsh plants including shrubby sea-blite (*Suaeda maritima*), cord-grass (*Spartina anglica*), sea aster (*Aster tripofolium*) and glasswort (*Salicornia sp*.). The saltmarsh had a distinct boundary of a <1 m soft vertical cliff on the seaward side, to the mid-shore intertidal area as result of erosion from the tidal wave action (visible in background of Figure 3.2).

Figure 3.1: Established Saltmarsh at the northern boundary of the survey area

3.3 Mid Shore

3.3.1 In the mid shore, a narrow band of rock and mixed sediment habitats occur immediately below the saltmarsh (i.e. at the foot of the soft vertical cliff), separating the saltmarsh from the extensive mudflat characterising much of the intertidal (Figure 3.2). The most abundant biotopes in the mid shore were *Fucus vesiculosus* on moderately exposed to sheltered mud eulittoral rock (LR.LLR.F.Fves) and Low Energy Littoral Rock (LR.LLR).

3.3.2 LR.LLR.F.Fves (Figure 3.2) was found in four distinct areas across the mid shore over the whole width of the survey area. This habitat consisted of large artificially placed boulders (rock protection) overlying mixed sediments. The species composition was dominated by a dense canopy of superabundant fucoid seaweeds, primarily *Fucus vesiculosus*. It also contained frequent spiral wrack (*Fucus spiralis*) on the upper extents of the biotope and frequent *Ulva lactuca* on the lower extent of the biotope. A single gammarid amphipod (i.e. *Echinogammarus marinus*) was also observed in this biotope. At the western edge of the survey area, egg wrack (*Ascophyllum nodosum*) was found to be present (occasional abundance) at the lower extent of the fucoid seaweeds and *F. spiralis* was present (occasional abundance) at the upper extent of the fucoid seaweeds. In this part of the survey area, these boulders were overlying muddy sediments, found to be characterised by the intertidal mud biotope LS.LMu.MEst.HedMacScr, which characterised most of the intertidal (Figure 3.4; Section 3.4 below).

3.3.3 The LL.LLR biotope was found across the centre of the mid shore survey area. The habitat consisted of large artificially placed boulders overlying mixed sediments forming a steeper slope right up to the saltmarsh extent, compared to the LR.LLR.F.Fves habitat (Figure 3.3). Fucoid seaweeds were absent with extensive bare rock frequent green algal matting. The rough periwinkle *Littorina saxatilis* were occasional with individuals present in small groups, the largest of which was no more than 30 individuals per m^2. *U. lactuca* was occasional on the lower extent of the habitat.

3.3.4 The *Hediste diversicolor* in littoral gravelly muddy sand and gravelly sandy mud (LS.LMx.GvMu.HedMx) biotope was found along the mid shore, as narrow strips among the LL.LLR and LR.LLR.F.Fves habitats. The habitat consisted of mixed sediment and gravel overlaying mud (Figure 3.5). No anoxic layer or fauna were observed in the dig over samples taken in these areas although the underlying mud and proximity to the mudflat habitats makes it possible that *H. diversicolor* were present. Occasional fucoid seaweeds and *Scrobicularia plana* shells were on the surface of the sediment. This is considered to be a transition biotope between the upper/mid shore mixed sediments and the lower shore biotopes (discussed in Section 3.4 below).

3.3.5 At the top of the mid shore, at the eastern boundary of the survey area, there was a strandline (LS.LSa.St) on course sand and mixed sediments, roughly 10 m long (Figure 3.10; Figure 3.6). Sandhoppers (*Talitrus s*p.) were abundant within the washed up fucoid seaweed, with broken glass and plastics also present in the strandline.

Figure 3.2: *Fucus vesiculosus* on moderately exposed to sheltered mud eulittoral rock LR.LLR.F.Fves. Saltmarsh habitat in background.

Figure 3.3: Low Energy Littoral Rock LR.LLR

Figure 3.4: Boundary between LS.LMu.MEst.HedMacScr and LR.LLR.F.Fves at the western boundary of the survey area.

Figure 3.5: Mixed sediment biotope (LS.LMx.GvMu.HedMx) in the midshore.

Figure 3.6: Strandline (LS.LSa.St) at the upper mid shore

3.4 Lower Shore

3.4.1 The majority of the mid and lower shore was found to be characterised by a wide mud flat which extends down to low water. The shore side of the mud flats, covering the larger proposition of the lower shore within the survey area, was classified as the *Hediste diversicolor*, *Macoma balthica* and *Scrobicularia plana* in littoral sandy mud biotope (LS.LMu.MEst.HedMacScr). This area comprised soft sandy mud up the mid shore with a shallow anoxic layer (approx. 10 cm from the surface). The estuarine rag worm (*H. diversicolor*) and the furrow shell bivalve (*Scrobicularia plana*) were abundant in the sediment samples taken within this area (Figure 3.7).

3.4.2 Further sea-ward on the lower shore, the sediments become more exposed to the tidal currents and muddy sediments were observed to be slightly more consolidated. There was a shallow ridge observed in the lower shore, which broadly marked the end of the LS.LMu.MEst.HedMacScr biotope; Figure 3.8). No fauna were observed in the sediment samples taken on the seaward side of this sediment ridge (ST01 and ST02; Figure 2.1) and the anoxic layer was at the surface (Figure 3.9). This part of the survey area was classified as the Littoral Mud biotope (LS.LMu; see Figure 3.10).

Figure 3.7: ***S. plana*** **shell and siphon marks on the surface of the mud.**

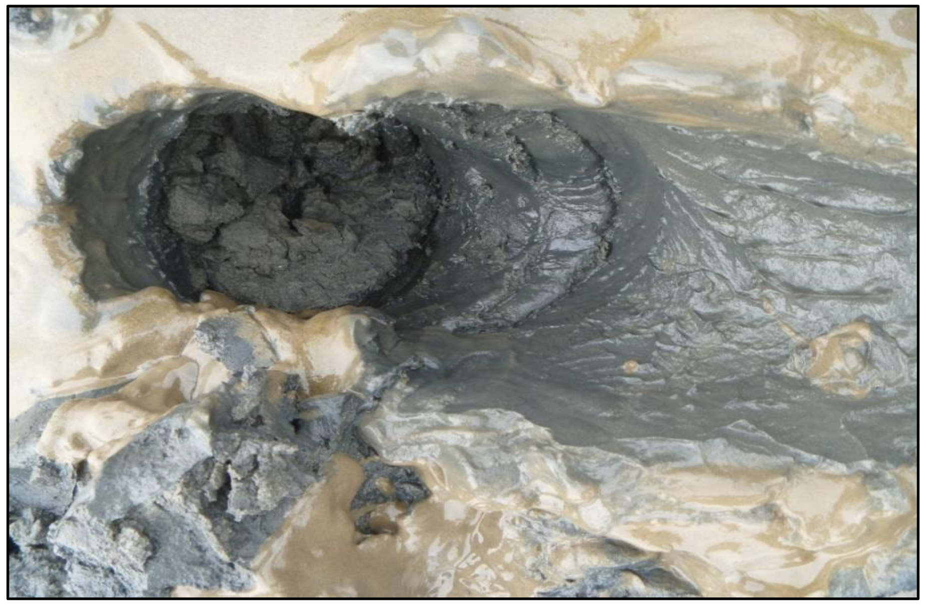

Figure 3.9: Anoxic layer at the surface of the Littoral Mud at ST01

Figure 3.8: Sediment ridge in the lower shore mud flats where the sediments became more consolidated.

Table 3.1: Littoral Biotopes present as described by JNCC (JNCC, 2019)

Shore position	Biotope/NVC Code	Biotope Name	Biotope Description (JNCC, 2019)
Upper Shore	LS.LMp.Sm	Saltmarsh	Angiosperm-dominated stands of vegetation, occurring on the extreme upper shore of sheltered coasts and periodically covered by spring high tides. Saltmarshes are located on the upper shore above sheltered sand, muddy sand, mud, and more marine biotopes. They are generally confined to estuaries and other sheltered marine inlets.
Mid Shore	LR.LLR.F.Fves	*Fucus vesiculosus* on moderately exposed to sheltered mid eulittoral rock	Moderately exposed to very sheltered mid eulittoral bedrock and large boulders characterised by a dense canopy of the wrack *Fucus vesiculosus*.
	LS.LMx.GvMu.HedMx	*Hediste diversicolor* in littoral gravelly muddy sand and gravelly sandy mud	Sheltered gravelly sandy mud, subject to reduced salinity, mainly on the mid and lower shore (although at the Thurrock intertidal survey area, in the mid shore, just below the saltmarsh). The infaunal community is dominated by abundant ragworms *Hediste diversicolor*.
	LR.LLR	Low energy littoral rock	Sheltered to extremely sheltered rocky shores with very weak to weak tidal streams. At the Thurrock intertidal survey area, no seaweed (e.g. fucoids) were recorded in this biotope.
	LS.LSa.St	Strandline	Line of dead and decomposing fucoid seaweed and debris deposited at the retreat of high tide on barren shingle and mixed sediments. Sandhoppers present within seaweed.
Lower Shore	LS.LMu.MEst.HedMacScr	*Hediste diversicolor, Macoma balthica* and *Scrobicularia plana* in littoral sandy mud	Mainly mid shore mud or sandy mud subject to variable salinity on sheltered estuarine shores. Typically, the sediment is wet in appearance and has an anoxic layer below 1 cm depth. Contains *Scrobicularia plana*.
	LS.LMu	Littoral mud	Shores of fine particulate sediment, mostly in the silt and clay fraction. Littoral mud typically forms extensive mudflats. Little oxygen penetrates these cohesive sediments, and an anoxic layer is often present within millimetres of the sediment surface.

Figure 3.10: Biotopes within the Thurrock Intertidal Survey Area

4. Habitats of Conservation Importance

4.1.1 The following habitats of conservation importance have been considered in the context of the intertidal biotopes identified at the proposed causeway location.

Saltmarsh

4.1.2 Saltmarsh habitats were present in the upper shore of the survey area, including overlapping the footprint of the proposed causeway. Saltmarsh habitats are offered protection by conservation legislation, being listed as a habitat of principal importance under the Natural Environment and Rural Communities (NERC) Act 2006. This is also listed as a UK Biodiversity Action Plan Priority habitat. Saltmarsh is also an Annex I habitats under the EU Habitats Directive however it should be noted that the saltmarsh within the survey is not within a SAC.

4.1.3 Saltmarsh habitats are features of designated sites within the Thames Estuary. Mucking Flats and Marshes SSSI is approximately 3 km away and is designated for its uncommon saltmarsh habitat. The West Thurrock Lagoon & Marshes SSSI is approximately 7.5 km away and is also designated for its saltmarsh habitat. Despite their protection status, the saltmarshes of the Thames estuary have experienced rapid erosion and internal segmentation in recent years (Van Der Wal and Pye, 2004).

Intertidal mudflats

4.1.4 Intertidal mudflats are offered protection by conservation legislation, being listed as a habitat of principal importance under the Natural Environment and Rural Communities (NERC) Act 2006. This is also listed as a UK Biodiversity Action Plan Priority habitat. Intertidal mud flats also quality as Annex I habitats under the EU Habitats Directive, however the mudflat within the Thurrock intertidal survey area is not within a SAC therefore does not qualify as an internationally important Annex I habitat. However, these habitats may provide feeding habitat for the designated bird species from the nearby European designated SPA (i.e. Thames Estuary and Marshes SPA). Intertidal birds are considered in the Thurrock onshore ecology assessment of the EIA (see Volume 3, Chapter 9: Ecology).

Fucoid habitat

4.1.5 The fucoid habitat does not contain any rare or protected species and is not protected under any conservation legislation.

5. Sediment chemistry analysis

5.1.1 As described in Section 2.2, an assessment of the physio-chemical qualities of the sediment was undertaken on samples collected from the Thurrock Flexible Generation Plant survey area. This section presents the results of the assessment along with the Cefas Action Level 1 (AL1) / Action Level 2 (AL2), which give an indication of how suitable the sediments are for disposal at sea. Contaminant levels which are below AL1 are of no concern and are unlikely to influence the marine licensing decision while those above AL2 are considered unsuitable for disposal at sea. Those between AL1 and AL2 would require further consideration before a licensing decision can be made. Sediment chemistry data were also compared to the Canadian Sediment quality guidelines (CCME, 2001), which give an indication on the degree of contamination and the likely impact on marine ecology. For each contaminant, the guidelines provide threshold effects levels (TEL), which is the minimal effect range at which adverse effects rarely occur and a probable effect levels (PEL), which is the probable effect range within which adverse effects frequently occur.

5.1.2 Where contaminant levels exceed the Cefas action levels their cells have been highlighted with the corresponding colour. Where contaminant levels exceed the Canadian TEL they have been marked with an asterisk. No contaminants were found to exceed Cefas AL2 or the Canadian PEL.

5.2 Metals

5.2.1 Heavy metals are readily adsorbed by sediments, this can lead to metals accumulating to concentrations far higher than the surrounding environment. These sediments can become re-suspended through bioturbation or through physical processes/disturbances. Metals will tend to accumulate in these fine-grained sediments and can become bioavailable to marine organisms through ingestion. The uptake of heavy metals by marine organism can lead to bioaccumulation through tropic levels leading to apex organisms accumulating metals to adverse and toxic levels. This could result in significant adverse effects including mortality, impaired reproduction, reduced growth, alterations in metabolism as a result of oxidative stress and disruption to the food chain.

5.2.2 The sediment chemistry results, presented in Table 5.1, conclude that the majority of metal contaminants in the survey area did not exceed the Cefas AL1. The main exceptions were mercury and chromium, both of which exceeded Cefas AL1 at all three sampling locations, although it should be noted that chromium was below the Canadian TEL for two of the locations. Nickel and zinc also exceeded Cefas AL1, although at one location only (i.e. ST05). Canadian TELs were also exceeded for arsenic, copper and nickel (all 3 stations) and lead (1 station only), however metal concentrations within sediments across the survey area were well below the Canadian PEL and Cefas AL2.

5.2.3 Sediment chemistry data from the adjacent Tilbury 2 development were also reviewed to provide some context for the site specific sediment chemistry data. Intertidal and subtidal ecology surveys were conducted in June 2017 for Tilbury 2. Arsenic, chromium and nickel were found to exceed Cefas AL1 in all sample sites with other metals exceeding AL1 in individual samples. Metals in all samples were well below Cefas AL2 levels, with the exception of mercury in one sample which was only just below Cefas AL2 (Port of Tilbury London Ltd, 2017). This is consistent with the slightly elevated levels of metal contamination, including mercury, found in the Thurrock Flexible Generation Plant survey.

Table 5.1: Metals recorded in samples taken from the Thurrock Flexible Generation Plant survey area,

Description (Metals)		Arsenic	Cadmium	Chromium	Copper	Lead	Mercury	Nickel	Zinc
Units		mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg
Detection Limit		0.5	0.1	0.5	0.5	0.5	0.01	0.5	3
Cefas AL1 (mg/kg)		20	0.4	40	40	50	0.3	20	130
Cefas AL2(mg/kg)		100	5	400	400	500	3	200	800
Canadian TEL(mg/kg)		7.2	0.70	52.3	18.7	30.2	0.13	15.9	124
Canadian PEL(mg/kg)		41.6	4.2	160	108	112	0.7	-	271
Sample No.	**Sample Type**								
ST02	**Core Sample**	11.2*	0.19	41.5	23.0*	19.0	0.44*	19.0*	99.4
ST04	**Core Sample**	10.0*	0.15	40.3	20.0*	17.1	0.30*	17.1*	93.6
ST05	**Core Sample**	16.8*	0.27	73.5*	37.9*	31.3*	0.50*	31.3*	158*

5.3 Organotins

5.3.1 Organotin compounds are based on tin with hydrocarbon substitutes, these include the historically used biocides dibutyltin (DBT) and tributyltin (TBT). Primarily used as antifungal and anti-fouling agents to improve the efficiency, performance and longevity of marine structures and vessels. Concerns over toxicity of these compounds to biological organisms led to the International Maritime Organisation introducing a worldwide ban. Adverse biological effects are comparable to hydrogen cyanide, whereby the compound halts cellular respiration within the mitochondria leading to cell and organism death. Legacy trace TBT and DBT can still be present within sediments in harbours and low energy environments.

5.3.2 Levels of DBT and TBT for all samples were found to be under the Cefas Action levels (Table 5.2). This is consistent with the Tilbury 2 survey which also found TBT & DBT levels well below Cefas action levels (Port of Tilbury London Ltd, 2017).

Table 5.2: Organics and organotins recorded in samples taken from the Thurrock Flexible Generation Plant survey area.

Description (DW, DBT, TBT)		dry solids (at 105°C)	total organic carbon	total hydrocarbon content by fluorescence	dibutyltin (DBT)	tributyltin (TBT)
Units		%	%	mg/kg	mg/kg DW	mg/kg DW
Cefas AL1 (mg/kg)		-	-	-	0.1	0.1
Cefas AL2(mg/kg)		-	-	-	1	1
Sample No.	**Sample Type**					
ST02	**Core Sample**	58.1	1.3	57.5	<0.005	0.00411
ST04	**Core Sample**	54.1	1.3	76.2	<0.005	0.00459
ST05	**Core Sample**	45.7	1.9	102	0.00529	0.00501

5.4 Polychlorinated biphenyls (PCBs)

5.4.1 PCBs are toxic to fish and other aquatic organisms. Reproductive and developmental problems have been observed in fish at low PCB concentrations, with the early life stages being most susceptible. There is growing evidence linking PCBs and similar compounds with reproductive and immuno-toxic effects in wildlife, including effects on seals and other marine mammals. Due to their persistence and lipophilic nature, PCBs have the potential to bioaccumulate, particularly in lipid rich tissue such as fish liver. Bioaccumulation of PCBs is recorded in fish, birds and marine mammals with known sublethal toxicological effects. Accumulation of PCBs in sediments poses a potential hazard to sediment-dwelling organisms.

5.4.2 The sediment chemistry results, presented in Table 5.3, show that the sum of the ICES7 PCBs is significantly below the Cefas AL1 for all samples. There are no Cefas AL2 or Canadian TEL/PEL for these contaminants.

Table 5.3: PCBs recorded in samples taken from the Thurrock Flexible Generation Plant survey area.

Description (PCB congener)		28	52	101	118	138	153	180	Sum of ICES 7
Units		mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg
Cefas AL1 (mg/kg)		-	-	-	-	-	-	-	0.01
Cefas AL2(mg/kg)		-	-	-	-	-	-	-	none
Sample No.	**Sample Type**								
ST02	**Core Sample**	<0.0009	<0.0007	<0.0006	<0.0008	0.00181	0.00134	<0.0006	0.00315
ST04	**Core Sample**	<0.0009	<0.0007	<0.0006	<0.0008	0.00215	0.00183	0.00152	0.0055
ST05	**Core Sample**	<0.0009	<0.0007	<0.0006	<0.0008	0.00273	0.00247	0.00188	0.00708

5.5 Polycyclic Aromatic hydrocarbons (PAHs)

5.5.1 PAHs enter the environment through a number of sources, these include road run-off, sewage, atmospheric circulation and from historical industrial discharge. Once in the environment, PAHs exert a strong affinity for organic carbon and as such organic sediment in rivers can act as a substantial sink. Due to the high affinity for organic carbon, once ingested by fauna the PAHs cause oxidative stress and lead to adverse effects in the organism. Most species have a limited ability to metabolize PAHs and as a result can bioaccumulate to toxic levels.

5.5.2 PAH levels at all three sampling stations were found to exceed Cefas AL1 and/or Canadian TEL (where available) for most of the individual determinants (Table 5.4). Where individual PAHs exceeded these thresholds, however, these were usually relatively small increases over the relevant threshold and were considerably lower than the Canadian PEL (levels above which adverse effects frequently occur). These results showed higher contamination than found in the Tilbury 2 survey which reported very few samples with contaminants exceeding Cefas AL1 (Port of Tilbury London Ltd, 2017).

Table 5.4: PAHs recorded in sample taken from the Thurrock Flexible Generation Plant survey area.

Description (PAH)	Units	Cefas AL1 (µg/kg)	Canadian TEL (µg/kg)	Canadian PEL (µg/kg)	ST02	ST04	ST05
					Core Sample	Core Sample	Core Sample
naphthalene	ug/kg	100	34.6	391	22.6	55.3*	49.3*
acenaphthylene	ug/kg	100	5.87	128	18.5*	57.2*	44.6*
acenaphthene	ug/kg	100	6.71	88.9	22.5*	22.7*	16.2*
fluorene	ug/kg	100	21.2	144	19.9*	31.5*	28.0*
phenanthrene	ug/kg	100	86.7	544	150*	190*	165*
anthracene	ug/kg	100	46.9	245	52.6*	80.1*	72.5*
fluoranthene	ug/kg	100	113	1494	284*	473*	373*
pyrene	ug/kg	100	153	1398	257*	438*	342*
benzo(a)anthracene	ug/kg	100	74	693	122*	264*	193*
chrysene	ug/kg	100	108	846	123*	271*	205*
benzo(b)fluoranthene	ug/kg	100	n/a	n/a	177	403	330
benzo(k)fluoranthene	ug/kg	100	n/a	n/a	89.4	186	197
benzo(a)pyrene	ug/kg	100	88.8	763	196*	441*	350*
indeno(1,2,3-c,d)pyrene	ug/kg	100	n/a	n/a	164	340	295
dibenzo(a,h)anthracene	ug/kg	100	6.22	135	26.8*	59.9*	45.9*
benzo(g,h,i)perylene	ug/kg	100	n/a	n/a	144	338	277
Perylene	ug/kg	100	n/a	n/a	69.3	158	148

5.6 Particle Size Analysis

5.6.1 The Particle Size Analysis (PSA) results are presented in Table 5.5, which identifies the sediment characteristics and categorises them into Folk and Ward sediment classifications (Long, 2006).

5.6.2 PSA of the three sediment chemistry samples identified two Folk sediment classifications: Coarse Silt and Medium Silt; the Medium silt was found at ST05 which was on the mid shore at the upper section of the mudflats. None of the samples contained gravel which is expected as samples were taken from the mud flats. All samples were consisted of majority mud with varying fractions of sand. ST04 and ST05 has a lower percentage of sand then ST02 which was nearly 50% sand.

Table 5.5: Particle size analysis of the core sample taken from the Thurrock Flexible Generation Plant survey area.

Station		ST02	ST04	ST05
Textural Group Classification		Sandy Mud	Sandy Mud	Sandy Mud
Folk and Ward Description		Coarse Silt	Coarse Silt	Medium Silt
Mean µm		30.0	19.7	14.9
Mean phi		5.06	5.67	6.07
Major Sediment Fractions	% Gravel	0.00	0.00	0.00
	% Sand	46.5	35.9	24.0
	% Mud	53.5	64.1	76.0

6. Historic datasets

Tilbury 2

6.1.1 Tilbury 2 is a development of a new port terminal on the north bank of the River Thames, the site of which is roughly 500 m to the west from the Thurrock Flexible Generation Plant intertidal site boundary. Intertidal and subtidal ecology surveys were conducted in June 2017 for Tilbury 2 and comprised of habitat surveys along a greater length of coastline with four intertidal transects and subtidal sampling in the vicinity of the development footprint (i.e. nine subtidal sediment samples). These samples recorded details of both faunal composition and particle size analysis.

6.1.2 A total of 47 species were observed in subtidal surveys but none were protected, rare or otherwise notable (Port of Tilbury London Ltd, 2017). Subtidal samples were dominated by polychaete *Polydora*, with oligochaete *Tubificoides* dominating one sample. All samples within the subtidal zone were characterised by high abundances of *Tubificoides* and *Corophium* (Port of Tilbury London Ltd, 2017).

6.1.3 Dense saltmarsh was observed along the front of the seawall almost continuously along the Tilbury 2 site, i.e. contiguous with the saltmarsh at the Thurrock intertidal survey area. Intertidal boulders/rocks (rock armour) with brown algae beds (mostly bladder wrack *Fucus vesiculosus*) beds covering the lower part of the rock armour, seaward of the saltmarsh (Port of Tilbury London Ltd, 2017). The boundary between the saltmarsh and intertidal area was defined by a small vertical soft cliff, around 1-1.5 m high. Most of the site was recorded as intertidal mud, which was relatively impoverished with a total of 29 species recorded in the intertidal area.

6.1.4 The intertidal samples were less diverse than the subtidal samples however, subtidal samples were less abundant, i.e. subtidal samples showed abundances of 1,675 to 8,370 individuals per 0.5 m2 compared to between 50 to 26,000 individuals per 0.5 m2 in intertidal samples. Higher abundances were observed in the upper intertidal zone and lowest abundances in the lower-subtidal area. Intertidal samples were dominated by *Tubificoides*, and numbers of *Corophium* increased in the seaward samples (Port of Tilbury London Ltd, 2017).

6.1.5 Differences observed between intertidal and subtidal communities were described as related to tidal-exposure, and communities identified were typical for the natural estuarine conditions they are exposed to. Sediment particle size analysis and faunal identification allowed for the assigning of biotopes to each sample, displayed within Table 6.1. The biotope 'SS.SMu.SMuVS.PolCvol' was assigned for all subtidal samples. LS.LMu.MEst.HedMac and LS.LMu.MEst.HedMacScr were recorded in the intertidal mud flats in Tilbury 2 surveys, the latter of which was also recorded for the intertidal mudflats in the Thurrock intertidal survey (although both are very similar biotopes to one another). LS.LMu.UEst.Hed.Ol biotope was recorded in the Tilbury 2 survey and would be expected to align with the LS.LMu biotope recorded in the lower shore of the Thurrock Flexible Generation Plant intertidal survey area.

6.1.6 Overall the description of the intertidal area is very similar between the Tilbury 2 report and the Thurrock survey area, both describing dense saltmarsh on the upper shore, intertidal boulders with brown algal beds, a small vertical cliff separating the saltmarsh from the rest of the intertidal zone and a large proportion of the intertidal zone as mudflats. This helps validate the results of the current survey are builds up a picture of the habitats in this part of the Thames Estuary.

Table 6.1: Biotopes identified in Tilbury 2 2017 survey (Port of Tilbury London Ltd, 2017)

Biotope Code	Biotope Description
SS.SMu.SMuVS.PolCvol	*Polydora ciliata* and *Corophium volutator* in variable salinity infralittoral firm mud or clay.
LS.LMu.MEst.HedMac	*Hediste diversicolor* and *Macoma balthica* in littoral sandy mud.
LS.LMu.MEst.HedMacScr	*Hediste diversicolor*, *Macoma balthica* and *Scrobicularia plana* in littoral sandy mud.
LS.LMu.UEst.Hed.Ol	*Hediste diversicolor* and oligochaetes in littoral mud.
LS.LMu.UEst.Hed.Str	*Hediste diversicolor* and *Streblospio shrubsolii* in littoral sandy mud.

Tilbury Energy Centre – Marine Ecology

6.1.7 The Tilbury Energy Centre was a proposed power station in the Thames estuary and is located adjacent to the Thurrock Flexible Generation Plant project boundary. Marine ecology surveys, including intertidal transects and subtidal sampling, was undertaken in May 2017. The Tilbury Energy Centre survey area encompasses part of the Thurrock Flexible Generation Plant intertidal survey area, although no samples were taken directly within the Thurrock footprint. The Tilbury Energy Centre samples recorded details of both faunal composition, particle size analysis and sediment chemistry.

6.1.8 The subtidal stations recorded sediment as sandy mud. Seventy-nine taxa were identified from the subtidal samples. Similar to the Tilbury 2 surveys, *Corophium* species were the most abundant taxon across both subtidal and intertidal samples. Polychaetes and oligochaete worms were the most abundant taxon groups. Subtidal samples were assigned five different biotopes (Table 6.2; APEM, 2018; see Appendix 17.4: Third Party Survey Reports).

6.1.9 Sediment type in the intertidal zone was generally classified as sandy mud with patches of slightly gravelly muddy sand. Fifty-two taxa were identified from the intertidal zone with biotic assemblages being fairly homogenous and no invertebrate species of conservation importance were recorded. Density of invertebrates at each station was highly variable ranging from 7,500 to 233,500 individuals per m^2. The invasive polychaete *Hypereteone lighti* specimens found in the Tilbury Energy Centre survey are the first records of this species from the Thames Estuary. The ragworm *H. diversicolor* was also abundant in the intertidal zone (APEM, 2018; see Appendix 17.4), reflective of the results found in the Thurrock intertidal survey area.

6.1.10 Overall both intertidal and subtidal assemblages were typical of those found throughout the Thames Estuary and are consistent with the results of other surveys in the area. Sediment particle size analysis and faunal identification allowed for the assigning of biotopes to each sample, displayed within Table 6.2. Intertidal stations were all (except one) assigned the biotope LS.LMu.UEst.Hed.Cvol (*Hediste diversicolor* and *Corophium volutator* in littoral mud). One station was assigned a variant of this, LS.LMu.UEst.Hed.Cvol due to the absence of *H. diversicolor* (APEM, 2018 see Appendix 17.4).

6.1.11 This survey has a similar conclusion to that of the Tilbury 2 and Thurrock Flexible Generation Plant surveys. Although the assigned biotopes differ slightly due to slight differences in survey area, they all found littoral mud present with *H. diversicolor* and *Corophium* abundant, showing consistency in the habitat types and species present in this area of the Thames Estuary.

Table 6.2: Subtidal and Intertidal biotopes found in the Tilbury Energy Centre 2017 survey (APEM, 2018 see Appendix 17.4)

Biotope Code	Biotope Description
LS.LMu.UEst.Hed.Cvol	*Hediste diversicolor* and *Corophium volutator* in littoral mud.
LS.LMu.UEst.Hed.Cvol variant	*Hediste diversicolor* and *Corophium volutator* in littoral mud. Differs from the described biotope due to the lower diversity in the sample and the absence of *Hediste diversicolor*.
SS.SMu.SMuVS.CapTubi	*Capitella capitata* and *Tubificoides spp*. in reduced salinity infralittoral muddy sediment.
SS.SMu.SMuVS.PolCvol	*Polydora ciliata* and *Corophium volutator* in variable salinity infralittoral firm mud or clay.
SS.SMu.SMuVS.AphTubi	*Aphelochaeta marioni* and *Tubificoides spp*. in variable salinity infralittoral mud.
S.SSa.SSaVS.NcirMac	*Nephtys cirrosa* and *Macoma balthica* in variable salinity infralittoral mobile sand), differing from the described biotope in the large numbers of oligochaetes and absence of the orbiniid worm *Scoloplos armiger*.
SS.SMu.SMuVS.OIVS	Oligochaetes in variable or reduced salinity infralittoral muddy sediment, differing from the described biotope in its higher diversity, including many Crustacea and Nemertea.

Tilbury Energy Centre – Saltmarsh Survey

6.1.12 APEM also conducted a saltmarsh survey for the Tilbury Energy Centre project, in August 2017. The survey area covered an area from west of the Tilbury Power Station to Coalhouse Fort in the east. This overlaps with the intertidal survey area for the Thurrock Flexible Generation Plant survey area, with one sample station within this area.

6.1.13 A total of eight main NVC types and two sub-types were recorded across the survey area. The NVC type SM12a (Rayed *Aster tripolium* on salt-marshes) had the greatest extent covering just under a third of the saltmarsh area. Large areas of saltmarsh were also comprised of SM14a (*Halimione portulacoides* salt-marsh community) and SM24 (*Elymus pycnanthus* salt-marsh community). A total of 23 plant species were recorded within the survey area, including the nationally scarce plant species Golden Samphire *Inula crithmoides* and Slender Hare's Ear *Bupleurum tenuissimum* (APEM, 2019; see Appendix 17.4).

6.1.14 Based on the Tilbury Energy Centre data, the saltmarsh habitats within the Thurrock Flexible Generation Plant survey area were classified as a mosaic of SM13 *Puccinellia maritima* and SM14 *Halimione portulacoides* saltmarsh communities. The species present were: *A. tripolium, H. portulacoides*, filamentous green algae, *I. crithmoides*, *Limonium vugare, Plantago maritima, Puccinellia maritima* and *S. anglica* (APEM, 2019; see Appendix 17.4).

6.1.15 This survey recorded broadly comparable vegetation types to those recorded during a previous survey in July 2007 for the proposed Tilbury Biomass Power Station project (RWE nPower 2011). This suggests a stable saltmarsh habitat in this area with only localised accretion and erosion. It also gives further detail to the saltmarsh community within the Thurrock Flexible Generation Plant survey area.

7. Discussion

7.1.1 Based on the results of the Phase 1 intertidal survey and the desktop review, the following Important Ecological Features (IEFs) were identified according to the Chartered Institute for Ecology and Environmental Management (CIEEM) for Ecological Impact Assessment (EcIA).

7.1.2 Intertidal mudflats dominated the Thurrock intertidal survey area, the mudflats were made up of soft sandy mud along the lower shore. *Hediste diversicolor*, *Macoma balthica* and *Scrobicularia plana* were found in the near shore section of the mudflat but in the lower shore, faunal diversity was reduced. Intertidal mudflats are offered protection by conservation legislation, being listed as a habitat of principal importance under the Natural Environment and Rural Communities (NERC) Act 2006. This is also listed as a UK Biodiversity Action Plan Priority habitat. Intertidal mud flats also quality as Annex I habitats under the EU Habitats Directive, however the mudflat within the Thurrock intertidal survey area is not within a SAC. These intertidal mudflats are common to the wider Thames estuary and are extensive in this region (Port of Tilbury London Ltd, 2017; APEM, 2018; see Appendix 17.4).

7.1.3 Established saltmarsh habitats made up the majority of the upper shore. Previous surveys in the same concluded that the saltmarsh was made up of SM13 *Puccinellia maritima* and SM14 *Halimione portulacoides* saltmarsh communities (APEM, 2019). Saltmarsh habitats are offered protection by conservation legislation, being listed as a habitat of principal importance under the Natural Environment and Rural Communities (NERC) Act 2006. This is also listed as a UK Biodiversity Action Plan Priority habitat. Saltmarsh is also an Annex I habitat under the EU Habitats Directive however it should be noted that the saltmarsh within the survey is not within a SAC. Several surveys in the area have found extensive established saltmarsh in the upper shore of the Thames Estuary (Port of Tilbury London Ltd, 2017; APEM, 2018; see Appendix 17.4).

7.1.4 The fucoid habitats and the narrow strips of gravelly sandy mud that made up the mid shore constituted the majority of biotopes reported and supported that majority of fauna. They are not protected by any conservation legislation.

7.1.5 Sediment chemistry analysis across the site indicated that the levels of contaminants in the sediments were typically of a busy estuary such as the Thames. Metals and PAHs were elevated above the Cefas AL1 and the Canadian TEL, but well below Cefas AL2 and Canadian PELs (where relevant). The levels of metals and PAHs were comparable with those reported from surveys at the adjacent Tilbury 2 development (Port of Tilbury London Ltd, 2017).

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