

## Chapter Eighteen ◆ Soils, Hydrogeology and Ground Conditions

### INTRODUCTION

- 18.1 This chapter provides an assessment of the geoenvironmental information and likely significant effects of the Proposed Development in terms of soils, hydrogeology and ground condition impacts with respect to the Project Site. This chapter was originally published in December 2020 but has since been updated (July 2021) to reflect; the notification of the Swanscombe Peninsula as a SSSI, changes to the proposed development, additional work undertaken with respect to ground conditions and further information received. Consideration has been given to the Project Site conceptual models including geology, hydrology, hydrogeology and the geoenvironmental conditions (including issues associated with soil gases, chemicals within soils and groundwater). A range of impacts associated with the design, construction and operation of the Proposed Development have been assessed.
- 18.2 The information provided in this chapter has been compiled from desk studies of available background data for the Project Site, which were produced or updated during 2020. These desk studies included a review of available ground investigation reports, including an investigation that was undertaken on the Kent Project Site during 2015. This chapter also reflects additional data obtained from groundwater monitoring on the Kent Project Site between September 2020 and May 2021.
- 18.3 The descriptions of the Project Site and the Proposed Development are provided in Chapter 2 (Site description) and Chapter 3 (Project description) of the Environmental Statement (ES). The areas that are subject to study with respect to the soil, hydrogeology and ground conditions is illustrated by Figure 18.1 and are considered as two separate sites; the Kent Project Site (south bank of the River Thames) and Essex Project Site (north bank). The Kent Project Site is further divided into (i) the Swanscombe Peninsula (Zones 1 to 5) and (ii) the Resort Access Road and A2 Highway Works (Zones 6 to 9). The areas covered by these zones are illustrated by Figure 18.2 and Figure 18.3.

### METHODOLOGY AND DATA SOURCES

#### EIA scoping

- 18.4 The Applicant submitted an EIA Scoping Report under Regulation 10 of the Infrastructure

Planning (Environmental Impact Assessment) Regulations 2017<sup>1</sup>, to the Planning Inspectorate on the 15<sup>th</sup> June 2020. This set out the proposed approach to assessing soils, hydrogeology and ground conditions effects in relation to the Proposed Development.

- 18.5 The EIA Scoping Opinion was received from the Planning Inspectorate in July 2020 and further comments were received in August 2020 from other consultees. The 2020 Scoping Opinion comments and responses are summarised in Table 18.1. All comments received have been given thorough consideration and have been addressed in the assessment within this ES chapter.

**Table 18.1: 2020 scoping opinion comments and responses**

<b>Consultee</b>	<b>Scoping opinion comment</b>	<b>Response</b>
Planning Inspectorate	The Inspectorate reiterates that the ES should explain and justify the extent of the study area, how the constraints with respect to this topic informed the project design, how mitigation measures are addressed and related to the relevant impact pathways identified, and that a full description of residual effects on receptors should be provided.	Noted. The study area, constraints mitigation and residual effects have been identified and described.
Planning Inspectorate	The ES will have to carefully consider CKD dumps, and measures to prevent leachate from them. It must also detail specific measures to protect the River Thames and salt marsh areas from leachate should incidents occur, and in worst-case scenarios what decontamination and clean-up measures might be required.	The presence of the CKD (cement kiln dust) landfills and the current management of leachate associated with them is recognised and the significance understood. The management of this leachate both during construction and in operation has been considered. Mitigation measures to protect the natural environment (including the Salt Marshes and the River Thames) have been addressed. Incident management has been considered and is included in the CEMP. These incident management plans will be further developed once a contractor is appointed for the works.

<sup>1</sup> HM Government. Infrastructure Planning (Environmental Impact Assessment) Regulations 2017

Consultee	Scoping opinion comment	Response
Planning Inspectorate	The ES will need to include maps of hard and drift geology, peat deposits and waterlogged sediments, past and active landfill sites, and the likely extent of CKD and dredged deposits. Geophysical survey and geotechnical data from boreholes and test pits should be used to inform detailed deposit modelling. Such work also needs to be cross-referenced with possible impacts on archaeology.	The natural and man-made geology including existing ground investigation data is described in the ‘Baseline’ section of this chapter and illustrated by Figure 18.4, 18.5 and to Figure 18.6. The source data/information is included as appendices to this chapter. Investigations in the area of archaeological interest are planned and are subject to agreement with both relevant consultation bodies (Natural England and Historic England) – Chapter 14 (Cultural heritage and archaeology)
Planning Inspectorate	The Inspectorate notes the proposed approach to the assessment and the reliance placed on a conceptual site model. The Applicant should make effort to agree the approach to Phase 2 assessment including the need for intrusive investigations to inform the assessment of likely significant effects. The ES should also use the historic aerial photographs and lidar information to inform the Phase 1 work.	The need for Phase 2 ground investigations is understood and acknowledged. Following discussions and agreement with the EA this ground investigation will be carried out following submission of the ES. The design and implementation of these investigations to further inform the conceptual site model will be subject to agreement with local authority and EA regulators. The results of existing investigations, current sampling and testing of groundwater, aerial photography and Lidar information have informed the current baseline described in the text of this chapter.
Planning Inspectorate	The results summarised in Table 17.4 of the Scoping Report are generic hazards. The ES should provide details of the main potential effects from land contamination at the Kent and Essex Project Sites.	The main potential effects from land contamination at the Kent and Essex Project Sites are assessed and described in the text of this chapter.
Planning Inspectorate	A series of mitigation measures are outlined in the Scoping Report to deal with any significant adverse	The mitigation measures relied upon in the assessment of significant effects, their likely efficacy, and how

Consultee	Scoping opinion comment	Response
	<p>effects. These are all extremely generic, however, with no details of approaches to the Development Area, nor any specific hazards such as leaching or contamination of groundwater or the River Thames. For example, remedial action (treatment, isolation or removal) of any areas of gross contamination are noted, but not how contaminated areas would be treated, or where contaminated material would be removed to. The ES should describe measures relied upon in the assessment of significant effects, their likely efficacy, and how they will be secured.</p>	<p>they will be secured are described in the text of this chapter. The detail presented is commensurate with the available information. Earthworks (the cut and fill of suitable materials) have been described together with the potential treatment options at the proposed soil treatment centre presented in the Contaminated Land Management Strategy (Appendix 18.9).</p>
<p>Planning Inspectorate</p>	<p>The Scoping Report includes no baseline data for the existing Proposed Development areas nor any description of the likely impact to soils, geology, hydrogeology and ground conditions. The ES should include this information and explain the anticipated volume of soil and other deposits to be removed and/or imported during construction.</p> <p>The ES should assess any likely significant effects associated with these activities. The assessment should cross-refer to relevant design parameters for footings, basements and underground car parks, service trenches, and excavated areas for attractions.</p>	<p>This chapter includes the available baseline data for the Proposed Development including reference to relevant design parameters for footings, basements and underground car parks, service trenches, and excavated areas. The anticipated volumes of soils to be excavated, removed and/or imported during construction are described and have formed a part of the assessment.</p>
<p>Natural England</p>	<p>The ES will need to provide details concerning the future protection and management of the Baker’s Hole Site of Special Scientific Interest, agreed with the relevant</p>	<p>Liaison with the archaeologists, road engineering and ground engineering teams will ensure a coherent approach which will be agreed with both relevant consultation bodies</p>

Consultee	Scoping opinion comment	Response
	consultation bodies.	(Natural England and Historic England).
National Grid	Ground levels above our cables must not be altered in any way. Any alterations to the depth of our cables will subsequently alter the rating of the circuit and can compromise the reliability, efficiency and safety of our electricity network and requires consultation with National Grid prior to any such changes in both level and construction being implemented.	Any earthworks in the vicinity of National Grid cables will be subject to consultation and agreement with National Grid. Initial contact has been made and information on the project provided. National Grid has responded and provided a set of their Template Protective Provisions.
Public Health England	We would expect the promoter to provide details of any hazardous contamination present on-site (including ground gas) as part of the site condition report. Emissions to and from the ground should be considered in terms of the previous history of the site and the potential of the site, once operational, to give rise to issues. Public health impacts associated with ground contamination and/or the migration of material off-site should be assessed and the potential impact on nearby receptors and control and mitigation measures should be outlined.	The contamination profiles (including hazardous ground gas) of the various zones across the Project Site are described in the desk study reports and summarised in this chapter of the ES. Potential impacts to human health associated with ground contamination and/or the migration of material off-site have been assessed and the potential impact on nearby receptors and control and mitigation measures are outlined.

**Consultation**

***Environment Agency***

18.6 A series of briefings and meetings were held with the Environment Agency with respect to earlier plans for the Proposed development in 2014/ 15 and again in 2017. A telephone meeting was held with the Environment Agency (Sustainable Places) on 27 March 2020 to reintroduce the Proposed Development and agree a process for future liaison with the

various Environment Agency teams, including Waste and Contamination. The Environment Agency officer with responsibility for land contamination (and with particular knowledge of the Project areas) has remained in post throughout this period.

18.7 A further telephone meeting was held with the Environment Agency on 17 June 2020 at which the planned programme of work with respect to soils, hydrogeology and ground conditions was discussed and agreed. This comprised;

- updating the desk studies on the Kent Project Site;
- undertaking a new study desk study on the Essex Project Site;
- collating existing / recent relevant information from planning applications;
- obtaining recent monitoring data from existing management systems;
- obtaining current groundwater data from re-sampling wells installed in 2015.

18.8 The Environment Agency confirmed some of their key areas of interest on the Kent Project Site, namely;

- for the masterplan and infrastructure to be sympathetic to the existing topography as far as possible (i.e. minimising earthworks especially in landfilled / licensed areas);
- the implications of the various Environmental Permits on several of the areas of the Kent Project Site (Swanscombe Peninsula and A2 Highway Works);
- surface water drainage and leachate management;
- Botany Marsh; and
- the effects of pumping at Eastern Quarry and HS1 (on groundwater/leachate and surface water regimes).

18.9 It was agreed that, in principle no additional intrusive ground investigation would be needed prior to DCO submission provided the wells installed in 2015 could be found and the groundwater sampled / tested, and that in addition, as much data as possible from other existing sources be obtained and used to inform the assessment. These wells were located and confirmed to be functional during a site visit undertaken in July 2020. A year-long programme of monthly monitoring (of groundwater, surface waters and sediments) is in progress. The monitoring data obtained between September 2020 and May 2021 are currently available (Appendix 18.20).

18.10 A meeting was held with the Environment Agency on 2<sup>nd</sup> June 2021 to discuss the Environment Agency representation on the project. In addition to discussion on flood risk and the marine and land environments, the proposed programme of ground investigation was discussed, and the Environment Agency were provided with a copy of the ground investigation scoping report (Appendix 18.18) for their information.

### **PEIR consultation**

18.11 A PEIR was submitted for consultation in July 2020, with the consultation period ending on 21<sup>st</sup> September 2020. Consultation responses relevant to this chapter were received from: Gravesham BC, Ebbsfleet DC, EA, HS1 and Highways England and are summarised in Table 18.2. Ebbsfleet DC provided commentary on each section of the PEIR – those actionable comments are also summarised in Table 18.2. This was followed by more specific comments on particular elements.

**Table 18.2: PEIR consultation comments and responses**

<b>Consultee</b>	<b>PEIR consultation comment</b>	<b>Response</b>
Dartford BC	<i>'The Council would suggest the involvement of their contaminated land officer in the detailed site investigation methodology and assessment methodology in order to ensure that the risk to human health is prevented.'</i>	Noted. The design and implementation of any ground investigations will be subject to agreement with local authority and EA regulators, as well as other stakeholders.
Ebbsfleet DC	<i>'The current scope for this chapter... is focussed on contamination and associated risks. In Chapter 17... it states that "A separate assessment of the potential effects on groundwater resources and groundwater quality is provided in Chapter 18 Soils, hydrogeology and ground conditions." Whilst groundwater quality in relation to contamination is included within the current assessment... effects on groundwater resources is not included.'</i>	Effects on groundwater quality are described in this chapter. Effects on groundwater resources are described in Chapter 17 (Water resources and flood risk).
Ebbsfleet DC	<i>'Comment 4.10.13 within the 2020 Scoping Opinion relates to the re-commissioning of 2 disused groundwater extraction boreholes. The assessment of the impacts on</i>	Effects on groundwater resources (including as a result of re-commissioning of the groundwater extraction boreholes) are described in Chapter 17 (Water resources and

Consultee	PEIR consultation comment	Response
	<i>water levels and water quality of re-commissioning these boreholes is not included within either chapter.'</i>	flood risk).
Ebbsfleet DC	<i>'Consultation has been undertaken with the Environment Agency in relation to contamination and elements regarding the scope and planned programme of works agreed. In principle, no further intrusive investigations are required if the 2015 wells previously installed were able to be used for groundwater monitoring... Whilst the EA have agreed no further investigation is required, consultation with other stakeholders such as GBC should be undertaken to confirm that they agree with this approach.'</i>	A consultation meeting was held between Gravesham BC, Dartford BC and Ebbsfleet DC on 21st October 2020, during which proposals for future work were outlined (including that ground investigation would be undertaken in 2021, post-DCO submission). Whilst it is acknowledged that this consultation was held late in the DCO programme, the local planning authorities were in general agreement to the proposals and no objection or concern was raised.
Ebbsfleet DC	<i>'The EA have confirmed their key areas of interest for the Kent Project site. These include Botany Marsh, implications of various Environmental Permits and effects of pumping on groundwater / leachate and surface water regimes. Details relating to these elements need to be included within the appropriate sections of the chapter so an assessment can be undertaken e.g. Botany Marsh is not detailed in the baseline section.'</i>	The ecological sensitivity of Botany Marsh is considered in the baseline description for the Swanscombe Peninsula and potential significant effects are assessed. The proposed mitigation measures are sympathetic to the ecological sensitivity. The groundwater / leachate and surface water regimes on the Kent Project Site are well understood and described. The implications of various Environmental Permits are acknowledged and described (Appendix D of the CLMS – Appendix 18.9 to this chapter).
Ebbsfleet DC	With regards to the study area for contamination / ground conditions, it was stated <i>'These areas should be clearly described within the ES and illustrated on a figure/plan.'</i>	The study area (DCO Order Limits with 1km buffer) is illustrated by Figure 18.1.
Ebbsfleet DC	Ebbsfleet DC noted that some guidance, legislation and policy relevant to contamination was referenced inaccurately, namely The	Legislation, policy and guidance relevant to contamination has been updated.



Consultee	PEIR consultation comment	Response
	Contaminated Land (England) Regulations 2006, The Environmental Permitting (England and Wales) Regulations 2016, and Environment Agency CLR11 (superseded in June 2019).	
Ebbsfleet DC	<i>'Policy and guidance in relation to hydrogeology and soils should be provided in the ES.'</i>	Reference to LA 109 <sup>2</sup> and LA113 is made (although not strictly relevant as this is not a highways project).
Ebbsfleet DC	<i>'Details regarding environmental permits for landfill sites are not provided and should be included with the ES. The implications of the development on these permits should be discussed...'</i>	Landfills currently / previously managed under Environmental Permits are illustrated by Figure 18.6. The implications of the development on these areas are acknowledged in the 'Mitigation and avoidance measures' section and the Contaminated Land Management Strategy (Appendix 18.9).
Ebbsfleet DC	<i>'Baseline with regards to hydrogeology (limited) and soils (ALC) is not presented in the PEIR and should be included within the ES.'</i>	Baseline with regards to hydrogeology and soils (ALC) is described in this chapter.
Ebbsfleet DC	<i>'The assessment methodology does not make reference to any specific assessment guidance or methodology. No approach to assessment of soils / hydrogeology is provided. LA 109 and LA 113 of the DMRB provides guidance and is considered best practice for assessment of the highways elements of the proposed development. The general approach is also applicable to the other aspects of the development.'</i>	As above, although not strictly relevant as this is not a highways project, reference to LA 109 and LA 113 has been made in the assessment.
Ebbsfleet DC	<i>'...Measures relating specifically to the development site or specific contamination measures e.g. specific hazards such as leaching from the CKD landfills, specific remediation of</i>	The 'Avoidance and mitigation measures' section of this chapter first outlines generic / good practice mitigation measures that apply to the Essex Project Site, Swanscombe

<sup>2</sup> Highways England (2019) Design Manual for Roads and Bridges. LA 109 Geology and soils. Revision 0.

Consultee	PEIR consultation comment	Response
	<p><i>grossly contaminated areas and where contaminated material would be moved are not detailed in the PEIR. These should be considered within the ES. More bespoke mitigation may be necessary when other receptors (Bakers Hole SSSI, soils, hydrogeology) are considered. Mitigation measures in relation to the EA key areas of interest (Botany Marsh, implications of various Environmental Permits and effects of pumping on groundwater / leachate and surface water regimes) are not specifically presented...'</i></p>	<p>Peninsula and A2 Highway Works. Following this, additional specific mitigation measures to address other potential adverse effects / challenges (including areas of CKD landfilling, the approach to management of more grossly contaminated areas, soil management and implications of Environmental Permits) are outlined. These additional specific mitigation measures are also described in the Contaminated Land Management Strategy (Appendix 18.9).</p>
<p>Ebbsfleet DC</p>	<p><i>'Aspects relating to Soils and Hydrogeology are not included within the PEIR. These aspects have not been scoped out and therefore relevant information should be included in all sections of the chapter and assessment undertaken. Further comments provided in Scoping Report review.'</i></p>	<p>Hydrogeology aspects (quality and resources) are addressed by this chapter and Chapter 17 (Water resources and flood risk). Soil resources (ACL) at the Project Site are briefly described in this chapter and justification provided as to why the soil resources are not assessed as a key receptor.</p>
<p>Ebbsfleet DC</p>	<p><i>'Drawings to show baseline features e.g. superficial / bedrock geology and sources of contamination would benefit the reader and understanding of the ES. Spatial drawings showing areas of contamination identified by the investigations would also be beneficial due to the size of the site.'</i></p>	<p>Noted. A series of figures are included with this chapter.</p>
<p>Ebbsfleet DC</p>	<p><i>'Consultation should be undertaken with all appropriate stakeholders during the EIA process to seek approval of the process being undertaken e.g. Local Authorities (contamination), Natural England (SSSI / Soils) and EA (Hydrogeology).'</i></p>	<p>Consultation was undertaken with the Environment Agency on 27th March 2020 and 17th June 2020 and with local planning authorities (Gravesham BC, Dartford BC and Ebbsfleet DC) on 21st October 2020. Discussions are also being held between Natural England, Historic England and the Applicant with regards to the Baker's Hole SSSI. This is detailed within the 'Consultation'</p>

Consultee	PEIR consultation comment	Response
		section of this chapter.
Ebbsfleet DC	<i>'This paragraph states - in principle no additional intrusive site investigation would be needed prior to DCO submission .... It is unclear if further investigation would be undertaken after submission but before DCO being granted.'</i>	Ground investigation is planned to be undertaken in early 2021 – i.e. post-DCO submission.
Ebbsfleet DC	<i>'The NPPF is not quoted entirely accurately.'</i>	Text has been updated.
Ebbsfleet DC	<i>'A brief summary is provided of the previous investigation undertaken in each zone...No comment is provided about gas monitoring data and if high levels are present around the existing landfills / limited groundwater quality data provided. Details of the assessment criteria used to determine of exceedances of soils / groundwater should be included to demonstrate the relevance to the Proposed Development.'</i>	Known investigations within the Project Site (where the information / data was available) are summarised in this chapter. Further information can be found in the complete reports (provided as technical appendices), or the more complete descriptions of the previous work provided within those technical appendices. No reassessment of the previous data has been undertaken as much of the data is aged or the data is so sporadic that drawing conclusions could be misleading. However, the overall descriptions of the ground conditions and datasets have informed the assessments presented in this chapter.
Ebbsfleet DC	<i>'Bakers Hole (geological) SSSI is detailed as a receptor but few details are provided within the baseline section.'</i>	Baker's Hole SSSI has been removed as a potential receptor to contamination, reflecting that it is designated as a SSSI due to its geological characteristics (i.e. rather than ecological). However, discussions are ongoing between Natural England, Historic England and the Applicant to determine an agreeable strategy to bring forward the Proposed Development whilst taking into account the SSSI and Scheduled Monument designation.
Ebbsfleet DC	<i>'Botany Marsh is detailed as a key</i>	Botany Marsh is of particular interest

Consultee	PEIR consultation comment	Response
	<i>area of interest by EA. It is not included in baseline or as a receptor.'</i>	to the EA due to its ecological sensitivity. The ecological sensitivity is now reflected in the baseline description for the Swanscombe Peninsula.
Ebbsfleet DC	<i>'Para 18.86 states that a Code of Construction Practice will be employed. Is this referring to the Construction Environmental Management Plan secured through requirement 7 of the draft DCO?'</i>	Proposed mitigation measures will (in-part) be secured through a CEMP and not a Code of Construction Practice. Reference to the correct document is now made.
Environment Agency	Requirement 7 <i>'The CEMP identifies a number of plans and strategies but noting on water pollution. We would expect to see a pollution incident response plan covering protection of surface and groundwater.'</i>	Noted. The CEMP now includes pollution incident response plans related to protection of surface and groundwater.
Environment Agency	Requirement 20 <i>'...Under this requirement there should also be included a verification reporting requirement in accordance with best practice...'</i>	The 'Avoidance and mitigation measures' section of this chapter acknowledges that successful implementation of remediation will be demonstrated via publication of a Verification Report.
Environment Agency	Requirement 20 <i>'We also need a requirement to ensure that; No works are carried out under any approved scheme that interferes with the permit requirements of landfill sites with extant Environmental Permits, without formal agreement in writing by the EA for permit variations...'</i>	The complexities and requirements associated with investigation and construction works within areas managed under Environmental Permits is understood and acknowledged throughout this chapter. A requirement has been included in the DCO as requested.
Environment Agency	<i>'It is possible for contaminant within the land being protected by revetment to enter into the Thames estuary if the revetment around the peninsula is not maintained. It is the Developers responsibility to ensure pollution prevention is in place and therefore must evidence how the</i>	The need for pollution control associated with construction activities in such areas of sensitivity is recognised and understood. The planned mitigation and Remediation Strategy incorporate provision for pollution control measures for all such surface water bodies including

Consultee	PEIR consultation comment	Response
	<i>revetment will be maintained to ensure this.'</i>	the River Thames.
Environment Agency	<i>'Criteria for determining sensitivity and effects is very crudely done. It isn't clear how the site fits into these criteria.'</i>	Assessment has been advanced and completed. The sensitivity of each receptor is now identified with justification provided. Potential effects are defined and further described.
Environment Agency	The Environment Agency noted that developments proposed on top of permitted landfills must not compromise the operator's ability to manage their site in accordance with their permit. The EA must be notified by the landfill operator before any infrastructure is installed if the development is likely to have impact on the landfill's infrastructure, maintenance or monitoring. Proposals for drilling boreholes through the landfill must also be submitted by the landfill operator to the Environment Agency.	Noted and acknowledged throughout this Chapter (see 'Avoidance and mitigation measures' section).
Environment Agency	In relation to Appendix 18.5, the Environment Agency note: 'The risk assessment concluded that the risk to groundwater and surface water were low. The report recommended groundwater is also monitored. We agree that this should be carried out so that the risk to groundwater and surface water can be further refined, and we would suggest that it should not be excluded at this stage...without further evidence...'	Noted and agreed. The design and implementation of any ground investigations will be subject to agreement with local authority and EA regulators, as well as other stakeholders.
Gravesham Borough Council	<i>'This chapter outlines the known information about ground conditions. It highlights that parts of the site are contaminated... As a site proposed to host thousands of people everyday it is essential that any pollutants are either removed or dealt with in such a</i>	Mitigation measures to isolate site visitors from potential contamination are outlined in the 'Avoidance and mitigation measures' section and described more fully in a Contaminated Land Management Strategy (Appendix 18.9).

Consultee	PEIR consultation comment	Response
	<i>way as to isolate them from the surrounding environment.'</i>	
HS1	<i>'Condition: Prior to the commencement of development, details of the design of the foundations and other works proposed below existing ground level shall be submitted in writing and approved by the Local Planning Authority in consultation with HS1...'</i>	Noted and understood. Reflected in the HS1 Impact Assessment (Appendix 18.17).
HS1	<i>'Condition: Prior to the commencement of any construction activity, details of the size, loading and proximity to HS1 of additional ground loads such as stockpiles shall be submitted in writing and approved by the Local Planning Authority in consultation with HS1...'</i>	
HS1	<i>'Condition: Prior to the commencement of site investigations [near to HS1 assets] ... details of the location and depth of site investigations including a method statement shall be submitted in writing and approved by the Local Planning Authority in consultation with HS1...'</i>	Ground investigations will be specified and undertaken post-DCO submission, during early 2021. The scope of any such investigations will be subject to agreement with all relevant stakeholders, including HS1.
HS1	<i>'An initial risk assessment should be completed for unexploded ordnance and, if found to be a potential issue, further site surveys should be undertaken. This comment remains to be addressed. While paragraph 18.86 of the PEIR refers to mitigation in respect of any unexploded ordnance, details as to any surveys are awaited.'</i>	A Preliminary UXO risk assessment for the Essex Project Site is presented in Appendix 18.5 and detailed UXO risk assessments for the Kent Project Site in Appendix 18.1 and 18.2 The potential for encountering UXO during demolition and construction is assessed throughout this chapter, and the mitigation measures include provision in case of encountering UXO.
Highways England (Atkins)	<i>'Information produced within the Phase 1 Geo-environmental Risk Assessment (December 2014),</i>	The referenced document (Appendix 18.1) was produced in 2014. The document has been updated

Consultee	PEIR consultation comment	Response
	<i>erroneously refers...to out of date DMRB Standards and accordingly the document will need to be updated to reflect the current DMRB standards namely CD 622 Revision 1 'Managing geotechnical risk' (formerly HD 22/08, BD 10/97, HA 120/08)... A number of the procedures concerned with regards to ground conditions should be completed as part of the preliminary design of any mitigation works to the SRN, and therefore before the draft DCO is submitted.'</i>	(Appendix 18.6), however much of the information related to ground conditions remains pertinent and so both documents are included as technical appendices to this ES chapter. The relevant DMRB standards will be adopted / referred to during geotechnical design of relevant aspects of the Proposed Development (but are not relevant to this chapter).
Highways England (Atkins)	<i>'In reviewing the area covered by the report it appears that the areas within the full DCO red line boundary have not been covered... the missed areas will need to be fully investigated before the report can be considered acceptable.'</i>	The DCO Order Limits have been refined / amended since the PEIR report was published. This chapter assesses the full area covered by the final DCO Order Limits plus a 1km buffer about this area.
Kent County Council	<i>'The impact of the proposals on the geological significance of Bakers Hole SSSI does not seem to have been assessed in this chapter or elsewhere in the PEIR. When it is assessed LRCH should be aware that geological character and value contributes to Palaeolithic significance also.'</i>	Noted and assessed within Chapter 14 (Cultural heritage and archaeology).

### **Local planning authorities**

18.12 A meeting (via Microsoft Teams) was held with Gravesham BC, Dartford BC and Ebbsfleet DC, Savills and Buro Happold on 21<sup>st</sup> October 2020 to outline proposals with regards to land affected by contamination at the London Resort. Discussions were predominantly related to the Kent Project Site (reflecting the local planning authorities in attendance). Attempt was made to engage with Essex County Council and Thurrock Council with regards to the Essex Project Site, however no response to the suggestion for a meeting was received.

18.13 The studies undertaken to date were summarised (which are included as appendices to this chapter). The conceptual site models for the Swanscombe Peninsula and A2 Highway Works elements of the Kent Project Site were described. The structure and approach to

this chapter was then outlined, in particular the division of the Project Site into the Essex Project Site, Swanscombe Peninsula and A2 Highway Works for the purposes of the baseline description, assessment of potential effects and mitigation measures.

18.14 Plans for future work were outlined, specifically the year long programme of groundwater and surface water monitoring (which commenced in September 2020) and the proposal that ground investigations will be undertaken across the Project Site planned to commence in 2021. It was emphasised that such investigations would include liaison with all key stakeholders (Gravesham and Dartford BCs were subsequently sent copies of the ground investigation scoping report [Appendix 18.18] for information). The meeting concluded with a question and answer session.

### **Relevant Representations**

18.15 Three Relevant Representations applicable to the Soils, Hydrogeology and Ground Conditions ES Chapter (submitted December 2020) were received by PINs. Two of the comments were concerned with the presence of contamination and whether the project has recognised the associated potential risks. The third comment was concerned with the absence of specificity related to the areas of the Project Site that will require remedial design or action.

18.16 The concerns raised regarding the understanding of contamination (in particular within Zones 1 to 5 of the Kent Project Site) and the need for remediation are addressed in the 'Baseline conditions' section of this chapter. The proposed mitigation is set out in the 'Avoidance and mitigation measures' section of this chapter. The specific responses to the Relevant Responses are provided in Table 18.3. The Relevant Responses did not raise any items that require specific update to the assessment approach presented in this Chapter.

**Table 18.3: Resources / receptors and potential effects**

<b>Relevant Representation</b>	<b>Matters raised</b>	<b>Response</b>
RR-698 Gravesham Borough Council	Pulverised fuel ash on Swanscombe Peninsula is highly alkaline and has implications in construction on workers, residents, wildlife and any structures upon it.	The presence and general nature of the cement kiln dust (CKD) on the Peninsula [note: the material is not pulverised fuel ash (PFA) which is a different material from a different process and source materials) is identified in Chapter 18 and in several of the supporting Appendices. The highly alkaline nature of this CKD material is well understood, reflected in both the assessment and in the Contaminated Land Management Strategy (CLMS - Appendix 18.9) and the potential implications of this high (alkaline) pH on people, flora, fauna and the environment (e.g. groundwater and surface waters) has been recognised and addressed. The potential risks to



Relevant Representation	Matters raised	Response
		<p>human health (construction workers – via direct contact and neighbours – via windblown dusts) and to the natural and built environments (flora, fauna, controlled waters and below ground buildings / structures) have been identified and assessed. These potential risks are capable of mitigation with the mitigation measures identified in the ES chapter, to be defined and secured in a Construction Environmental Management Plan (CEMP) which will be secured through a requirement in the DCO.</p>
<p>RR-409 Natural England</p>	<p>Greater clarity needed in the Contaminated Land Management Strategy regarding the land area requiring remedial works, with the ES updated to reflect this.</p>	<p>The CLMS (Appendix 18.9) envisages that all of the area within the DCO boundary will require investigation and assessment with respect to ground contamination. Areas not subject to built development may be subject to investigation and remediation in the event that as a result of historic uses, those area could (now or in the future) present a risk to people or the environment (i.e. they could otherwise be “Determined” as Contaminated Land under Part 2A of the Environmental Protection Act 1990). All of the areas of proposed built development will be subject to intrusive ground investigation and risk assessment with the need for and scope of remedial design and / or action being determined by the results of that work which will also reflect the site specific data and the proposed future use. Until the ground investigations are carried out and the development plans are more fully developed, it is not appropriate to delineate areas requiring remedial action in the way suggested by Natural England. Accordingly, there is no requirement for an update to the Environmental Statement in this regard.</p>
<p>RR – 792 Thurrock Council</p>	<p>Concern regarding potential contaminated land on site.</p>	<p>The potential presence and general nature of the contamination on the Essex Site is identified in the ‘Baseline – Essex Project Site’ section of this chapter and in Appendix 18.5 Planned intrusive investigations will define the presence, location, nature and extent of contamination in due course. The potential risks to human health (construction workers – via direct contact and neighbours – via windblown dusts) and to the natural and built environments (flora, fauna, controlled waters and below ground buildings / structures) have been identified and assessed here and in Appendix 18.5. These potential risks are capable of</p>

Relevant Representation	Matters raised	Response
		mitigation by the measures identified in the 'Avoidance and mitigation measures' section. These will be further defined and secured in a Construction Environmental Management Plan (CEMP) which will be secured through a requirement in the DCO.

18.17

**Approach and methodology**

***Defining the conceptual site models***

18.18 The following methodology will be utilised to assess the Proposed Development against the baseline at the Project Site. A conceptual model of the Project Site that describes the environmental features with the expected interaction of potential contamination sources will be developed for both the construction and operational phases of the Proposed Development. This will be carried out by undertaking a Source – Pathway – Receptor analysis of the Essex Project Site and the Kent Project Site (divided into the Swanscombe Peninsula and A2 Highway Works elements) with respect to construction and operational effects and in accordance with the guidance documents referred to in this chapter. These terms as defined below:

- Sources. Potential or known sources of potential contamination associated with historic or recent/ current land uses (e.g. disposal of wastes, spills and leaks).
- Pathways. Mechanisms / systems thorough which exposure of a receptor to a contaminant could occur e.g. direct contact with contaminated soils, migration through air, over land or via permeable ground.
- Receptors. Receptors of varying sensitivity that could be adversely affected by contact (direct or indirect) with a contaminant. E.g. people living, working or visiting the Project Site and surrounding area, groundwater and surface water bodies, ecological resources (flora and fauna).

18.19 Where a source, relevant pathway and receptor are present, a “contaminant linkage” is created whereby there is a circumstance through which some level of environmental harm could occur, which has to be assessed and mitigation identified as appropriate.

18.20 Baseline conditions for the Project Site will be assessed within the DCO Order Limits and for a buffer distance of up to 1km beyond (Figure 18.1). Consideration of this 1km ‘halo’ around the boundaries of the Essex Project Site and Kent Project Site is necessary to take

into account the potential for off-site contamination sources and for the potential for impact upon off-site receptors.

- 18.21 The baseline data for the Project Site has been sourced from desk-based studies and site walkover surveys. A review has been undertaken of published information and existing borehole data published by the British Geological Survey, together with available extensive data on the geological and geoenvironmental conditions from existing ground investigations and remedial activities.
- 18.22 Groundwater monitoring and sampling from existing wells (constructed in 2015) on the Kent Project Site commenced during September / October 2020 (one monitoring round undertaken to date). Return visits to record groundwater levels in these wells and obtain samples will continue on a monthly basis for the next 12 months.

***Assessment significance criteria***

- 18.23 The methodology for impact prediction is based on assessing both the magnitude of the changes expected and the sensitivity of the receptors. Criteria for assessing the significance of potential human and environmental impacts is based on a qualitative assessment of the magnitude of the impact, or how far the impact deviates from the baseline condition, and the receptor sensitivity.
- 18.24 The receptors and the main potential effects outline in Table 18.4 are considered in the assessment. It is not anticipated that these resources/receptors will all be significantly affected, but it is necessary to demonstrate that these important receptors have been considered.

**Table 18.4: Resources / receptors and potential effects**

Receptor	Effect
Construction Workers	Direct or indirect ingestion of contaminated soil and groundwater, inhalation, dermal contact. Inhalation of contaminated dusts and/ or hazardous fibrous substances.
Future Site Users (residents/workers/visitors)	Direct or indirect ingestion of any residual contaminated soil, inhalation of contaminated dusts and/ or hazardous fibrous substances, dermal contact in areas of soft landscaping. Exposure to hazardous atmospheres presented by accumulation of flammable or asphyxiating ground gases and vapours in enclosed spaces or outside.

Receptor	Effect
Surrounding Land Users (neighbours)	Inhalation or deposition of wind-borne contaminated dusts and/ or hazardous fibrous substances mainly during construction but also in operation. Exposure to hazardous atmospheres presented by migration of contamination via permeable strata and in air.
Controlled Waters (groundwater and surface waters)	Contamination of water resources with consequent reduction in water quality. Impacts to aquatic environment.
Ecology	Phytotoxic impacts on plant species. Toxic impacts on fauna.
Built Environment	Chemical attack on buried concrete structures. Permeation of plastic pipes and contamination of water supply. Exposure to hazardous atmospheres presented by accumulation of flammable ground gases and vapours in enclosed spaces.

18.25 Receptors are considered to have varying degrees of sensitivity to contamination potentially present beneath the Project Site, based on the potential scale of exposure and the integrity of any site-specific exposure pathways. The scale of receptor sensitivity is defined in Table 18.5 below.

**Table 18.5: Criteria for determining receptor sensitivity**

Sensitivity	Description
High	People (on-site or on neighbouring properties) occupying land in residential use with gardens or using allotments, children’s play areas etc. Construction workers engaged in extensive earthworks. Principal aquifer of regional importance used for potable water supply. Highly ecologically sensitive watercourse or water bodies. Nationally or internationally designated ecological sites. Buildings of high historic or local importance.
Moderate	People (on-site or on neighbouring properties) occupying land in residential use without gardens or using public areas of soft landscaping / open spaces. Construction workers engaged in moderate earthworks.

Sensitivity	Description
	Principal and / or Secondary aquifer, local watercourse or non-designated water bodies not used for large scale human consumption which can be used for industrial purposes; may be important for local recreational purposes. Locally designated ecological sites. Buildings, including services and foundations.
Low	People (on-site or on neighbouring properties) occupying or using commercial or industrial buildings, car parking, hard landscaping. Construction workers site but with minimal disturbance to the ground. Non-potable water resources, water body of low recreational qualities. Sites of low ecological value, and flora and fauna occupying non-designated open areas. Infrastructure (e.g. roads, highways and railways).
Very Low	Land with no access to people and no neighbouring properties. Construction workers on-site, but with no disturbance to the ground on-site. Non-aquifer, no nearby watercourses or water bodies within 1km. No sites of significant ecological value No built development within 1km.

18.26 The criteria used to assess the magnitude of effects is based on a qualitative assessment of the potential impact of the effect or how far the effect deviates from the baseline condition and the period of time that the effect could last (see Table 18.6).

**Table 18.6: Criteria for determining effect magnitude**

Magnitude	Description
Large	Short term (acute) or long term (chronic) adverse effects on human health, broadly equivalent to “significant harm” as defined by the Environmental Protection Act 1990. Persistent and extensive pollution of water resource or ecosystem broadly equivalent to Category 1 pollution incident <sup>3</sup> (major pollution release). Catastrophic damage to crops / building / infrastructure.
Medium	Short term (acute) or long term (chronic) adverse effects on human health but not equivalent to “significant harm” as defined by the Environmental Protection Act.

<sup>3</sup> Environment Agency. Incidents and their classification: the Common Incident Classification Scheme (CICS). 2016

Magnitude	Description
	Non-persistent pollution of water resource or ecosystem broadly equivalent to Category 2 pollution incident (moderate pollution release). Significant damage to crops / buildings / infrastructure (on or off-site). Contamination of off-site soils.
Small	Easily preventable, non-permanent health effects on humans. Minor, low-level, localised, temporary pollution of water resources or ecosystem (broadly equivalent to Category 3 pollution incident). Easily repairable / localised damage to crops, buildings and / or infrastructure.
Negligible	No discernible negative effects.

18.27 The combination of the sensitivity of the receptor and the magnitude of the impact provides an indication of the level of contamination on the Project Site, and the nature and severity of possible effects. It should be noted that both rankings may vary in accordance with the different scenarios being considered (i.e. construction and operation).

18.28 Effects can be described as:

- Beneficial or adverse;
- Permanent or reversible;
- Short, medium or long term; and
- Significant (major or substantial) or insignificant (indiscernible or minor).

18.29 Positive or negative effects to the relevant receptors during construction and when the Project Site is operational are identified and assessed. Beneficial (or positive) effects are associated with the mitigation of risks associated with contamination (e.g. as a result of the breaking of a pollutant linkage). The adverse (or negative) effects are normally temporary during the construction phase and relate to the increased potential for contaminant exposure (e.g. from the generation of contaminated dusts), or long-term from the use of the Project Site during the operational phase (e.g. associated with any residual contamination).

18.30 Effects that are generated as a result of the enabling and construction works (i.e. those

that last for this set period of time) are classed as ‘temporary’; these may be further classified as either ‘short term’ or ‘medium term’ effects depending on the duration of the enabling and construction works that generate the effect in question. Effects that result from the completed and operational Proposed Development are classed as ‘permanent’ or ‘long-term’ effects.

18.31 The significance of a potential effects is derived by considering both the sensitivity of the feature and the magnitude of change, as demonstrated in Table 18.7.

**Table 18.7: Matrix for determining effect significance**

		Magnitude of effect			
		Large	Medium	Small	Negligible
Receptor sensitivity	High	Major	Major	Moderate/Minor	Negligible
	Moderate	Major	Moderate	Minor	Negligible
	Low	Moderate/Minor	Minor	Minor	Negligible
	Very low	Negligible	Negligible	Negligible	Negligible

18.32 As set out above, the potential effects are determined by considering the sensitivity of the receptor and the magnitude of potential impact. Significant effects for the purposes of this assessment are deemed to be those that are moderate and major. Moderate/minor, minor or negligible effects may often be mitigated, but are not considered to be significant (with or without mitigation) with respect to the assessment presented in this chapter. A summary of the nature of the effects is presented in Table 18.8.

**Table 18.8: Categorising likely effects**

Effect	Nature
Major adverse	Potentially major impact upon human health. Severe temporary reduction in the quality of a potable groundwater or surface water resource of local, regional or national importance. Temporary detrimental impact on animal or plant populations.
Moderate adverse	Potentially moderate impact upon human health or safe occupancy of buildings. Moderate temporary change to water quality of ground water or surface water body. Temporary harmful impact on animal or

Effect	Nature
	plant populations.
Minor adverse	Potentially temporary or minor impact upon human health. Minor, local-scale reduction in the quality of potable groundwater or surface water resources of local importance, reversible with time. Reversible widespread reduction in the quality of groundwater or surface water resources used for commercial or industrial abstractions. Reversible small-scale detrimental impact on animal or plant populations.
Negligible	No appreciable impact upon human health, potable groundwater or surface water resources of any importance, animal or plant health. Any minor impacts are reversible.
Minor beneficial	Minor reduction in potential impacts upon human health. Minor local-scale improvement to the quality of potable groundwater or surface water resources. Moderate to significant improvement to the quality of groundwater or surface water resources used for commercial or industrial abstraction only. Minor reduction in potential impact on animal or plant populations.
Moderate beneficial	Moderate reduction in potential impacts upon human health and safe occupancy of buildings. Moderate local scale of improvement to the quality of controlled waters. Moderate reduction in potential impact on animal or plant populations.
Major beneficial	Major reduction in potential impacts upon human health. Significant local-scale/ moderate to significant regional scale improvement to the quality of potable groundwater or surface water resources. Major reduction in potential impacts on animal or plant populations.

**Study area**

18.33 The study area encompasses all land within the Order limits and a 1 km zone around the Kent Project Site and Essex Project Site, within which Desk Study data has been collated on potential sources and pathways for contaminant migration. As discussed above, this “halo” around the Project Site is considered in order to take into account the potential for off-site contamination sources and receptors. That is, the 1km zone is the maximum extent of neighbouring land that could plausibly be affected by sources of contamination in the study area. Similarly, it is also the maximum extent of the neighbouring land where



sources of contamination could plausibly affect the ground conditions within the study area.

### **Cumulative and in-combination effects**

18.34 The list of developments considered in the assessment of cumulative, in-combination and transboundary effects is presented in Chapter 22 of this ES. Consideration was given to the location, nature and scale of the identified developments in determining whether there were any developments with potential cumulative or in-combination effects relevant to Ground Conditions.

### **Timescales of surveys**

18.35 Groundwater monitoring wells installed on the Kent Project Site in 2015 were inspected (June 2020) and their functionality confirmed. A year-long programme of monthly monitoring (from the located groundwater monitoring wells, but also of surface water and sediments) commenced in September 2020. Data from the monitoring undertaken between September 2020 and May 2021 are currently available (Appendix 18.20).

18.36 Combined geotechnical / geoenvironmental intrusive ground investigations across both the Kent Project Site and Essex Project Site are planned to take place after the DCO submission, commencing in 2021. This approach has been agreed with the Environment Agency and local planning authorities (see 'Consultation' section). A ground investigation scoping report (Appendix 18.18 and a technical specification (Appendix 18.19) have been prepared for the Resort area.

### **Limitations and uncertainties**

18.37 The principal sources of information used to describe the baseline conditions at both the Essex Project Site and Kent Project Site are the Phase 1 Desk Study reports. As described above these reports are informed by review of historical and current topographical maps, public register information, information from the British Geological Survey, Environment Agency and other online sources, existing ground investigation and monitoring data, together with observations from the site walkover surveys. The scope and methodology of this work is designed to provide a reasonable level of certainty about ground conditions. Any key gaps or critically important uncertainties will be addressed by particular investigation, monitoring or assessment (with design level information to be obtained by more comprehensive ground investigations in due course).

18.38 It is important to recognise that there are inherent uncertainties associated with ground conditions and the data that informs its understanding, both geotechnical and geoenvironmental. For example, geological strata can be very consistent or highly variable, both laterally and vertically. Similarly, contamination can be both widespread and relatively localised, depending upon its source, location, nature and mobility. This

variability is compounded on the Kent Project Site, by the very large area of land involved and by the large range of activities that have taken place over more than 100 years. No investigation, however comprehensive can be expected to determine absolutely the geological conditions, the geotechnical parameters or the nature and extent of contamination which could be present on any site. There will always be an element of uncertainty about the ground conditions, including contamination.

- 18.39 This potential for uncertainty must (and will) therefore be taken into account in any risk assessment (including Environmental Impact Assessment) for example, in the assessment of the need for, scope and design of the remediation strategy, in geotechnical design, in health and safety planning, in financial risk management and in the implementation of any remediation works.
- 18.40 Accordingly, in carrying out this assessment, consideration has been given to the level of uncertainty associated with each of the identified potential sources of contamination and also with the migration pathways that could link such sources to any of the identified receptors. For example, much of the information is based upon historical records which are partial and not complete. The existing ground investigation reports do not provide current, comprehensive, design level data. Because of this uncertainty, the identification of the sources is based upon and reflects a conservative assessment of the potential location, nature and extent of the source(s), including the potential for currently unforeseen contamination.
- 18.41 The probability or likelihood of the hazard being realised has been assessed by consideration of the directness / integrity of the potential exposure pathways that could link the receptor to the source and the uncertainties associated with those pathways. As described above, the assigned level of risk has been determined by the terms of consequence and probability in accordance with the relevant guidance, but it will also take into account the uncertainties associated with all the elements of the contaminant linkages.

#### Data sources

- 18.42 The data sources listed below were used for the baseline study and are also included as a series of technical appendices. Many of these reports also included the review of many site-specific reports, which have therefore been incorporated into this assessment, but which (for brevity) are not repeated again here.
- Appendix 18.1 – Atkins (2014) Paramount Park Entertainment Resort. Phase 1 Geo-environmental and Geotechnical Risk Assessment. Ref: 5134008/Phase I/FinalRev3.0.
  - Appendix 18.2 – Atkins (2015) Paramount Park Entertainment Resort. Phase 1 Geo-environmental and Geotechnical Risk Assessment (A2(T) Corridor and Access

Roadway). Ref: 5139214/AdditionalPhase1/Rev1.0

- Appendix 18.3 – Atkins (2015) Paramount Park Entertainment Resort. Geotechnical and Geo-environmental Interpretive Report. Ref. 5139214/GIR/Draft/Rev1.0.
- Appendix 18.4 - Geotechnical Engineering Limited (2016). London Paramount Entertainment Resort. Factual Report on ground investigation. Ref 30766.
- Appendix 18.5 - Buro Happold (2020) The London Resort. Phase 1 Geo-environmental Assessment – Essex Project Site.
- Appendix 18.6 - Buro Happold (2021) The London Resort. Phase 1 Geo-environmental Assessment Update – Kent Project Site (Swanscombe Peninsula).
- Appendix 18.7 – Buro Happold (2021) The London Resort. Phase 1 Geo-environmental Assessment Update – Kent Project Site (A2 Access Corridor).
- Appendix 18.8 – Groundsure (2020) Groundsure Insight Report for London Resort.
- Appendix 18.9 - Buro Happold (2021). Contaminated Land Management Strategy.
- Appendix 18.10 – WSP (2020) Bamber Quarry Landfill Annual Report 2019.
- Appendix 18.11 – CMS Enviro (2020) Peninsula Annual Report 2019.
- Appendix 18.12 – CMS Enviro (2020) Northfleet Landfill Annual Monitoring Report 2019.
- Appendix 18.13 – CMS Enviro (2021) Swanscombe Landfills. Annual Report 2020
- Appendix 18.14 – WSP (2020) Route options across Bakers Hole SSS1.
- Appendix 18.15 – Minutes from meetings with Environment Agency and local authority regulators.
- Appendix 18.16 – Buro Happold (2020) Specification for groundwater and surface water monitoring.
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- Appendix 18.17 – Buro Happold (2020) Preliminary Tunnel Impact Assessment.

- Appendix 18.18 – Buro Happold (2021) London Resort. Ground investigation scoping – Swanscombe Peninsula
- Appendix 18.19 – Buro Happold (2021). London Resort. Specification for Phase 1 ground investigation
- Appendix 18.20 – Buro Happold (2021) London Resort. Water environment – Interim monitoring report.

## RELEVANT LAW, POLICY AND GUIDANCE

### Law

18.43 Land contamination is regulated under several regimes, including environmental protection, pollution prevention and control, waste management, planning and development control, and health and safety legislation. The key legislation under which contaminated land is managed in the UK are:

- Part 2A of the Environmental Protection Act 1990<sup>4</sup>;
- The Contaminated Land (England) Regulations 2006<sup>5</sup>;
- The Contaminated Land (England) (Amendment) Regulations 2012<sup>6</sup>;
- The Waste (England and Wales) Regulations 2011<sup>7</sup>; and
- The Environmental Permitting (England and Wales) Regulations 2016<sup>8</sup>.

18.44 Part 2A of the Environmental Protection Act 1990 (as amended) establishes a legal framework for dealing with land contamination in England. It provides a means of dealing with unacceptable risks posed by land contamination to human health and the environment. Government objectives with respect to land contamination policy and the Part 2A regime are set out in the Department for Environment Food and Rural Affairs (Defra) Contaminated Land Statutory Guidance 2012 as:

- to identify and remove unacceptable risks to human health and the environment;

<sup>4</sup> HM Government. Part 2A of the Environmental Protection Act 1990

<sup>5</sup> HM Government. The Contaminated Land (England) Regulations 2006

<sup>6</sup> HM Government. The Contaminated Land (England) (Amendment) Regulations 2011

<sup>7</sup> HM Government. The Waste (England and Wales) Regulations 2011

<sup>8</sup> HM Government. The Environmental Permitting (England and Wales) Regulations 2016

- to seek to ensure that contaminated land is made suitable for its current use; and
- to ensure that the burdens faced by individuals, companies and society as a whole are proportionate, manageable and compatible with the principles of sustainable development.

## Policy

### *National policy*

18.45 National Policy Statements (NPS) set out the need for and government's policies to deliver Nationally Significant Infrastructure Projects (NSIPs) in England. Chapter 5 (Relevant law and policy) of the ES explains that there is no NPS for business and commercial NSIP projects. However, to the extent that the Proposed Development includes transport and highways infrastructure, regard will be had to relevant policy in the NPS for National Networks<sup>9</sup> (NPS NN), (the NPS for Ports does not deal with contaminated land) including;

- Environmental and social impacts (NPS NN paragraphs 3.2 to 3.5);
- Pollution control and other environmental protection regimes (NPS NN paragraphs 4.48 – 4.56).

18.46 In addition to this, the primary policy under which contaminated land is managed in the UK is National Planning Policy Framework 2019<sup>10</sup> (NPPF) [6]. The NPPF states that local planning policies and decisions should ensure that:

- a site is suitable for its proposed use taking account of ground conditions and any risks arising from natural hazards or former activities such as mining, and any proposals for mitigation including land remediation (as well as potential impacts on the natural environment arising from that remediation);
- after remediation, as a minimum, land should not be capable of being determined as Contaminated Land under Part IIA of the Environmental Protection Act 1990; and
- adequate site investigation information, prepared by a competent person, is available to inform these assessments.

### *Local policy*

18.47 A review of Kent County Council, Dartford Borough Council and Gravesham Borough

<sup>9</sup> Department for Transport (2014) National Policy Statement for National Networks

<sup>10</sup> Ministry of Housing, Communities and Local Government (2019) National Planning Policy Framework

Council policies identified local planning policy documents relevant to the Proposed Development at the Kent Project Site. These are listed below along with corresponding policy numbers.

- Kent County Council. Kent Minerals and Waste Local Plan 2013-20 (adopted September 2020, as amended by Early Partial Review). Relevant policies are:
  - Policy CSW10 – Development at Closed Landfill Sites;
  - Policy CSW13 – Remediation of Brownfield Land;
  - Policy CSW16 – Safeguarding of Existing Waste Management Facilities;
  - Policy DM 1 – Sustainable Design;
  - Policy DM 2 – Environment and Landscape Sites of International, National and Local Importance;
  - Policy DM 18 – Land Stability; and
  - Policy DM 19 – Restoration, Aftercare and After-use.
- Kent County Council. Kent Minerals Site Plan (adopted September 2020).
- Dartford Borough Council. Contaminated Land Strategy (produced 2001, updated 2008).
- Dartford Borough Council. Dartford Core Strategy (adopted 2011).
- Dartford Borough Council. Dartford Development Policies Plan (adopted 2017). Relevant policies are:
  - Policy DP5 – Environmental and Amenity Protection.
- Gravesham Borough Council. Contaminated Land Strategy (adopted 2001, revision 2 adopted 2013).
- Gravesham Borough Council. Gravesham Local Plan First Review – Saved Policies (2014).
- Gravesham Borough Council. Gravesham Local Plan Core Strategy (adopted 2014). Relevant policies are:

- Policy CS19: Development and Design Principles.

18.48 A review of Thurrock Council policies identified local planning policy documents relevant to the Proposed Development at the Essex Project Site. These are listed below along with corresponding policy numbers.

- Thurrock Council. Schedule of saved Borough Local Plan policies, site allocations and annexes (2012).
- Thurrock Council. Thurrock Local Development Framework. Core Strategy and Policies for Management of Development, as amended (adopted 2015). Relevant policies are:
  - PMD1 – Minimising Pollution and Impacts on Amenity, Health, Safety and the Natural Environment.

## Guidance

18.49 The framework for the assessment of potential land contamination adopted in this assessment is based on current guidance documents regarding the implementation of these regimes and the assessment of potentially contaminated land, with particular reference to:

- Gov.uk “Land contamination: risk management” 2020<sup>11</sup>;
- Environment Agency “Guiding principles for land contamination” 2010<sup>12</sup>;
- British Standard BS 10175:2011+A2:2017 “Investigation of potentially contaminated sites”<sup>13</sup>;
- British Standard BS EN ISO 21365:2020 “Soil quality – Conceptual site models for potentially contaminated sites”<sup>14</sup>;
- British Standard BS 5930:2015+A1:2020 “Code of practise for ground investigations”<sup>15</sup>; and

<sup>11</sup> Gov.uk (2020) Land contamination risk management (LCRM)

<sup>12</sup> Environment Agency (2010) Guiding principles for land contamination

<sup>13</sup> British Standards Institute (2017) BS 10175:2011+A2:2017. Investigation of potentially contaminated sites. Code of practice.

<sup>14</sup> British Standards Institute (2020) BS EN ISO 21365:2020. Soil quality. Conceptual site models for potentially contaminated sites.

<sup>15</sup> British Standards Institute (2020) BS 5930:2015+A1:2020. Code of practice for ground investigations.

- Highways England “Design Manual for Roads and Bridges. LA 109 Geology and soils” 2019<sup>16</sup>.
- Highways England “Design Manual for Roads and Bridges. LA 113 Road drainage and the water environment”2020<sup>17</sup>

## BASELINE CONDITIONS

### Zoning

18.50 To facilitate assessment of the Project Site, the baseline conditions of the Essex Project Site and the Kent Project Site are described separately. The Kent Project Site is further divided into nine zones, referred to as Zones 1 to 9 (see Figure 18.2 and Figure 18.3). These zones have been defined based on location, land use patterns and current ownership. For the purpose of the assessment, the Kent Project Site is divided into two distinct areas: the Swanscombe Peninsula (Zones 1 to 5) and the A2 Highway Works (Zones 6 to 9). The Essex Project Site is not subdivided in any way. A summary of these various areas (the Essex Project Site and Zones 1 to 9 of the Kent Project Site) is presented below.

- The Essex Project Site is located on the north bank of the River Thames and is part of the port of Tilbury, north of the former Tilbury Riverside railway station and the current Cruise Terminal. It covers approximately 25.5 ha.
- Zone 1 (Kent Project Site) is located in the northernmost part of the Swanscombe Peninsula and is known as Broadness Marsh. It forms the tip of the peninsula with the River Thames adjacent to the north, north-west and north-east and has an approximate area of 47.7 ha. The zone is generally covered with scrub vegetation and is of undulating topography due to the historical infilling of Cement Kiln Dust (CKD).
- Zone 2 (Kent Project Site) is located in the north-western section of the Swanscombe Peninsula and has an approximate area of 54.3 ha. The zone is of highly varying topography due to the presence of licensed CKD landfills and is vegetated with shrubs and trees.
- Zone 3 (Kent Project Site) is located in the western part of the Kent Project Site, to the east of the Ingress Park residential development. It has been further divided into two sub-zones: Zone 3A (covering 24.5 ha) forming the northern part and Zone 3B (covering 11.4 ha) forming the southern part. The former comprises Blackduck Marsh

<sup>16</sup> Highways England “Design Manual for Roads and Bridges. LA 109 Geology and soils” 2019

<sup>17</sup> Highways England “Design Manual for Roads and Bridges. LA 113 Road drainage and the water environment”2020



(note – labelled Swanscombe Marshes in Appendix 18.1) and the latter comprises a more developed area with some current light commercial / industrial uses.

- Zone 4 (Kent Project Site) is located in the eastern part of the Swanscombe Peninsula. Zone 4A (covering 15.1 ha) and Zone 4D (20.1 ha) are currently marshland. Zone 4B covers about 21.8 ha. It is dissected by the HS1 railway and comprises a series of industrial/commercial units, including Northfleet Industrial Estate, Kent Kraft Industrial Estate and the eastern part of Manor Way Business Park. Zone 4C (4.1 ha) is to the south of Zone 4B and comprises open ground known as the Sportsground, which historically included a rifle range.
- Zone 5 (Kent Project Site) is located within the middle of the wider Swanscombe Peninsula, immediately north of the North Kent Line railway and west of HS1. The northern half of the zone, termed Zone 5A (covering about 12.8 ha), includes the western part of Manor Way Business Park, which consists of light / medium industrial units. The southern part of the zone, Zone 5B (7.1 ha), comprises an open area which is a part in-filled former chalk quarry off Craylands Lane, known as Craylands Lane Pit.
- Zone 6 (Kent Project Site) is located to the south of the Swanscombe Peninsula. It is subdivided into three subzones: Zone 6A, Zone 6B and Zone 6C. Zone 6A covers about 13.9 ha and comprises a former chalk pit, “Bamber Pit”, which is partially landfilled and overgrown open land. Zone 6B covers 33.7 ha and includes “Northfleet Landfill”, Ebbsfleet International Station and an area of associated carparking. The River Ebbsfleet passes through Zone 6C (8.4 ha). It also includes a short stretch of railway line and carparking.
- Zone 7 (Kent Project Site) is located to the north of the A2(T) and is bisected by the A2260. It comprises part of “Southfleet Pit” landfill and is also occupied by infrastructure associated with Ebbsfleet International Station in the north of the zone and Springhead Nurseries in the southeast corner. The River Ebbsfleet flows from south to north, parallel to the eastern boundary of part of the zone. It covers about 35.7 ha.
- Zone 8 (Kent Project Site) is located in the southeast of the Project Site and covers some 18.3 ha. It encompasses an approximately 1km long stretch of the A2(T) road to the east of the A260 junction. It also includes an area to the north of the A2(T) occupied by Northfleet East Grid Substation.
- Zone 9 (Kent Project Site) covers 37 ha. It is located in the southwest of the Kent Project Site and encompasses the A2(T) between approximately the A260 junction in the east and the B225 junction in the west.

### Baseline - Essex Project Site

**Site description**

18.51 The Essex Project Site covers some 25.54 ha. It is located in Tilbury (and is a part of the port of Tilbury), in the borough of Thurrock, Essex. The majority of the area is currently used as parking / storage for new Hyundai cars and with a Cruise Terminal, Ferry Terminal and Passenger Landing Stage on the southern boundary adjacent to the River Thames. Along the northern boundary runs a newly constructed road linking the port of Tilbury with the new port of Tilbury2. There is a large light industrial warehouse (Unit 1) in the approximate centre of the Essex Project Site which is not within the DCO order limits. Further information describing the baseline condition of the Essex Project Site can be found in Appendix 18.5.

**Geological conditions and soil resources**

18.52 The anticipated geology is a heterogeneous composition of Made Ground (including ash, concrete, brick, timber, flint), typically between about 1 and 3m, underlain by a natural geological sequence comprising about 15m of Alluvium (very soft to firm clays, peats and sands) over a relatively limited thickness (approximately 2 to 5m) of River Terrace Gravels. Beneath these is the Upper Chalk at about 18 to 24m bgl. The anticipated natural superficial and bedrock geology is illustrated by Figure 18.4 and Figure 18.5.

18.53 Part of the Essex Project Site extends onto the shore of the River Thames. This area is underlain by tidal deposits. BGS borehole records indicate this to include about 12 to 20m of alluvial clays and peats, over River Terrace Gravels, with Chalk present at about 22 to 23m bgl.

18.54 The Agricultural Land Classification (ALC) of the majority of the Essex Project Site is identified as 'Non-agricultural land'. About 10% of the area is identified as Grade 3 (good to moderate quality). However, most of the surface is covered by hardstanding. The Essex Project Site is therefore not a viable resource of agricultural soils, and agricultural soils are not considered as a potential receptor with regards to this chapter of the ES.

**Hydrogeology**

18.55 Perched groundwater is likely to be present above low permeability bands in both the Made Ground and the Alluvium. Environment Agency Aquifer maps show the Essex Project Site to be underlain by a Secondary (Undifferentiated) Aquifer in superficial Alluvium and River Terrace Gravel deposits. The Upper Chalk bedrock is classified as a Principal Aquifer. This stratum may support water supply and / or river base flow – although it is unlikely to be utilised for potable water supply in the vicinity due to its proximity to the River Thames. Groundwater levels across the Essex Project Site will be influenced by its proximity to the River Thames and associated tidal flows. The nearest

record of groundwater abstraction is about 965m east, a historical record related to Tilbury Power Station.

- 18.56 There are limited records of groundwater strikes on BGS borehole records. However, where recorded / encountered shallow groundwater ingress was generally at approximately 1 to 2m bgl in Made Ground or Alluvium. A deeper groundwater body was recorded at the top of River Terrace Deposits at approximately 16 to 17m bgl, rising to between 8 and 9m bgl, indicating sub-artesian pressures due to confinement by the overlying Alluvium. This deeper body is likely to be in continuity with the Chalk.

### ***Hydrology***

- 18.57 The Essex Project Site is located on the north bank of the River Thames, with the southern part extending onto the river foreshore. The River Thames is tidal in this location. A number of other surface water drains are present within the Essex Project Site, generally orientated approximately north-south with outfall to the River Thames. There are known issues with siltation within these drains that causes flooding upstream. Ponding is also a known issue within part of the Essex Project Site. Wet docks (part of Port of Tilbury) are present from about 150m west and moats associated with Tilbury Fort are present about 150m east. Both of these water bodies are supplied by water from the River Thames.

### ***Ecology***

- 18.58 The Essex Project Site does not support any ecologically sensitive species.

### ***Historical land uses***

- 18.59 The Essex Project Site has been located in a commercial / industrial area since at least the late 1800s. The earliest available map (1872) shows the area to be partially developed, occupied by a railway line (London, Tilbury and Southend Railway), railway station (Tilbury Station, later becoming Tilbury Riverside Station) and ancillary buildings (engine shed, goods shed, associated housing). A small disused gasworks was present adjacent to the northern boundary. Tilbury Docks were developed to the immediate west by 1895. The area was further developed until the mid-1960s, by expansion to the railway sidings, addition of buildings associated with operation of Tilbury Docks (hospital, mortuary, works, smithy etc.) and expansion to the pontoon / terminal on the River Thames (addition of passenger facilities and increased infrastructure within the river).
- 18.60 Redevelopment of the Essex Project Site had commenced by the 1970s, by scaling back of the rail sidings, which had mostly been removed by the 1990s. By the mid-2000s, the eastern part of the area was covered by hardstanding and used for car parking. The 2010 map shows the Essex Project Site developed to its current configuration (mostly covered by hardstanding for car parking but the ferry terminal and pontoon still present).

18.61 The available historical mapping dated between 1939 and 1945 does not show any evidence of bomb damage on the Essex Project Site. However, online records do report that the London, Tilbury and Southend Railway suffered bomb damage, including a direct hit to sidings near Tilbury Riverside Station.

### ***Previous ground investigation***

18.62

Known previous ground investigations are summarised in Table 18.9. These reports have principally informed the anticipated geological sequence and hydrogeological regime. Much of the chemical / geotechnical data is aged and no reassessment of this has been undertaken.

**Table 18.9: Summary of previous ground investigations (Essex Project Site).**

<b>Report title</b>	<b>Number of exploratory holes</b>	<b>Brief summary</b>
Port of London Authority Drawing Office (1943) Tilbury Docks Borings <sup>18</sup>	10 boreholes	Historical borehole logs (undated, 1914, 1923)
CEDAC (1994) Tilbury Riverside. Desk Top Geotechnical Assessment <sup>19</sup>	3 hand auger holes 13 trial pits	Desk study supported by limited investigation. Comment on; geology, water table, bearing capacity, drainage and recommendations for further assessment
Geotechnical Developments (1996) Preliminary Ground Investigation at Cruise Terminal <sup>20</sup>	4 boreholes	Interpretative report including gas monitoring and laboratory testing (geotechnical and geochemical)
RSA Geotechnics (1999) Proposed Link Road. Ground Investigation Report <sup>21</sup>	10 boreholes 16 trial pits	Interpretative geotechnical report for proposed link road including geochemical testing

<sup>18</sup> Port of London Authority Drawing Office (1943) Tilbury Docks Borings. Drawing no. 8452002

<sup>19</sup> CEDAC (1994) Tilbury Riverside Automotive Terminal. Desk Top Geotechnical Assessment.

<sup>20</sup> Geotechnical Developments (1996) Report of Preliminary Investigation at London International Cruise Terminal. Port of Tilbury, Essex for Port of Tilbury London Ltd. E1072/96.

<sup>21</sup> RSA Geotechnics Ltd (1999) Proposed Link Road at Fort Land, Tilbury for Port of Tilbury London Limited. Ground Investigation Report Number 7227.

Report title	Number of exploratory holes	Brief summary
Site Analytical Services Ltd (2000) Fortress Distribution Park. Report on Ground Investigation <sup>22</sup>	5 boreholes 10 trial pits 20 WS holes	Interpretative report including in situ testing, monitoring and laboratory testing (geotechnical and geochemical)

### ***Unexploded ordnance (UXO)***

18.63 The Essex Project Site and surrounding area was subject to the direct impact of bombs during World War 2. Whilst the Essex Project Site has undergone significant post war development (>80% of the site), there remains a potential for UXO to exist. A Preliminary UXO Risk Assessment undertaken by Buro Happold (included with Appendix 18.5) concluded that the risk associated with UXO is moderate.

### ***Baseline conceptual site model***

18.64 Hazard identification and assessment involve the development of the Conceptual Site Model (CSM). A CSM is the description of the contaminant linkages formed (or potentially formed) when a source of contamination is linked to a receptor via a pathway of exposure/migration. A baseline CSM describes the contaminant linkages already potentially present at a site in its current condition, prior to any construction and operation.

18.65 Potential sources of contamination across the Essex Project Site include: Made Ground from historical land use on-site and surrounding area (rail sidings, ancillary buildings associated with railway use, hospital, mortuary, works, gas works); current site use (car parking, passenger terminal, electricity substation); and Alluvium (ground gas).

18.66 Receptors to the identified sources of contamination and their sensitivity, based on the current understanding of the condition of the Essex Project Site and the Proposed Development are summarised in Table 18.10.

**Table 18.10: Receptors and their sensitivity on the Essex Project Site.**

Receptor	Sensitivity	Justification
Construction workers	Moderate	During construction, construction workers involved in below ground works may be exposed to contaminants via direct or

<sup>22</sup> Site Analytical Services Ltd (2000) Fortress Distribution Park. Westerlund Site, Tilbury, Essex. Report on Ground Investigation. Ref.00/9928

Receptor	Sensitivity	Justification
		indirect ingestion, inhalation and / or dermal contact. If working in confined spaces, workers could be exposed to flammable or asphyxiating gases.
Site visitors or workers	Low	During operation future site visitors/ workers may be exposed to contaminants via direct or indirect ingestion, inhalation and / or dermal contact in areas of soft landscaping. Future site users could also be exposed to flammable or asphyxiating gases.
Neighbours	Low	During development, people occupying neighbouring land (workers at surrounding commercial / industrial properties) could be exposed to contaminants via windblown dusts or vapours. During operation future site visitors/ workers may be exposed to flammable or asphyxiating gases.
Secondary Aquifer – superficial deposits	Moderate	No local abstractions from Secondary Aquifer. Infiltration would generate leachate from Made Ground which would migrate via permeable soils to underlying Alluvium and River Terrace Deposits during construction and operation. Low permeability bands may inhibit downward migration of contamination. Potential for creation of preferential pathways (e.g. via piled foundations) during construction and operation. Groundwater in River Terrace Deposits likely to be in continuity with underlying Chalk (Principal Aquifer).
Principal Aquifer - Chalk	Moderate	No local groundwater abstractions from Chalk. Infiltration would generate leachate from Made Ground which would migrate via permeable soils to underlying Alluvium and River Terrace Deposits during construction and operation. Groundwater in River Terrace Deposits likely to be in continuity with underlying Chalk. Potential for the creation of preferential pathways (e.g. via piled foundations) during construction and operation.
River Thames	Moderate	Potential for migration of contamination via surface water run-off or shallow groundwater via permeable strata to the adjacent River.
Flora and Fauna	Low	Hardstanding cover over the large majority of the area. No ecologically sensitive species currently present – some scrub vegetation. In operation, flora will be in areas of soft landscaping / planters with imported subsoils and topsoils.
Built infrastructure	Low	In construction – potential for damage due to encountering UXO. In operation - potential for permeation / aggressive

Receptor	Sensitivity	Justification
		attack on below ground foundations, water supply and drainage systems.

## Baseline - Kent Project Site: Swanscombe Peninsula (Zones 1 to 5)

### *Site description*

18.67 The Swanscombe Peninsula (Zones 1 to 5) is an approximately triangular area of land in a meander of the River Thames, comprising predominantly low-lying marshland, landfills, business parks and commercial land, amongst other less dominant land uses. Known areas of landfilling are illustrated by Figure 18.6. Further information describing the baseline condition of the Swanscombe Peninsula of the Kent Project Site can be found in Appendix 18.1 and Appendix 18.6.

### *Geological conditions and soil resources*

18.68 Made Ground varies across the Swanscombe Peninsula. In the north (Zone 1, Zone 2 and Zone 3B) it comprises cement kiln dust (CKD), a waste product from the local cement industry. In the south there are areas where chalk, clay, sand and gravels which have been used to backfill pits and quarries (Zone 5B, Zone 4C) together with a mixture of domestic and commercial wastes within landfilled areas (Zone 3B, Zone 6A, Zone 6B). There are some areas with a limited history of development where no / limited Made Ground is expected (Zone 3A, Zone 4A, Zone 4B).

18.69 The general topography is variable across the Kent Project Site, with low-lying, undulating land towards the north due to natural marshland and historical landfilling. Substantial chalk spines are present in the centre of the Kent Project Site, upon which roads and railway lines run, approximately 16-20m above the surrounding ground.

18.70 The anticipated natural superficial and bedrock geology is illustrated by Figure 18.4 and Figure 18.5. Alluvium (clay, silt, sand and peat) covers a large portion of the Swanscombe Peninsula north of Manor Way. Historical borehole records indicate two prominent layers of peat in this area, at approximately -4 m and -8 m above Ordnance Datum (AOD). Head deposits (clay, silt, sand and gravel), formed from the Chalk bedrock, are anticipated across small pockets of the peninsula. Beneath the Alluvium and Head Deposits are River Terrace Deposits (Taplow Gravel Member and Boyne Hill Gravel Member). These comprise sands and gravels, with possible lenses of silt, clay or peat. The superficial deposits are underlain by Chalk bedrock, part of the White Chalk Subgroup (Seaford and Lewes Formations).

18.71 Soils on the Swanscombe Peninsula are identified as 'Urban land' in accordance with the

Agricultural Land Classification. This reflects that the vast majority of Zones 1 to 5 have been subjected to development or landfilling at some stage. The Swanscombe Peninsula (Zones 1 to 5) is therefore not considered to be a viable resource of agricultural soils, and agricultural soils are not considered as a potential receptor with regards to this chapter of the ES.

### **Hydrogeology**

- 18.72 The direction of groundwater flow on the Swanscombe Peninsula is not well understood. Regionally it is expected to flow northwards, towards the River Thames. Abstractions associated with the HS1 portal and quarries in the vicinity will have an impact on flow direction locally.
- 18.73 The Alluvium and Head Deposits are classified as Secondary A aquifers, defined as permeable layers capable of supporting water supplies at a local rather than strategic scale, and in some cases forming an important source of base flow to rivers. The River Terrace Deposits in this area are classified as Secondary (Undifferentiated) Aquifers. The Chalk bedrock is a Principal Aquifer, defined as layers of rock or drift deposits that usually provide a high level of water storage and may support water supply and/or river base flow on a strategic scale.
- 18.74 About half of the Swanscombe Peninsula area is located in a Source Protection Zone (SPZ), either Zone 2 (outer catchment) or Zone 3 (total catchment), associated with abstractions further south in / around the A2 Highway Works area. There is one record of a historical groundwater abstraction within Zone 2, which was operational between 2002 and 2004 for dust suppression and mineral washing. The nearest off-site record is located about 5m east of Zone 1, operated by CEMEX UK Materials Ltd for mineral washing.

### **Hydrology**

- 18.75 The Swanscombe Peninsula is located in a meander of the River Thames, and immediately next to part of the Kent Project Site (Zone 1, Zone 2, Zone 3A). The River Ebbsfleet flows in an approximately south to north direction from Springhead towards the River Thames, and joins the River Thames to the east of the Swanscombe Peninsula. The Swanscombe Peninsula is currently drained by a series of manmade drainage ditches and culverts to the River Thames, see Chapter 17 (Water resources and flood risk).
- 18.76 There are also artificial drains and ponds that have been constructed to assist in regulating areas of landfill. A surface water collection and treatment system is in place on Broadness Marsh (Zone 1), an area of historical CKD landfilling. Leachate from this zone is currently collected in a series of drains, pumped to a leachate treatment plant (consisting of aeration lagoons, soakaways and wetlands), and discharged via a jetty located in Zone 2. However, it is known that the ditches overtop during high rainfall events and discharge



directly to the River Thames. South Pit Leachate Treatment Plant is in place to treat leachate from landfills within Zone 2. This effluent is discharged to the Southern Water foul system.

### **Ecology**

18.77 The Swanscombe Peninsula supports a number of ecologically sensitive habitats. This includes open mosaic habitat on previously developed land, the reedbeds at Black Duck Marsh and surrounding the Channel Tunnel Rail Link tunnel portal, saltmarsh around the coast and grazing marsh within Botany Marsh. Almost the entirety of this area falls within the Swanscombe Peninsula SSSI (designated due to its ecological and geological value), which was notified on 11<sup>th</sup> March 2021.

18.78 Much of the ecological sensitivity stems from the protected and notable species that are present. A number of nationally scarce plants are found within grassland, marshland and ditches across the peninsula, including yellow and hairy vetchling, man orchid, divided sedge and round-leaved wintergreen, amongst others. Also present are a nationally significant invertebrate population, part of an internationally significant winter bird population associated with European Sites in the Thames Estuary, a regionally significant breeding bird population, breeding dormice, otter and water vole, and a large population of reptiles.

### **Historical land uses**

18.79 Zone 1 was shown to comprise Broadness Salt Marsh from at least 1865 until 1970, when the surface water features and salt marshes were infilled with waste by-products from the adjacent cement industry (predominantly CKD) and dredgings from the River Thames. The licensed CKD disposal commenced in approximately 1977 with the Waste Management Licence (WML) surrendered in 1992. The CKD wastes are understood to be between 4-7 m thick. The landfill operated on a 'dilute and disperse' basis and has not undergone any formal restoration. There is currently a leachate management system in operation within Zone 1, comprising a collection system, holding/treatment lagoons and a wetland filtration area in the north-eastern section adjacent to the River Thames.

18.80 Zone 2 historically comprised marshes prior to clay extraction in parts of the zone and subsequently landfilling (see Figure 18.6), predominantly with CKD wastes associated with the adjacent cement industry. Landfilling was undertaken in two main phases – North Pit, and South Pit and Surge Pile. North Pit comprised the initial phase, which took place in the north-western part of the zone in a former clay pit. It is thought to have been landfilled in the mid-1970s and the WML was surrendered prior to 1994. South Pit and Surge Pile landfill comprises three phases (Phases 1-3) and was first licensed in 1977 to accept CKD and a range of other wastes from the Blue Circle/Lafarge Northfleet cement works. There

remain two areas of Zone 2 with current waste management licenses. There were also some industrial uses in the south-western corner of the zone including cement manufacture and a small gasworks. The HS1 rail link crosses the zone partially within a tunnel and the tunnel portal is located in the south-eastern corner of the zone. A disused sewage treatment works is present in the centre of the zone.

- 18.81 Zone 3 mainly comprises undeveloped marshland in the northern half (Zone 3A), whilst the smaller southern part (Zone 3B) has historically been used for cement manufacture, as a whiting works, chalk extraction and landfilling (see Figure 18.6) and currently supports a range of light industrial and waste recycling operations. The landfilled area was used as a works tip for the adjacent Blue Circle/Lafarge Northfleet cement works and is understood to have accepted a range of waste materials including CKD and also demolition materials from the works possibly including asbestos. The landfill operated between 1980 and 1993 and does not have a current WML/Environmental Permit (EP).
- 18.82 Zone 4A and Zone 4D are not believed to have been subject to any industrial development or mineral extraction activities and have remained as marshland. Zone 4B has undergone substantial changes including development as a tar distillery, paper mills, a chemical works, various tramways and electricity substations. Part of an infilled chalk pit (Pilgrims Pit) and an infilled former lagoon are also present in the north-western/northern sections of Zone 4B. Part of Zone 4C, the Sportsground site, was partially in-filled and a rifle range was previously present in the western section.
- 18.83 Historical land uses within Zone 5 have been varied. Historically Zone 5A was part of the Portland Cement Works and also included railway tracks/tramways, an electricity substation, part of the former paper works and mills and part of the in-filled Pilgrim's Pit in the north-eastern section. Zone 5B is understood to have been part in-filled by arisings from the HS1 development, which runs through the adjacent Zone 4.

### ***Previous ground investigations***

- 18.84 Known previous ground investigations are summarised in Table 18.11. A number of the referenced reports are included as Appendices to this chapter, which should be referred to directly for more complete information.

**Table 18.11: Summary of previous ground investigations and monitoring (Zones 1 to 5).**

<b>Report title</b>	<b>Zone / exploratory holes</b>	<b>Brief summary</b>
Halcrow Group Limited, Swanscombe Peninsula West	Zone 2, 3 and 5 14 boreholes 40 window samples	A risk assessment recorded that no remediation action was required based on the assumption that the area would undergo a significant land raise. No

Report title	Zone / exploratory holes	Brief summary
Phase 1 Contamination Interpretive Report – January 2004.	52 trial pits	significant potential pollutant linkages were found for controlled waters receptors.
Hydrock (2008) Desk Study and Ground Investigation at Northfleet Industrial Estate <sup>23</sup>	Zone 4  8 trial pits 4 hand dug pits 2 trial trenches 3 boreholes	Ground investigation was designed to aid remediation of the lagoon. Ground investigation works were undertaken by Hydrock in December 2008, Consultants 2010 in November 2002 and Ground Solutions in August 2003. Chemical data was re-assessed in line with good practice and found no exceedances of the selected screening criteria in soils. There were exceedances of the selected screening criteria in groundwater, indicating a potential source of groundwater contamination.
Borehole logs available from the BGS from the HS1 ground investigation <sup>24</sup>	Zone 4  Complete report unavailable.	There was visual and olfactory evidence of contamination in Zone 4 within the publicly available boreholes for the HS1 ground investigation. Associated chemical data and reports are unavailable. The contamination included solvent odours, black ash, black oil, petrochemical odours, diesel oil odour, pulverised fuel ash, oil and clinker.
Parsons Brinckerhoff (2011) Bamber Quarry Landfill. Hydrogeological Risk Assessment <sup>25</sup>	Zone 6A and Zone 4C  5 trial pits (1988) 9 trial pits (up to 2004) 6 boreholes (up to 2004) 15 boreholes (2002-2007)	Summarised numerous ground investigations undertaken in Bamber Pit as part of ongoing permit requirements. Also, some monitoring locations within The Sportsground (Zone 4C). A controlled waters risk assessment identified a number of potential contaminants of concern which may have the potential to impact controlled waters receptors.
Geotechnical Engineering (2015) Factual Report on	Zone 1, Zone 2, Zone 3 and Zone 5	Factual and Interpretative reports of investigation (very limited number of exploratory holes). Confirmed occurrence

<sup>23</sup> Hydrock (2008) Desk Study and Ground Investigation at Northfleet Industrial Estate.

<sup>24</sup> Available at: <https://www.bgs.ac.uk/map-viewers/geology-of-britain-viewer/>

<sup>25</sup> Parsons Brinckerhoff UK Ltd (2011) Bamber Quarry Landfill. Hydrogeological Risk Assessment. Issue No. 2

Report title	Zone / exploratory holes	Brief summary
Ground Investigation (Appendix 18.4)  Atkins (2015) Geotechnical and Geo-Environmental Interpretative Report (Appendix 18.3)	3 trial pits 7 boreholes 7 window sample holes	of CKD deposits. Occasional exceedances of human health screening criteria were recorded (including presence of asbestos) in soils and groundwater. A number of contaminants exceeded the generic screening criteria within leachate, perched water and groundwater samples. Possible that Alluvium is providing a level of protection between perched water and deeper aquifers in River Terrace Deposits / Chalk.
CMS Enviro (2019), Swanscombe Landfills: Annual Report 2019 (Appendix 18.11)	Zone 2  No details of exploratory holes provided.	Combined annual monitoring report for South Pit Phase 3 Landfill and South Pit and Surge Pile Landfill, prepared to satisfy landfill permit requirements. Data was reported to be generally consistent with previous years and compliant with permit conditions (leachate, surface water, groundwater, landfill gas).
CMS Enviro (2020) Swanscombe Landfills: Annual Report 2020 (Appendix 18.13)	Zone 2  No details of exploratory holes provided.	Combined annual monitoring report for South Pit Phase 3 Landfill and South Pit and Surge Pile Landfill, prepared to satisfy landfill permit requirements. Data were reported to be generally consistent with previous years and compliant with permit conditions (leachate, surface water, groundwater and landfill gas). Improvements to the surface water drainage network are ongoing.
Buro Happold (2021) London Resort. Water environment – Interim monitoring report (Appendix 18.20)	Zones 1, 2, 5 and 7.	Factual summary of groundwater, surface water and sediment data obtained from year-long programme of monthly sampling across the Kent Project Site. Data from September 2020 to May 2021 are available.

### Unexploded Ordnance (UXO)

18.85 A detailed UXO risk assessment was commissioned by Atkins in 2014 (and is included with

Appendix 18.1). The overall risk associated with encountering UXO on the Swanscombe Peninsula is high, based on the potential threat associated with second world war German Wehrmacht Luftwaffe's air dropped high explosive bombs, incendiary devices and British anti-aircraft artillery projectiles together with a lesser threat from small arms ammunition.

### Baseline conceptual model

18.86 Hazard identification and assessment involve the development of the Conceptual Site Model (CSM). A CSM is the description of the contaminant linkages formed (or potentially formed) when a source of contamination is linked to a receptor via a pathway of exposure/migration. A baseline CSM describes the contaminant linkages already potentially present at a site in its current condition, prior to any construction and operation.

18.87 Potential sources of contamination across the Swanscombe Peninsula are discussed below, by zone:

- Within Zone 1, the landfill comprising the majority of the marsh that was previously used for the deposition of CKD and river dredgings. In addition, there is ongoing leachate collection and treatment being undertaken within Zone 1 from the areas of CKD landfilling.
- Within Zone 2, the identified sources of potential contamination include North Pit landfill, South Pit and Surge Pile (Phases 1 and 3), all of which were infilled with CKD. Leachate from the CKD landfills is being collected and discharged to foul sewer. Other identified sources include the derelict sewage works and operational sewage pumping station, Bell Wharf and White's Jetty (a derelict wharf and pier) and associated storage tanks, historical cement works and associated infrastructure and the former gasworks.
- Within Zone 3A (Swanscombe Marshes), the underlying alluvium and marshland are a potential source of ground gas. Within Zone 3B, sources of contamination relate to current and historical uses including: the cement works, welding works (Basic Engineering Co Ltd), the licensed Swanscombe Glass Recovery facility, whiting works (with tanks and silos), an electricity substation and conveyors. Swanscombe Cement Landfill, which may have been infilled with CKD and other wastes, is another potential source of contamination in Zone 3B. Alluvium and marshland in Zone 3B may also pose a risk of ground gas generation.
- Alluvium and marshland underlying Zone 4A and Zone 4D are a potential source of ground gas. There are also warehouses / a depot in the southeast corner of Zone 4D. Within Zone 4B, historical potentially contaminative land uses including the Thames Tar Distillery, paper mills, chemical works, tramways, electricity substations and a pipeline. Current potentially contaminative land uses in Zone 4B are the industrial uses

within Northfleet Industrial Estate and partial infilling of the lagoon. The firing range and historical infilling were deemed a potential source of contamination within Zone 4C. Potential off-site sources of contamination include Botany Road Landfill (adjacent to east of Zone 4D).

- Sources of contamination in Zone 5A include historical, potentially contaminative land uses, namely cement works, whiting works, tramway tracks, conveyors and railway sidings. Other identified sources are the potential contaminative industrial sites (a tank and electricity substation), infilled land within Pilgrims Pit, the licensed waste sites (including a change of use facility for the processing and recycling of plastic materials and a waste transfer station and treatment facility) and Made Ground beneath the zone. Within Zone 5B, potential sources of contamination included those associated with industrial sites (tanks and a conveyor) and infilled land within the former chalk quarry.

18.88 Receptors to the identified sources of contamination and their sensitivity, based on the current understanding of the condition of the Swanscombe Peninsula (Kent Project Site) and the Proposed Development are summarised in Table 18.12.

**Table 18.12: Receptors and their sensitivity on the Swanscombe Peninsula (Kent Project Site).**

<b>Receptor</b>	<b>Sensitivity</b>	<b>Justification</b>
Construction workers	High	During construction, construction workers involved in below ground works may be exposed to contaminants via direct or indirect ingestion, inhalation and / or dermal contact. If working in confined spaces, workers could be exposed to flammable or asphyxiating gases. Extensive earthworks will be undertaken in some areas.
Site visitors or workers	Moderate to Low	During operation future site occupiers / visitors may be exposed to contaminants via direct or indirect ingestion, inhalation and / or dermal contact in areas of public open space / soft landscaping. Future site users could also be exposed to flammable or asphyxiating gases. Public open space will be a mixture of soft-landscaping and hardstanding.
Neighbours	High	During development, people occupying neighbouring land (workers at surrounding commercial / industrial properties) could be exposed to contaminants via windblown dusts or vapours. Neighbours are a mixture of residential with gardens and commercial / industrial.
Secondary Aquifer –	Moderate	During construction and operation, infiltration would generate leachate from Made Ground / CKD / waste deposits, which

Receptor	Sensitivity	Justification
superficial deposits		would migrate via permeable ground to underlying superficial deposits (Alluvium, Head Deposits, River Terrace Gravels). No local abstractions but may provide baseflow to the River Thames.
Principal Aquifer - Chalk	Moderate	There is potential for contamination in the shallow aquifer to migrate vertically to the underlying Principal Aquifer in Chalk. There is potential for the creation of preferential pathways (e.g. via piled foundations) during construction and operation. There is record of historical groundwater abstraction on the Swanscombe Peninsula. The nearest active abstraction is adjacent to the Swanscombe Peninsula (non-potable supply).
River Thames	Moderate	Potential for migration of contamination via surface water run-off or migration of contaminated groundwater via shallow permeable strata to the adjacent River.
Built infrastructure	Moderate	Potential for aggressive attack on below ground site drainage system and foundations. [Note: Potential for engineering impact on existing HS1 tunnel infrastructure assessed in Appendix 18.17]
Flora and fauna	High	Most of the Swanscombe Peninsula falls within the Swanscombe Peninsula SSSI, designated due to its ecological and geological interest and which supports a range of ecologically sensitive habitats. This includes nationally scarce plants, a nationally significant invertebrate population and an internationally significant winter bird population, amongst others. In operation, there will be areas of managed marshland, as well as soft landscaping within the Resort.

### Baseline - Kent Project Site: A2(T) Highway Works (Zones 6 to 9)

#### *Site description*

18.89 The A2 Highway Works area (Zones 6 to 9) is located to the south of the North Kent Line and runs south in a corridor between HS1 and the A2260 and B259 roads to a junction with the A2 trunk road (Figure 18.3). The area is approximately 2 km north to south and 4.5 km east to west. It also encompasses a series of landfills and section of the A2(T) (which runs east to west) between approximately the A2(T) / B255 junction at Bean in the west and the A2(T) / B262 junction in the east. Aside from the roads and associated infrastructure, the A2 Highway Works area is currently used as; parking lots for Ebbsfleet International Station and associated infrastructure, Springhead Nurseries, a Grid Substation and a limited number of other commercial properties.

18.90 Further information describing the baseline condition of the A2(T) Highway Works (Zone 6 to Zone 9) of the Kent Project Site can be found in Appendix 18.1 and 18.6 for Zone 6, and Appendix 18.2 and Appendix 18.7 for Zones 7 to 9.

### ***Geological conditions and soil resources***

18.91 Made Ground varies across the A2 Highway Works area and includes substantial areas of landfilling, namely, Bamber Pit (commercial and inert waste), Northfleet Landfill (domestic / commercial waste) in Zone 6, and Southfleet Pit (CKD waste) in Zone 7. Elsewhere, the Made Ground will be consistent with more limited history of development, predominantly roads across Zone 8 and Zone 9 and some light commercial / industrial uses.

18.92 The anticipated natural superficial and bedrock geology is illustrated by Figure 18.4 and Figure 18.5. Most of the A2 Highway Works area is not underlain by natural superficial deposits. Where present, superficial deposits are mainly associated with the channel of the River Ebbsfleet, a relatively limited area underlain by Alluvium and Head Deposits. Both of these strata are classified as Secondary (Undifferentiated) Aquifers. There are other isolated areas in the centre and west where Head Deposits are present. River Terrace Deposits, a Secondary A Aquifer, are also present in the far west of the A2 Highway Works area.

18.93 Most of the A2 Highway Works area is underlain by Chalk and Thanet Formation bedrock, although the central portion of the corridor is underlain by the Lambeth Group and the London Clay Formation.

18.94 The Agricultural Land Classification of soils in the A2 Highways Works area (Zones 6 to 9) is a mixture of 'urban land' (about 40%), 'non-agricultural land' (about 40%) and 'Grade 2 – very good quality' (about 20%). None of A2 Highway Works area is currently used for cultivating crops and much of the land identified as 'Grade 2' is covered by the existing road network. The A2 Highway Works area (Zones 6 to 9) is therefore not considered to be a viable resource of agricultural soils, and agricultural soils are not considered as a potential receptor with regards to this chapter of the ES.

### ***Hydrogeology***

18.95 The Alluvium and Head Deposits are both classified as Secondary (Undifferentiated) Aquifers, whilst the River Terrace Deposits in this area are a Secondary A Aquifer. The Chalk is a Principal Aquifer. The Thanet Formation and Lambeth Group are both Secondary A aquifers. London Clay is an unproductive stratum, defined as layers of rock or drift deposits with low permeability, that have negligible significance for water supply or river base flow.



18.96 The entirety of the A2 Highway Works (Zones 6 to 9) is within a Source Protection Zone (SPZ), ranging from Zone 1 (inner zone) to Zone 3 (total catchment). There are a number of current and historical groundwater and potable water abstractions within these zones, the majority positioned within Zone 7 and Zone 8. Regional groundwater flow is likely to be towards the River Thames but also likely to be influenced locally by groundwater abstractions.

### ***Hydrology***

18.97 The River Ebbsfleet flow in an approximately south to north direction from its source near Springhead towards the River Thames, in part passing through Zone 7. There is a pond (known as Swanscombe Pond) in the valley between the two landfill mounds in Bamber Pit.

### ***Ecology***

18.98 The A2 Highway Works (Zones 6 to 9) support fewer sensitive habitats and species than the Swanscombe Peninsula, although a diverse breeding bird assemblage, many invertebrate species, reptiles and a strong breeding dormouse population are present. A small amount of ancient woodland is present along the southern edge of the A2 and small areas of marshy grassland and reedbed flank the River Ebbsfleet along its length. Most of Zones 6 and 7 fall within the Swanscombe Peninsula SSSI (designate due to its ecological and geological value), which was notified in 11<sup>th</sup> March 2021.

### ***Historical land uses***

18.99 The northern part of Zone 6 (Zone 6A) is known as Bamber Pit and is a permitted landfill (ref. WML P/01/16) within a former chalk quarry, now in the aftercare period. Bamber Pit received mixed wastes, predominantly associated with the adjacent paper industries, from 1974 until the mid-1980s. An active landfill gas extraction system is present in the western section of the landfill which manages the landfill gas risks associated with the adjacent properties in Swanscombe. To the south of Bamber Pit is a further partially infilled, non-permitted, quarry (referred to as Bamber Pit South) which includes a small pond in the north-eastern section (Swanscombe Pond). Zone 6B comprises Northfleet Landfill, a further permitted landfill (ref. WML BLU002 19375) in the aftercare period, operated by Lafarge. Northfleet Landfill was active between 1984 and 2006 and received mixed household, industrial and commercial wastes, latterly restricted to inert wastes. An active gas extraction and flaring system is present and operates full-time on-site with the plant located in the southern section of the landfill. Zone 6C, which is bisected by the River Ebbsfleet, has a limited history of development. It was used as a Sports Ground between approximately the 1930s and 1990s. It was developed to its current configuration (car parking) during construction of the HS1 railway.

18.100 The earliest available maps showed Zone 7 as open land used for the small-scale excavation of chalk. Large-scale chalk excavation occurred from around 1931 onwards, primarily in the northern part. These excavations were later infilled, by 1977-1982. The zone contained small industrial premises, such as a cement works wash mill, a miniature rifle range (which also bordered Zone 6 to the north), overhead electricity cables, pylons and a former petrol station. A number of archaeological features, including a Roman kiln and Neolithic pottery and flints were also found in the zone.

18.101 Since the earliest available map (1860s), Zone 8 has been characterised by the presence of a road running through its entire length. Around this time, a Roman town has also been discovered in the area. The Gravesend West Railway line had been constructed on an embankment by the 1880s, a short section of which crossed Zone 8. By the 1930s, the road within Zone 8 had been widened and further Roman artefacts discovered. A transformer substation was also present. By the 1960s, Watling Street had been expanded further and a roundabout constructed. 1980s mapping shows the railway line to have been dismantled and a car park and refuse tip had been developed adjacent to Zone 8. By the early 2000s, HS1 (passing under the zone in a tunnel) had been developed.

18.102 Zone 9 has a limited history of development. A road has intersected the eastern part of the zone since the earliest available map (dated 1865), whilst the western part was woodland / agricultural land. By the 1930s this section of road has been widened and was by now a main road. The A2 main road had been constructed through the entire length of the zone by the 1970s. Further alterations were undertaken during the early 2000s and by 2010 it had been developed to its current configuration. Northfleet West Grid Substation was present in the northeast of the zone between approximately the 1960s and early 2000s.

**Previous ground investigation**

18.103 Known previous ground investigations are summarised in Table 18.13. All of these reports are included as Appendices to this chapter. Reference to those reports should be made for more complete information. The locations of the Atkins (2015) exploratory holes (groundwater resampled during 2020) are shown on Figure 18.4 and Figure 18.5.

**Table 18.13: Summary of previous ground investigations (Zones 6 to 9).**

Report title	Zone / exploratory holes	Brief summary
Geotechnical Engineering (2015) Factual Report on Ground Investigation	Zone 7 2 trial pits 5 boreholes	Factual and Interpretative reports of investigation (very limited number of exploratory holes). No exceedances of human health general screening criteria

Report title	Zone / exploratory holes	Brief summary
(Appendix 18.4)  Atkins (2015) Geotechnical and Geo-Environmental Interpretative Report (Appendix 18.3)		were recorded within soils or groundwater. Asbestos was detected in one soil sample. Controlled waters risk assessment identified some exceedances of screening criteria, although water quality noted to be better than further north on the Swanscombe Peninsula. Limited investigation which did not include exploratory holes within landfilled areas.
WSP (2019) Bamber Quarry Landfill Annual Report 2019 (Appendix 18.10)	Zone 6A  No details of exploratory holes provided.	Annual monitoring report of Bamber Quarry Landfill. WSP concluded that the landfill poses little environmental risk. The integrity of the landfill is good. Emissions of greenhouse gases are currently minimised, both near to off-site receptors and within the main landfill. Monitoring of the water environment demonstrates that groundwater and surface water chemistry are generally stable.
CMS Enviro (2020) Northfleet Landfill Annual Monitoring Report 2019 (Appendix 18.12)	Zone 6B  No details of exploratory holes provided.	Annual monitoring report for Northfleet Landfill over period April 2019 to March 2020. The data collected were comparable to previous years. Primary risk noted to be landfill gas and secondary risk related to leachate. Very limited exceedances of landfill gas compliance limits recorded, and generally associated with low or falling atmospheric pressure. The landfill gas extraction system was noted to be operating efficiently. Leachate levels remained low and quality is indicative of an ageing domestic waste landfill site. No exceedances of control limits recorded for surface waters.
Buro Happold (2021) London Resort. Water environment – Interim monitoring report (Appendix 18.20)	Zones 1, 2, 5 and 7.	Factual summary of groundwater, surface water and sediment data obtained from year-long programme of monthly sampling across the Kent Project Site. Data from September 2020 to May 2021 are available.

***Unexploded Ordnance (UXO)***

18.104 A detailed UXO risk assessment for the A2 Highway Works (Zones 6 to 9) was commissioned by Atkins in 2014 (and is included within Appendix 18.2). It was deemed highly likely that bombs landed within the A2 Highway Works area, considering the bombing densities and number of bombs that affected nearby villages, and anecdotal evidence suggests that bombs fell in the fields around Northfleet and Swanscombe.

18.105 The most probably UXO threat was identified as second world war German Wehrmacht's Luftwaffe high explosive bombs, whilst incendiary bombs and British anti-aircraft ammunition pose a residual threat. The UXO risk assessment identified the overall risk for the A2 Highway Works area (Zones 6 to 9) as high.

***Baseline conceptual site model***

18.106 Potential sources of contamination across the A2 Highway Works (Zones 6 to 9) are detailed below:

- Identified sources of contamination within Zone 6A include Bamber Pit landfill itself (predominantly Bamber Pit North), which received waste from local paper manufacture and the cement works and included putrescible waste. Historically, there were also railway lines, a pump house, engine house and pipeline in this area. Northfleet Landfill is the main source of contamination within Zone 6B. This received mixed household, industrial and commercial wastes. Further sources include: the former rifle range; former railway uses and conveyor; the former pumping station; the former army barracks along the western boundary of the landfill area; and the current car parking use. The superficial deposits (Alluvium and Head Deposits) are a potential source of ground gas within Zone 6C. The other main sources of contamination within the Zone 6C relate to the historical tramway and current car parking, train station and railway line.
- Within Zone 7, the sources of potential contamination include CKD waste deposited within Southfleet Landfill, the former cement works wash mills, the miniature rifle range and current car parking.
- Identified sources of potential contamination within Zone 8 include the current A2 road and Northfleet East Grid Substation. In the surrounding area are a refuse tip (with potential for infilling), later labelled as a recycling facility and waste transfer station and a former railway line.
- The main source of contamination within Zone 9 is the current A2 road and the former

Northfleet West Grid Substation. In the surrounding area, sources include Made Ground arising from historical off-site land uses (water / pumping works, former brick works, A2 car breakers).

18.107 Receptors to the identified sources of contamination and their sensitivity, based on the current understanding of the condition of the A2 Highway Works (Zones 6 to 9) and the Proposed Development are summarised in Table 18.14.

**Table 18.14: Receptors and their sensitivity in the A2 Highway Works (Kent Project Site).**

<b>Receptor</b>	<b>Sensitivity</b>	<b>Justification</b>
Construction workers	High	During construction, construction workers involved in below ground works may be exposed to contaminants via direct or indirect ingestion, inhalation and / or dermal contact. If working in confined spaces, workers could be exposed to flammable or asphyxiating gases. Extensive earthworks will be undertaken in some areas.
Visitors and site workers	Moderate	During operation future site occupiers / visitors may be exposed to contaminants via direct or indirect ingestion, inhalation and / or dermal contact in limited areas of public open space / soft landscaping. Future site users could also be exposed to flammable or asphyxiating gases in any buildings / enclosed structures. Most public open space will be areas of hardstanding.
Neighbours	High	During development, people occupying neighbouring land (residents in adjacent housing developments) could be exposed to contaminants via windblown dusts or vapours. During operation neighbours may be exposed to hazardous gases / vapours migrating from site via permeable strata. Neighbours are a mixture of residential and commercial / industrial.
Secondary Aquifer – superficial deposits	Moderate	During construction and operation, infiltration would generate leachate from Made Ground / waste deposits, which would migrate via permeable ground to underlying superficial deposits (Alluvium, Head Deposits, River Terrace Gravels). No local abstractions from shallow aquifer but may provide baseflow to the River Ebbsfleet.
Principal Aquifer - Chalk	High	There is potential for contamination in the shallow aquifer to migrate vertically to the underlying Principal Aquifer in Chalk. There is potential for the creation of preferential pathways (e.g. via piled foundations) during construction and operation. There are a number of groundwater abstractions within the area.

Receptor	Sensitivity	Justification
River Ebbsfleet	Moderate	Potential for migration of contamination via surface water run-off or migration of contaminated groundwater via shallow permeable strata to the River Ebbsfleet.
Built infrastructure	Low	Potential for aggressive attack on below ground site drainage system and foundations. Potential for permeation of water supply pipework. Development within the area principally encompasses works to existing road network and associated infrastructure (including bridges).
Flora and fauna	High	Most of Zones 6 and 7 fall within the Swanscombe Peninsula SSSI, designated due to ecological and geological sensitivity. There is also a small amount of designated Ancient Woodland along the southern edge of the A2, and areas of marshy grassland and reedbed flanking the River Ebbsfleet. The area also supports a range of birds, invertebrates and mammals which, during construction, may be exposed to contaminants via direct or indirect ingestion, inhalation and / or dermal contact.

**ASSESSMENT OF LIKELY SIGNIFICANT EFFECTS**

**Demolition and Construction Effects - Essex Project Site**

***Relevant aspects of the scheme***

18.108 Approximately 2,500 visitor car parking spaces will be provided at the Essex Project Site, with these visitors transported to the main part of the Resort via ferry crossing. The development proposals for car parking include parking at ground level (i.e. in areas of existing car parking) and in multi-storey facilities (in the current location of the former railway sidings now laid out as the cruise terminal’s car park). Dedicated facilities for passengers will also be provided at the ferry terminal. These will include basic information, retail and catering amenities to serve passengers during their waits for ferry services. The illustrative masterplan and proposed soft landscaping for the Essex Project Site is shown by Figure 18.7 and Figure 18.8, respectively.

***Effects on construction workers***

18.109 There is a potential for workers involved in any below ground works to be in contact with soils or other contaminated materials. Such works include; demolition, remediation (if any) and construction. Earthworks are relatively limited but could include preparation of the formation for the car park by shallow excavation and compaction of imported soils and the construction of piled foundations for the multi-storey car park. There is therefore the potential for human uptake (via ingestion of soils, inhalation of dusts and vapours /

gases and dermal contact) of contaminants associated with these activities. Effects are generally likely to be short term and therefore the main contaminants of concern are those of potential acute hazard (e.g. asbestos, carcinogens etc.). The sensitivity of construction workers / visitors in these circumstances is moderate (due to the relatively limited earthworks). The magnitude of this potential impact is medium resulting in a potential effect of moderate significance.

### ***Effects upon neighbours***

18.110 The relatively limited earthworks have the potential for contaminants to migrate to adjacent land mainly via air (e.g. as wind-borne dusts). The neighbouring land is occupied by the commercial / industrial use of the port. There is therefore a potential for human uptake via inhalation of contaminated dusts - although contaminant concentrations will reduce during migration and exposure is likely to be relatively short term. The works may also lead to the creation of new pathways for ground gas / vapour migration (e.g. caused by the sealing of previously permeable surface), which could potentially result in the build-up of hazardous or explosive gas within off-site buildings. The neighbours in these circumstances are low sensitivity receptors. The magnitude of the potential impact is medium resulting in an adverse effect of minor significance without mitigation.

### ***Effects upon Secondary Aquifer***

18.111 During construction activities there is a potential for; the disturbance of contaminated materials (contained within Made Ground or perched above low permeability bands), increased rainwater infiltration, mobilisation of contamination, contaminated run off and the creation of preferred migration pathways. This could result in the contamination of the groundwater within the underlying shallow Secondary Aquifer (Alluvium and River Terrace Deposits) with subsequent impacts to the River Thames and the Principal Aquifer in Chalk (see below). The quality of the Secondary Aquifer is likely degraded by the long history of industrial use and its location adjacent to the tidal River Thames. Although the aquifer is acting primarily as a migration pathway (rather than a sensitive receptor in its own right), there is a potential for an adverse effect as additional pollutant loading. The Secondary Aquifer is of moderate sensitivity and the magnitude of the potential impact is medium. This results in an adverse effect of moderate significance without mitigation.

### ***Effects upon Principal Aquifer***

18.112 In addition to the potential for impact associated with the disturbance of contaminated materials (described above), deep foundations (e.g. piles) present a potential for the creation of preferential migration pathways through the superficial deposits (and cohesive bands in the Alluvium) and a consequent downward migration of contamination in the shallow strata / aquifer to the underlying Principal Aquifer in Chalk. The aquifer is of

moderate sensitivity (reflecting the nature, extent and geological setting of the groundwater body) and the magnitude of the potential impact is medium. This results in an adverse effect of moderate significance without mitigation.

### ***Effects upon surface waters***

18.113 The River Thames is a large tidal water which lies adjacent to the Essex Project Site. There is a potential for contaminant migration via run-off and via shallow permeable strata associated with the proposed construction activities. There are also a number of surface water drains crossing the Essex Project Site, in part culverted and part open channel sections, with outfall to the River Thames. This includes a gravity outfall sluice adjacent to the west of the proposed multi-storey carpark, which the Environment Agency have advised will be sensitive to construction due to its condition. The River is of moderate sensitivity and the magnitude of the potential impact is medium. This results in an adverse effect of moderate significance without mitigation.

### ***Effects upon flora and fauna***

18.114 The relatively limited earthworks have a potential for contaminants to affect flora and fauna mainly via air (e.g. as wind-borne dusts) although such effects are likely to be short term. There is also a potential for flora and fauna in the river to be affected by contaminant migration via run-off, drainage or shallow permeable strata. The flora and fauna at this location is of low sensitivity and the magnitude of the potential impact is small. This results in an adverse effect of minor significance without mitigation.

### ***Unexploded Ordnance***

18.115 UXO can pose a threat to the human receptors and built environment (moderate and low sensitivity receptors, respectively). A preliminary assessment of risk in accordance with CIRIA good practise guidance<sup>26</sup> indicates the Essex Project Site is at moderate risk. The proposed construction activities at the Essex Project Site include intrusive site investigation and excavation associated with construction of the multi-story carpark and improvements to the drainage system. It is reasonable to assume that UXOs in the developed part of the site (e.g. rail sidings, railway station) would have been dealt with at the time. However, any UXOs in the less developed areas may not have been observed or recorded (including the areas now used for carparking). Any below ground works in such areas are more likely to encounter UXO, which will be addressed during detailed assessment.

### ***Summary of potential effects***

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<sup>26</sup> CIRIA (2009) Unexploded ordnance (UXO) A guide for the construction industry (C681)



18.116 The potential demolition and construction effects on the Essex Project Site that are described above are summarised in Table 18.15.

**Table 18.15: Summary of effects during demolition and construction (Essex Project Site).**

Receptor	Sensitivity	Description of effect	Magnitude of effect	Effect significance
Construction workers	Moderate	Contact with contaminated materials (including UXO)	Medium	Moderate adverse
Neighbours	Low	Inhalation of contaminated dusts	Medium	Minor adverse
		Migration and accumulation of ground gas to hazardous concentrations		
Secondary Aquifer	Moderate	Derogation of quality by leaching and migration of contamination	Medium	Moderate adverse
Principal Aquifer	Moderate	Derogation of quality by leaching and migration of contamination	Medium	Moderate adverse
River Thames	Moderate	Derogation of quality by contaminant migration via permeable strata, run-off, drainage.	Medium	Moderate adverse
Flora and fauna	Low	Impeded health and growth of plants and animals	Small	Minor adverse

## Demolition and Construction Effects - Kent Project Site, Swanscombe Peninsula (Zones 1 to 6)

### *Relevant aspects of the scheme*

18.117 The Proposed Development is described in detail in Chapter 3 (Site description) of this ES with a brief summary presented here and illustrated by Figure 18.7. The Proposed Development will include the construction of a range of events spaces, themed rides and attractions, entertainment venues, cinema, theatres, plazas and back of house facilities developed in two phases, (Gate One and Gate Two). Buildings will also include hotels, housing for resort workers, multi-storey car parks, a Conferention Centre with associated retail and amenity facilities, including restaurants and cafes.

18.118 A hard and soft landscape strategy (Figure 18.8), including amenity water features such as ponds and watercourses, will provide the setting for these rides, attractions and

amenities. Comprehensive landscape works and planting are proposed on the periphery of the London Resort. A perimeter service road, pedestrian and cycle routes and security requirements around the Leisure Core will be integrated into the landscape treatment. The masterplan seeks to work with the grain of the existing terrain, but substantial earthworks will be required to create the particular landscape required for the Leisure Core and to provide a flood resilient design.

Landscape works are also planned on both Black Duck Marsh and Broadness Salt Marsh, involving the restoration and creation of a series of areas of woodlands, scrub, grasslands, salt marsh, wetlands and standing water, watercourses and other water bodies. The detail of these works is presented in Chapter 12 (Terrestrial and freshwater ecology and biodiversity) and illustrated by Figure 18.8. Restoration works on Broadness Salt Marsh will include the lowering of the area behind the existing riverbank to achieve a target number of inundations by the tidal River Thames per year that is consistent with that expected for typical saltmarsh. Based on current modelling, an area of about 20m length behind the existing riverbank will be lowered to about 3.3m AOD. A 1 in 3 slope will be used between the lowered area and the new river bank line (comprising the existing topography at about 6m AOD). The total excavation volume based on this scenario is 55,000m<sup>3</sup>, but may be refined based on the results of further surveys and subsequent design, for example, potential changes being considered within the landscape design and drainage strategy to minimise the impact of the development on the SSSI, would reduce this excavation volume.

18.119 A preliminary earthworks plan for the Proposed Development on the Swanscombe Peninsula has been prepared (Figure 18.9). This Figure illustrates the scale of excavation (cut) and fill currently anticipated and has enabled an estimation of the potential volumes of spoil likely to be generated and the need for fill. Currently preliminary estimates are that the total cut (volume of spoil arising from excavations) is approximately 860,000m<sup>3</sup> and the total requirement for fill is approximately 490,000m<sup>3</sup>. These volumes, although substantial, have been derived from initially modelling of the current and planned topographies with the overall aim of minimising the volumes of excavation (particularly into contaminated and licenced land) whilst also being consistent with various other aspects (such as flood risk, accessibility, landscape aesthetics for example). These volumes therefore are not “absolute”, and must be treated with caution and will change as a result of further surveys and subsequent design, but nonetheless they are useful in assessing the scale of the work to be undertaken.

18.120 It is anticipated that a proportion of the spoil arisings would be directly suitable for re-use, a proportion would be suitable following treatment (on-site) and a proportion would not be suitable for re-use and would be disposed off-site to landfill. Further information on the proposed soil treatment centre is included in the Contaminated Land Management Strategy (Appendix 18.9). Currently a cautious approach would be to assume that 40% of the spoil arisings could be re-used on-site (either directly or following treatment) and 60% would be disposed to off-site appropriately licensed facilities / landfills as either Inert, Non

Hazardous or Hazardous wastes, see Chapter 19 (Waste and materials).

- 18.121 There are some particular issues associated with the potential beneficial re-use of any excavated cement kiln dust (CKD) which currently occupies significant areas of the Peninsula. These issues involve its physical and chemical properties and its potential as a fill material, and as an additive to treat / improve other soil arisings. A brief note of this is included in the Contaminated Land Management Strategy (Appendix 18.9).
- 18.122 Currently there is very little drainage infrastructure within the Swanscombe Peninsula. It has been agreed with the EA (see Chapter 17, Water resources and flood risk) that surface water from the Proposed Development can be discharged unrestricted to the River Thames. Within the Leisure Core, a large proportion of the area will become impermeable surface. Here, a positive drainage system will be utilised to collect rainfall runoff through a network of open swales or a piped system (if required). These swales will have several outfalls to the three marsh areas: the existing Black Duck and Botany Marshes and the new constructed wetland (within Zone 1). Part of Zone 5A is proposed to be drained via infiltration (in the form of soakaways, infiltration basins, permeable pavements and raingardens).
- 18.123 The existing overland / known discharge regimes to the Black Duck and Botany Marshes will be preserved where possible, with a further ditch network also created within the Botany Marsh (east) to provide habitat enhancement. Discharge outfalls from Black Duck Marshes and Botany Marsh to the River Thames will include manual flow / level control, such as sluice gates, to adjust water levels as required. Discharge from Botany Marsh will be via either a gravity outfall to the River Thames (via Britannia Metals land) or via pumping to the new constructed wetland. Two new gravity outfalls with non-return valves are proposed to allow discharge from Black Duck Marsh to the River Thames.
- 18.124 A new constructed wetland is proposed within Zone 1, the primary purpose of which is deliver ecological benefits as well as water treatment and storm water attenuation. The new wetland will discharge stormwater to the bay to the north of the Swanscombe Peninsula via gravity culvert or new open lined channel to the River Thames.
- 18.125 The leachate treatment plant on Broadness Marsh (Zone 1) will be adapted to increase its capacity. The conveyance channels around the marsh are proposed to be enlarged and formalised to capture the leachate and surface water runoff. The flows will be conveyed to open-lined detention ponds within Broadness Marsh and pumped to the upgraded leachate treatment plant. South Pit Leachate Treatment Plant (located in Zone 2) will need to be relocated to enable the Proposed Development. The most appropriate location for this on the Swanscombe Peninsula will be considered during detailed design.

### ***Effects on construction workers***

18.126 There is a potential for workers involved in any below ground works to come into contact with soils, waste materials (including CKD) or other contaminated materials. In particular, this potential exists during the substantial programme of earthworks that will be required to achieve the proposed landscaping and topography, but also during remediation (e.g. on-site treatment of soils) and construction. There is therefore the potential for human uptake (via ingestion of soils, inhalation of dusts and vapours / gases and dermal contact) of contaminants. Effects are generally likely to be short term and therefore the main contaminants of concern are those of potential acute hazard (e.g. asbestos, carcinogens etc.). The sensitivity of construction workers in these circumstances is high (reflecting the scale, nature and extent of earthworks). The magnitude of this potential impact is medium resulting in a potential effect of major adverse significance without mitigation.

### ***Effects upon neighbours***

18.127 The works have the potential for contaminants to migrate to adjacent land mainly via air (e.g. as wind-borne dusts). The neighbouring land is occupied by a mixture of residential properties with gardens and areas of public open space (in particular Ingress Park to the west and Swanscombe to the south) and by commercial / industrial uses. There is therefore a potential for human uptake via inhalation of contaminated dusts - although contaminant concentrations will reduce during migration and exposure is likely to be relatively short term. The works could also enhance the potential for ground gas / vapour migration in the vicinity of these neighbourhoods (e.g. by affecting the source and /or by the creation of new pathways) which could potentially result in the build-up of hazardous or explosive gas within neighbouring buildings. The neighbours in these circumstances are high sensitivity receptors. The magnitude of the potential impact is large (gas) to medium (contaminated dusts) resulting in an adverse effect of major significance without mitigation.

### ***Effects upon Secondary Aquifer***

18.128 There is potential for construction activities to disturb contaminated materials (for example, within landfill wastes) and for rainwater infiltration, mobilisation of contamination and contaminated run-off and the creation of preferred migration pathways. This could result in the contamination of the groundwater within the shallow Secondary Aquifer (Alluvium, Head Deposits and River Terrace Deposits), with subsequent impacts to the River Thames and the Principal Aquifer in Chalk (see below). The shallow aquifer is degraded in quality by the historic industrial uses (particularly landfilling) and its location adjacent to the tidal River Thames. Although the aquifer is acting primarily as a migration pathway (rather than a sensitive receptor in its own right) there is a potential for an adverse effect as additional pollutant loading. The Secondary Aquifer is of moderate sensitivity and the magnitude of the potential impact is medium. This results in an adverse effect of moderate significance without mitigation.

***Effects upon Principal Aquifer***

18.129 Further to migration of contamination via the Secondary Aquifer, deep foundations (e.g. piles) present a potential for the creation of preferential migration pathways to the underlying Chalk Principal Aquifer. The Principal Aquifer is of moderate sensitivity in the area, reflecting its location and the absence of abstractions for potable supply in the immediate vicinity. The magnitude of the potential impact is large (reflecting the nature of the ground to be disturbed and the extent of that disturbance). This results in an adverse effect of major significance without mitigation.

***Effects upon surface waters***

18.130 During construction, there is potential for migration of contamination to the River Thames via run-off / drainage (i.e. during excavation / earthworks) or via migration in shallow permeable strata. The storm water drainage strategy for the Swanscombe Peninsula will largely utilise the ability to discharge to the River Thames. The existing overland / known discharge regimes will be preserved / upgraded where possible, however, there will be a requirement to construct further drains to the river in the form of open swales, open channels and gravity outfall pipework. The proposed works also include the re-routing / upgrade to the existing leachate treatment plants. During the construction process, these existing and proposed surface water drains could act as pathways for the migration of contamination to the River Thames (e.g. in particular in the areas of CKD landfilling). The River Thames is of moderate sensitivity and the magnitude of the potential impact is large, resulting in an adverse effect of major significance without mitigation.

***Effects upon flora and fauna***

18.131 The Swanscombe Peninsula, most of which falls within the Swanscombe Peninsula SSSI, currently supports a number of ecologically sensitive habitats (including reed beds, saltmarsh) and a range of protected / notable species. The plants currently growing on-site do not show any evidence of effects obviously related to phytotoxic ground contamination, and the unusual ecological assemblages are likely part-governed by the particular soil chemistry arising from the industrial uses of the Swanscombe Peninsula (particularly the landfilling of CKD). Without mitigation, the current flora and fauna will be lost or damaged during construction due to the extensive earthworks that are required to achieve the Proposed Development. The sensitivity of the flora and fauna is high and the magnitude of the potential effect is large. This results in an effect of major significance without mitigation.

***Unexploded Ordnance (UXO)***

18.132 UXO can pose a threat to human receptors and the built environment (high and moderate sensitivity receptors, respectively). A detailed risk assessment for the Swanscombe

Peninsula identified the potential risk associated with encountering UXO as high. It is reasonable to assume that UXOs in the developed parts of the site would have been noted and dealt with at the time or during post second world war development. However, there are undeveloped / less developed areas, where substantial earthworks are proposed, and where UXO may not have been observed or recorded. Therefore, any below ground works in these areas are more likely to encounter UXO.

### ***Summary of potential effects***

18.133 The potential demolition and construction effects on the Swanscombe Peninsula (described above) are summarised in Table 18.16.

**Table 18.16: Summary of effects during demolition and construction on the Swanscombe Peninsula (Kent Project Site).**

<b>Receptor</b>	<b>Sensitivity</b>	<b>Description of effect</b>	<b>Magnitude of effect</b>	<b>Effect significance</b>
Construction workers	High	Contact with contaminated materials (including UXO)	Medium	Major adverse
Neighbours	High	Inhalation of contaminated dusts	Medium	Major adverse
		Migration and accumulation of ground gas to hazardous concentrations	Large	Major adverse
Secondary Aquifer	Moderate	Derogation of quality by leaching and migration of contamination	Medium	Moderate adverse
Principal Aquifer	Moderate	Derogation of quality by leaching and migration of contamination	Large	Major adverse
River Thames	Moderate	Derogation of quality by contaminant migration via permeable strata, run-off, drainage.	Large	Major adverse
Flora and fauna	High	Impeded health and growth of plants and animals	Large	Major adverse

### **Demolition and Construction Effects - Kent Project Site, A2 Highway Works (Zones 6 to 9)**

#### ***Relevant aspects of the scheme***

18.134 These works comprise the construction of a proposed Resort Access Road from the A2(T)

to the Resort and a People Mover route from Ebbsfleet International Station to the Resort entrance plaza and beyond to the proposed ferry terminal on the western edge of the Swanscombe Peninsula. The People Mover route will be located to the west of the new Access Road. This is illustrated by Figure 18.10, Figure 18.11 and Figure 18.12.

- 18.135 A new at grade junction with the A2 will involve limited earthworks but as the highway moves north it (and the People Mover) traverse several landfills (including Northfleet Landfill and Bamber Pit) both on embankment and in cutting (see Chapter 9, Land transport) including a SSSI and Scheduled Monument (see Chapter 14, Cultural heritage and archaeology). A total of six tunnels would be constructed for both the Access Road and the People Mover to traverse chalk spines which carry existing roads and railways roads.
- 18.136 The foundations of the People Mover on the length to the south of Bamber Pit (Zone 6A) will be constructed on a shallow embankment utilising polystyrene blocks. The polystyrene blocks are placed on top of a sand layer (with nominal thickness 150-300mm) following the stripping of topsoil, thus minimising the need for intrusive excavations in the protected area. No other excavation is required. The principle of the construction approach is to minimise the loads that will be transferred to the existing ground. This method will help to protect below-ground features of archaeological and geological interest in-situ, with the additional benefit that if there was a substantiated requirement to investigate the Baker's Hole SSSI area in the future it would be relatively easy to remove the People Mover route foundations and realign the carriageway.
- 18.137 Preliminary earthworks plans for the A2 Highway Works and the People Mover have been prepared (Figure 18.13, Figure 18.14 and Figure 18.15). These show the scale of excavation (cut) and fill currently anticipated and has enabled an estimation of the potential volumes of spoil likely to be generated and the need for fill. Currently preliminary estimates are that the total cut (volume of spoil arising from excavations) is some 190,000m<sup>3</sup> (approximately) and the total requirement for fill is 120,000m<sup>3</sup> (approximately). These volumes, although substantial have been derived from initial modelling of the current and planned construction and are considered to represent a realistic worst case. These volumes therefore are not "absolute", must be treated with caution and will change as a result of further surveys and subsequent design, but nonetheless are useful in assessing the scale of the work to be undertaken.
- 18.138 As discussed above, these works traverse a highly diverse range of ground conditions, with some construction carried out directly on or through competent chalk whilst other sections will cross landfills of inert soils (Thanet Sand), domestic and industrial wastes. These landfills present both practical and regulatory constraints to the construction associated with infrastructure to monitor and manage landfill gas and leachate and Environmental Permit conditions.

***Effects on construction workers***

18.139 Although the A2 Access Road and People Mover has been designed to minimise the earthworks necessary for its construction, there is a potential for workers involved in any such earthworks to come into contact with soils or other contaminated materials (including excavation within areas of landfill). There is also potential for workers to come into contact with soils during tunnelling / piling, although the large majority of that spoil will be inert natural soils and rock. Consequently, there is a potential for human uptake (via ingestion of soils, inhalation of dusts and vapours / gases and dermal contact) of contaminants. Effects will predominantly be short term and therefore the main contaminants of concern are those posing a potential acute hazard (e.g. asbestos, carcinogens etc.). The sensitivity of construction workers in these circumstances is high and the magnitude of the potential effect is medium. This results in a major adverse effect without mitigation.

***Effects upon neighbours***

18.140 Parts of the A2 Highway Works (Zones 6 to 9) are surrounded by residential development with private gardens and further sensitive land uses including public open space and children's playgrounds. The earthworks have the potential for contaminant generation and migration to adjacent land mainly via air (e.g. as wind-borne dusts). There is therefore a potential for human uptake via inhalation of contaminated dusts - although contaminant concentrations will reduce during migration and exposure is likely to be relatively short term. The neighbours in these circumstances are high sensitivity receptors and the magnitude of the potential impact is medium, resulting in an adverse effect of major significance without mitigation.

18.141 The works include excavation within or construction on permitted landfill and could lead to the creation of new pathways for ground gas / vapour migration. In particular, this could occur due to disruption of the existing gas management / extraction systems which currently regulate release of landfill gas in the vicinity of off-site receptors. Such an event could potentially result in the build-up of hazardous or explosive gas within neighbouring buildings. The neighbours in these circumstances are high sensitivity receptors. The magnitude of the potential impact is large. This results in a major adverse event without mitigation.

***Effects upon Secondary Aquifer***

18.142 Most of the A2 Highway Works area is not underlain by natural superficial deposits (Secondary Aquifers). A proportion of the area has historically been used for Chalk extraction / quarrying which removed superficial overburden. During construction there is a potential for the disturbance of contaminated materials (within Made Ground or landfill wastes). There is also potential for increased rainwater infiltration, mobilisation of



contamination and contaminated run-off, and for the creation of preferred migration pathways. This could result in the contamination of the groundwater contained within the shallow Secondary Aquifer (Alluvium, Head Deposits, River Terrace Deposits). In this context the Secondary Aquifer is of low sensitivity and the magnitude of the effect is small. This results in an adverse effect of minor significance without mitigation.

### ***Effects upon Principal Aquifer***

18.143 Most of the A2 Highway Works (Zones 6 to 9) is underlain by Chalk and Thanet Formation bedrock, which are designated Principal and Secondary A Aquifers, respectively and are likely to be in hydraulic continuity. Groundwater from the Chalk in this area is abstracted for potable water supply. Earthworks and other construction activity present a potential for ground disturbance resulting in the mobilisation of contamination to directly impact upon the underlying aquifers. Deep foundations (e.g. piles) also present a potential to create or enhance preferential migration pathways to these aquifers. The Principal Aquifer is of high sensitivity and the magnitude of the effect is large. This results in an adverse effect of major significance without mitigation.

### ***Effects upon surface waters***

18.144 The River Ebbsfleet is a relatively short watercourse that flows from its source near Springhead (to the south of Zone 7) to the River Thames. Part of its length also crosses through Zone 7 and Zone 6C. During construction, there is a potential for migration via run-off, surface water drainage and via shallow permeable strata although limited construction works are proposed in the immediate vicinity of the river. The river channel is also underlain by superficial deposits that will be in part cohesive and may act to inhibit the migration of contamination. The river is of moderate sensitivity and the magnitude of the potential effect is small. This results in an adverse effect of minor significance without mitigation.

### ***Effects upon flora and fauna***

18.145 The A2 Highway Works (Zones 6 to 9) supports a range of animal / invertebrate species and small areas of sensitive habitat, including ancient woodland along with marshy grassland / reedbed flanking the River Ebbsfleet. Most of Zones 6 and 7 fall within the Swanscombe Peninsula SSSI, designated due to its ecological sensitivity. Relatively limited construction works are proposed in these locations, however there is a potential for loss / damage to species and habitat at particular localities, in particular where more substantial earthworks are required. The sensitivity of the flora and fauna is high and the magnitude of the effect is medium. This results in a major adverse effect without mitigation.

### ***Unexploded Ordnance***

18.146 UXO can pose a threat to human receptors and the built environment (high and low sensitivity receptors, respectively). A detailed risk assessment undertaken for the A2 Highway Works (Zones 6 to 9) identified the potential risk associated with encountering UXO to be high. It is reasonable to assume that any UXOs in the developed part of the site (e.g. in vicinity of roads, railway lines) would have been dealt with at the time. However, UXOs in less developed or undeveloped areas may not have been recorded. Any below ground works in these areas are more likely to encounter UXO.

**Summary of potential effects**

18.147 The potential demolition and construction effects on A2 Highway Works part of the Kent Project Site (Zones 6 to 9), described above, are summarised in Table 18.17.

**Table 18.17: Summary of effects during demolition and construction within the A2 Highway Works area (Kent Project Site).**

Receptor	Sensitivity	Description of effect	Magnitude of effect	Effect significance
Construction workers	High	Contact with contaminated materials (including UXO)	Medium	Major adverse
Neighbours	High	Inhalation of contaminated dusts and / or gases	Medium	Major adverse
		Migration and accumulation of ground gas to hazardous concentrations	Large	Major adverse
Secondary Aquifer	Low	Derogation of quality by leaching and migration of contamination	Small	Minor adverse
Principal Aquifer	High		Large	Major adverse
River Ebbsfleet	Moderate	Derogation of quality by contaminant migration via permeable strata, run-off, drainage.	Small	Minor adverse
Flora and fauna	High	Impeded health and growth of plants and animals	Medium	Major adverse

**Operational Effects - Essex Project Site**

***Relevant aspects of the scheme***

18.148 Approximately 2,500 visitor car parking spaces will be provided at the Essex Project Site, with these visitors transported to the main part of the resort via ferry crossing. The development proposals for car parking at ground level (i.e. in areas of existing car parking) and in multi-storey facilities (in the current location of the former railway sidings now laid out as the cruise terminal's car park). Dedicated facilities for passengers will also be provided at the ferry terminal. These will include basic information, retail and catering amenities to serve passengers during their short waits between ferry services.

***Effects upon site visitors and workers***

18.149 There is a limited potential for site occupiers and visitors of the redeveloped site to come into contact with contaminated soil materials. The large majority of contaminated Made Ground will be encapsulated by the construction of the development (car park, roads and paving). Very limited areas of open space are proposed but will include an appropriate thickness of suitable imported sub soils and topsoils (on existing ground, or in planters). These imported soils will comply with the BS 3882:2015<sup>27</sup> and meet appropriate chemical, physical and biological criteria, as outlined in the Contaminated Land Management Strategy (Appendix 18.9). There is therefore very limited potential for human uptake (via ingestion, inhalation and dermal contact) of any contaminants in the residual contamination in the Made Ground or in the imported soils. Site visitors and workers in this context are low sensitivity receptors. The magnitude of the potential impact is small, resulting in an effect of minor significance without mitigation.

18.150 There is also a potential for ground gas / vapour generation from the residual Made Ground / Alluvium and its migration potentially resulting in the build-up of hazardous ground gas within any enclosed spaces in buildings/structures. Site visitors and workers in this context are low sensitivity receptors. The magnitude of the potential impact is large, resulting in an effect of moderate / minor significance without mitigation.

***Effects upon neighbours***

18.151 In operation there is a potential for ground gas / vapour generation from the residual Made Ground / Alluvium and its lateral migration potentially resulting in the build-up of hazardous ground gas within any enclosed spaces in neighbouring buildings/structures. Neighbouring workers in this context are low sensitivity receptors. The magnitude of the potential impact is large, resulting in an effect of moderate / minor significance without mitigation.

***Effects upon Secondary Aquifer***


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<sup>27</sup> British Standards Institute (2015) BS 3882:2015. Specification for topsoil

18.152 In operation, some contaminated Made Ground will have been removed by the construction of the development and a large portion of the site will be covered by buildings and/or hardstanding. Any limited soft landscaped areas will be capped by suitable thicknesses of subsoil and topsoil, which together with the surface water drainage system will inhibit infiltration. Contamination could migrate laterally via permeable strata and vertically along newly created preferential pathways (such as piled foundations, drainage trenches etc.). Therefore, there is potential for contaminated water to migrate to the underlying shallow aquifer when the development is operational (although the potential is reduced from the construction stage due to the reduction in infiltration). The discontinuous shallow aquifer at the site is likely to be degraded in quality by the historic industrial use. The Secondary Aquifer is of moderate sensitivity and the magnitude of the potential impact during operation is small. This results in a minor adverse effect without mitigation.

#### ***Effects upon Principal Aquifer***

18.153 The shallow Secondary Aquifer may be in continuity with the underlying Chalk Principal Aquifer. There is therefore also potential for contamination to migrate laterally or vertically via permeable strata or newly created preferential pathways to the underlying Principal Aquifer. Cohesive bands within Alluvium (which is about 15m thick) will inhibit downward migration of contamination, however, the construction of deep foundations (piles) could create preferential contaminant migration pathways that breach any such layers. The aquifer is of moderate sensitivity and the magnitude of the potential impact is small. This results in an adverse effect of minor significance without mitigation.

#### ***Effects upon surface waters***

18.154 The River Thames is a large tidal water which lies adjacent to the Essex Project Site. There is a potential for contaminant migration via run-off and via shallow permeable strata associated with the proposed operational activities. However, the presence of the new development (hardstanding over most of the area) will reduce infiltration and inhibit lateral migration of contamination. As part of the Proposed Development, a new surface water drainage will be constructed from the proposed area of car parking / visitor plaza to the River Thames, further reducing infiltration (and issues of surface water ponding). The river is of moderate sensitivity and the magnitude of the potential impact is small. This results in an adverse effect of minor significance.

#### ***Effects upon flora and fauna***

18.155 The flora in public spaces will include an appropriate thickness of suitable sub soils and topsoils and all landscape areas (on residual ground or in landscaped planters) will be completed with imported topsoils. The flora is thus isolated from any residual contaminated Made Ground soils. The imported soils will comply with BS 3882:2015 and meet appropriate chemical, physical and biological criteria, as outlined in the Contaminated Land Management Strategy (Appendix 18.9). The flora at the redeveloped site is a low sensitivity receptor. The magnitude of the potential impact is negligible, resulting in a potential effect of negligible significance.

### ***Effects upon the built environment***

18.156 There is a potential for residual contamination in the Made Ground to affect integrity of below ground concrete. The sensitivity of the built environment in this context is low, the magnitude of the potential impacts is small, resulting in an effect of minor adverse significance without mitigation.

18.157 There is also a potential for ground gas / vapour generation from the residual Made Ground / Alluvium and its migration potentially resulting in the build-up of hazardous ground gas within any enclosed spaces in buildings/structures. The sensitivity of the built environment in this context is low, the magnitude of the potential impacts is medium, resulting in an effect of minor adverse significance without mitigation.

### ***Summary of potential effects***

18.158 The potential operational effects on the Essex Project Site, described above, above are summarised in Table 18.18.

**Table 18.18: Summary of effects during operation (Essex Project Site).**

<b>Receptor</b>	<b>Sensitivity</b>	<b>Description of effect</b>	<b>Magnitude of effect</b>	<b>Effect significance</b>
Site visitors and workers	Low	Contact with contaminated soils	Small	Minor adverse
	Low	Accumulation of ground gas to hazardous concentrations in confined spaces	Large	Moderate / minor adverse
Neighbours	Low			
Secondary Aquifer	Moderate	Derogation of quality by leaching and migration.	Small	Minor adverse
Principal Aquifer	Moderate		Small	Minor adverse
River Thames	Moderate	Derogation of quality by contaminant migration via	Small	Minor adverse

Receptor	Sensitivity	Description of effect	Magnitude of effect	Effect significance
		permeable strata, run-off, drainage.		
Flora and fauna	Low	Impeded health and growth of plants	Negligible	Negligible
Built environment	Low	Aggressive attack on below ground infrastructure	Small	Minor adverse
		Accumulation of ground gas to hazardous concentrations in confined spaces	Medium	Minor adverse

**Operational Effects - Kent Project Site, Swanscombe Peninsula (Zones 1 to 5)**

***Relevant aspects of the scheme***

18.159 The Proposed Development is Described in detail in Chapter 3 (Project description) of this ES with a brief summary presented here. In operation, the majority of the Leisure Core of the Resort will be encapsulated by development (including buildings, roads and paving) described in more detail below. Landscaped areas will be included within the Leisure Core (i.e. on residual ground or landscaped planters) and landscape works on Black Duck Marsh and Broadness Salt Marsh will have restored and created a range of habitats and public open space.

18.160 The Proposed Development will comprise a range of events spaces, themed rides and attractions, entertainment venues, cinema, theatres, plazas and back of house facilities developed in two phases, (Gate One and Gate Two). Buildings will include hotels, housing for resort workers, multi-storey car parks, a Conferention Centre with associated retail and amenity facilities, including restaurants and cafes.

18.161 A hard and soft landscape strategy, including amenity water features such as ponds and watercourses, will provide the setting for these rides, attractions and amenities. Comprehensive landscape works and planting are proposed on the periphery of the London Resort. A perimeter service road, pedestrian and cycle routes and security requirements around the leisure core will be integrated into the landscape treatment.

18.162 Substantial landscape works are also planned on both Black Duck Marsh and Broadness Salt Marsh (areas which fall within the Swanscombe Peninsula SSSI, designated due to its ecological sensitivity), involving the restoration and creation of a series of areas of woodlands, scrub, grasslands, salt marsh, wetlands and standing water, watercourses and other water bodies. The detail of these works is presented in Chapter 11 (Terrestrial and freshwater ecology and biodiversity).

- 18.163 Stormwater drainage will be discharged unrestricted to the River Thames. Within the Leisure Core, a large proportion of the area will be impermeable surface with a drainage system utilised to collect rainfall runoff through a network of open swales or a piped system (if required). These swales will have several outfalls to the three marsh areas: the existing Black Duck and Botany Marshes and the new constructed wetland (within Zone 1). Part of Zone 5A is proposed to be drained via infiltration (in the form of soakaways, infiltration basins, permeable pavements and raingardens).
- 18.164 The existing overland / known discharge regimes to the Black Duck and Botany Marshes will be preserved where possible, with a further ditch network also created within the Botany Marsh (east) to provide habitat enhancement. Discharge outfalls from Black Duck Marshes and Botany Marsh to the River Thames will include manual flow / level control, such as sluice gates, to adjust water levels as required. Discharge from Botany Marsh will be via either a gravity outfall to the River Thames (via Britannia Metals land) or via pumping to the new constructed wetland. Two new gravity outfalls with non-return valves are proposed to allow discharge from Black Duck Marsh to the River Thames.
- 18.165 A new constructed wetland is proposed within Zone 1, the primary purpose of which is deliver ecological benefits as well as water treatment and storm water attenuation. The new wetland will discharge stormwater to the bay to the north of the Swanscombe Peninsula via gravity culvert or new open lined channel to the River Thames.
- 18.166 The leachate treatment plant on Broadness Marsh (Zone 1) will have increased capacity with conveyance channels around the marsh enlarged and formalised to capture leachate and surface water runoff. The flows will be conveyed to open-lined detention ponds within Broadness Marsh and pumped to the upgraded leachate treatment plant. The South Pit Leachate Treatment Plant (located in Zone 2) will have been relocated. Potential changes are being considered within the landscape design and drainage strategy to minimise the impact of the development on the SSSI (refer to Appendix 17.2 – Surface Water Drainage Strategy for more information).

### ***Effects upon site visitors and workers***

- 18.167 In operation, as described above, the majority of the Leisure Core of the Resort will be encapsulated by development (including buildings, roads and paving) with some landscaped areas. These landscaped areas will be formed on residual ground or in above ground planters etc. and will have been completed with imported soils, complying with the relevant British Standard (British Standards Institute 2015) meeting appropriate defined chemical, physical and biological criteria. Outside of the Resort Core, restored habitats and areas of public open space will occupy Black Duck Marsh and Broadness Salt Marsh (having utilised existing on-site soils as far as practicable). In the Proposed Development, there is therefore a potential for human uptake (via ingestion, inhalation

and dermal contact) of contamination in soils that are imported, re-used or left in-situ in the near surface. The site visitors and workers are of moderate sensitivity and the magnitude of the potential effect is small. This results in an effect of minor significance without mitigation.

18.168 Due to the introduction of buildings / structures, there is also a potential for ground gas / vapour migration into confined spaces and its accumulation to hazardous concentrations. In this context site visitors and workers are moderate sensitivity receptors. The magnitude of the potential impact is large, resulting in an effect of major significance without mitigation.

### ***Effects upon neighbours***

18.169 In operation there is a potential for ground gas / vapour generation from the residual Made Ground / Alluvium and its lateral migration potentially resulting in the build-up of hazardous ground gas within any enclosed spaces in neighbouring buildings/structures. Neighbours in this context are moderate sensitivity receptors. The magnitude of the potential impact is large, resulting in an effect of major significance without mitigation.

### ***Effects upon Secondary Aquifer***

18.170 The substantial earthworks undertaken by the Proposed Development will have involved the removal of considerable volumes (estimated at approximately 400,000m<sup>3</sup>) of contaminated Made Ground (due to its unsuitable geoenvironmental / geotechnical properties). The majority of the Leisure Core of the Proposed Development will be covered by buildings and hardstanding (that will also include soft landscaping at Podium level) that will inhibit infiltration. Areas of soft landscaping on existing ground will be constructed with a suitable thickness of low permeability soils and surface water drainage system (see LCMS – Appendix 18.9). Any storm water run-off will be routed to marshland or constructed wetland that where possible will occupy much of the remainder of the Swanscombe Peninsula. In these areas of marshland / constructed wetland, the existing drainage system will be maintained where possible, however, in some areas further open drains / swales will be constructed and these will be lined, where possible. All of these measures will reduce the potential for leaching and downward migration of contamination. However, where unlined open channel features and soft landscaping on existing soils are present, there remains a potential for leaching of contamination from the near surface soils to the underlying shallow aquifer. Piled foundations may also act as a preferential migration pathway for contamination during operation. The Secondary Aquifer is of moderate sensitivity and the potential impact during operation is small. This results in an adverse effect of minor significance without mitigation.

### ***Effects upon Principal Aquifer***



18.171 The Principal Aquifer in the Chalk is located immediately beneath the Secondary Aquifer. The strata of the Secondary Aquifer (Alluvium, Head Deposits and River Terrace Deposits), comprise a mixture of cohesive and granular strata which may act as a preferential pathway to the migration contamination in some locations, or an inhibition/ partial barrier in others. In operation, piled foundations may also act as a preferential pathway to the Principal Aquifer. However, buildings / structures requiring piled foundations will normally be located in areas covered by an impermeable surface reducing the potential for infiltration and mobilisation of contamination. The Principal Aquifer in this context is a moderate sensitivity receptor. The magnitude of the potential impact is small, resulting in a minor adverse effect without mitigation.

### ***Effects upon Surface Waters***

18.172 In operation, the Leisure Core of the Proposed Development will be covered by buildings and hardstanding that will inhibit infiltration. Any storm water run-off will be routed to marshland or constructed wetland and the Swanscombe Peninsula area will be served by a drainage system that utilises the ability to discharge uncontaminated surface waters to the River Thames. As described above, this will include a series of open water drains, channels and swales, routed through shallow strata, with outfall to the river. The earthworks strategy will have removed a considerable volume of unsuitable (chemically and physically) near surface soils reducing the potential for leaching of contamination from the shallow strata to these water bodies and the River Thames. The River Thames is a moderate sensitivity receptor and the magnitude of the potential impact is small. This results in a minor adverse effect without mitigation.

### ***Effects upon flora and fauna***

18.173 In operation, most of the Leisure Core will be encapsulated by hardstanding and buildings / structures. Any flora present will be introduced in accordance with the landscaping masterplan and will be planted within an appropriate thickness of suitable sub soils and topsoils (that meet appropriate chemical, physical and biological criteria, as defined by the Remediation Strategy), which will therefore be isolated from residual Made Ground.

18.174 Elsewhere on the Swanscombe Peninsula (including areas which fall within the Swanscombe Peninsula SSSI, designated due to its ecological sensitivity, such as the restored marshes and wetlands, for example) there is a potential for the flora and fauna to come into contact with soils (such as CKD) or surface waters with potentially phytotoxic or zootoxic contaminants. However, the presence and nature of some of these species relies upon the presence of this particular geology and the restored areas will have reflected that. These flora and fauna are high sensitivity receptors and the magnitude of the potential impact is small. This results in a moderate/ minor adverse effect without mitigation.

***Effects upon the built environment***

18.175 There is a potential for aggressive attack to below ground concrete by residual contamination within Made Ground or shallow natural strata. There is also a potential for this contamination to permeate through potable water supply pipework. The sensitivity of the built environment in this context is moderate. The magnitude of the potential impact is medium. This results in a moderate adverse effect without mitigation.

18.176 There is also a potential for ground gas / vapour generation from the residual Made Ground / Alluvium and its migration potentially resulting in the build-up of hazardous ground gas within any enclosed spaces in buildings/structures. The sensitivity of the built environment in this context is moderate, the magnitude of the potential impacts is medium, resulting in an effect of moderate adverse significance without mitigation.

***Summary of potential effects***

18.177 The potential operational effects on the Swanscombe Peninsula (Kent Project Site), described above, are summarised in Table 18.19.

**Table 18.19: Summary of effects during operation on the Swanscombe Peninsula (Kent Project Site).**

Receptor	Sensitivity	Description of effect	Magnitude of effect	Effect significance
Site visitors and workers	Moderate	Contact with contaminated soils	Small	Minor adverse
Neighbours		Accumulation of ground gas to hazardous concentrations in confined spaces	Large	Major adverse
Secondary Aquifer	Moderate	Derogation of quality by leaching and migration.	Small	Minor adverse
Principal Aquifer	Moderate		Small	Minor adverse
River Thames	Moderate	Derogation of quality by contaminant migration via permeable strata, run-off, drainage.	Small	Minor adverse
Flora and fauna	High	Impeded health and growth of plants and animals	Small	Moderate/Minor adverse
Built environment	Moderate	Aggressive attack on below ground infrastructure	Medium	Moderate adverse

Receptor	Sensitivity	Description of effect	Magnitude of effect	Effect significance
		Accumulation of ground gas to hazardous concentrations in confined spaces	Medium	Moderate adverse

### Operational Effects - Kent Project Site – A2 Highway Works (Zones 6 to 9)

#### *Relevant aspects of the scheme*

18.178 The operation of the proposed Resort Access Road from the A2(T) and People Mover route from Ebbsfleet International Station both to the Resort on the Swanscombe Peninsula will involve limited if any impact upon ground conditions other than the potential to affect the environmental management of the landfill and associated infrastructure.

#### *Effects upon site visitors and workers*

18.179 Once redeveloped, there will be very limited areas of public open space within the A2 Highway Works area and therefore very limited potential for site visitors to come into contact with contaminated soils. The large majority of these areas will be encapsulated by development (road, infrastructure etc.). Any limited areas of soft landscaping will include an appropriate thickness of suitable subsoils and topsoils complying with the relevant BS3882:2015 (British Standards Institute 2015) and meet appropriate chemical, physical and biological criteria, as outlined in the Contaminated Land Management Strategy. Site workers (or trespassers) will have access to a greater area of the A2 Highway Works area (Zones 6 to 9), including landfilled areas, but the potential period for exposure will be very limited. There is therefore very limited potential for human uptake (via ingestion, inhalation and dermal contact) of any contaminants in the residual contamination in the Made Ground or in the imported soils. The sensitivity of these receptors is moderate. The magnitude of the potential impact is negligible, resulting in a negligible effect without additional mitigation.

18.180 There is also a potential for ground gas / vapour migration and accumulation in any confined spaces. However, there are no buildings planned to be constructed on the A2 Highway Works (Zones 6 to 9) and thus no potential for site visitors or workers to be affected.

#### *Effects upon site neighbours*

18.181 Once operational, there will remain a potential for the migration of ground gas / vapour from the areas of landfill in the corridor of the A2 Highway Works to adjacent residential properties with the potential for accumulation to hazardous concentrations. In this

context, neighbours are moderate sensitivity receptors and the potential impact is large. This results in an effect of major significance without mitigation.

### ***Effects upon Secondary Aquifer***

18.182 Contaminated Made Ground (including landfilled wastes) and underlying strata of the Secondary Aquifer will be removed during construction or for particular remediation. The construction of the new A2 Access Road and People Mover will effectively provide a cap to the underlying soils (and any residual contamination) and the provision of a suitable surface water drainage system in these areas will reduce infiltration. Outside of the footprint of the new road and People Mover, the remainder of the area will remain relatively undeveloped (although the areas of landfilling include an engineered cap that will inhibit infiltration). In operation, piled foundations or drainage trenches can provide a preferential pathway for the migration of contamination. Therefore, there is a potential for contaminated water to migrate to the underlying shallow aquifer. The shallow aquifer is a low sensitivity receptor and the magnitude of the potential effect is small. This results in an effect of minor adverse significance without mitigation.

### ***Effects upon Principal Aquifer***

18.183 In operation, the A2 Highway and People Mover corridor will largely be capped from the underlying soils and will also be served by a surface water drainage system that will prevent infiltration through potentially contaminated soils. However, where such road surfacing is not present, surface water will be able to infiltrate with the potential to mobilise contamination to the Chalk aquifer, which is directly below Made Ground / landfilled wastes in places. The presence of piled foundations could also create preferential migration pathways to the aquifer. The Chalk Principal aquifer is a high sensitivity receptor. The magnitude of the potential effect is small, resulting in an adverse effect of moderate / minor significance without mitigation.

### ***Effects upon surface waters***

18.184 In operation, the area surrounding the River Ebbsfleet will remain largely undeveloped. As described above, areas of new development will be served by an appropriate surface water drainage system that will control run-off and inhibit infiltration through potentially contaminated soils. Shallow groundwater flow is likely to be towards the River Ebbsfleet. The river is of moderate sensitivity and the magnitude of the potential impact is negligible. This results in a negligible effect without additional mitigation.

### ***Effects upon flora and fauna***

18.185 The flora introduced in areas of public spaces will include an appropriate thickness of suitable sub soils and topsoils and all landscape areas (on residual ground, at podium levels

or in landscaped planters) will be completed with imported topsoils. The imported soils will comply with the relevant BS3882:2015 and meet appropriate chemical, physical and biological criteria, as outlined in the Contaminated Land Management Strategy. An appropriate surface water drainage system will control run-off and inhibit infiltration through potentially contaminated soils. The flora is thus isolated from any residual contaminated Made Ground soils. The flora and fauna within the designated SSSI is a high sensitivity receptor. The magnitude of the potential impact is negligible, resulting in a negligible effect without additional mitigation.

### ***Effects upon the built environment***

18.186 There is a potential for residual contamination in Made Ground to affect integrity of below ground concrete. Any such concrete (e.g. piles) will have been manufactured in accordance with the relevant BRE guidance<sup>28</sup> to address any aggressive ground conditions (BRE SD1). The sensitivity of the built environment in this context is low, the magnitude of the potential impact is negligible, resulting in a negligible effect without additional mitigation.

### ***Summary of potential effects***

18.187 The potential operational effects within the A2 Highway Works area (Zones 6 to 9) of the Kent Project Site, described above, are summarised in Table 18.20.

**Table 18.20: Summary of effects during operation within the A2 Highway Works area (Kent Project Site).**

<b>Receptor</b>	<b>Sensitivity</b>	<b>Description of effect</b>	<b>Magnitude of effect</b>	<b>Effect significance</b>
Site visitors and workers	Moderate	Contact with contaminated materials	Negligible	Negligible
Site neighbours	Moderate	Accumulation of ground gas to hazardous concentrations in confined spaces	Large	Major adverse
Shallow Aquifer	Low	Derogation of quality by leaching and migration.	Small	Minor adverse
Deep Aquifer	High	Derogation of quality by leaching and migration.	Small	Moderate / minor adverse
River Ebbsfleet	Moderate	Derogation of quality by contaminant migration via permeable strata, run-off,	Negligible	Negligible

<sup>28</sup> BRE Group (2005) BRE Special Digest. Concrete in aggressive ground (SD1: 2005)

Receptor	Sensitivity	Description of effect	Magnitude of effect	Effect significance
		drainage.		
Flora and fauna	High	Impeded health and growth of plants and animals	Negligible	Negligible
Built environment	Low	Aggressive attack on below ground concrete	Negligible	Negligible

## AVOIDANCE AND MITIGATION MEASURES

### Ground investigation

18.188 Limited ground investigation has been undertaken across the Project Site to date and this was undertaken when the details of the development proposals were unknown. There is some data from past investigation on particular parts of the Project Site, but there are also large areas where no recent investigation has been undertaken, for example within areas of permitted landfills. A programme of site-wide groundwater monitoring / sampling is currently underway (from existing groundwater wells on the Kent Project Site, see Figure 18.4, Figure 18.5 and Appendix 18.20). However, it will be necessary to undertake further ground investigation prior to any construction works that is targeted to specific areas of the Project Site and to elements of the Proposed Development (e.g. building and infrastructure locations etc.). Such investigations will have combined geotechnical and geoenvironmental objectives and will have considered other relevant disciplines (e.g. ecology, archaeology etc – see below). They will include a suitable number of exploratory holes to appropriate depths and with adequate sampling / testing and duration / frequency of monitoring to enable the characterisation of soils, rocks and the groundwater / surface water and ground gas regimes. Liaison with the relevant local planning authorities (for both the Kent Project site and Essex Project Site), and the Environment Agency and key stakeholders (e.g. HS1, Historic England, Natural England and landowners) will be carried out to agree scope and location of any such investigation, as well as analytical suites and reporting protocol. These works will enable appropriate remediation to be designed into the Proposed Development to ensure safe operation, mitigating the potential risks to people and the natural and built environments. A ground investigation scoping report (Appendix 18.18) has been prepared for the Swanscombe Peninsula in collaboration with relevant specialists (geotechnical, geoenvironmental, ecological and archaeological), which sets out the approach to determining a scope of ground investigation works within this area. It also defines the aims and objectives of these ground investigation works and proposes a series of exploratory holes such that relevant information / data can be obtained to achieve those aims.

18.189 Standard health and safety precautions will be adopted during ground investigation works to mitigate any potential adverse effect to the contractors engaged. By undertaking these

ground investigations, particular precautions can be adopted during the main construction period (where earthworks are more extensive) in areas where particular contamination is present (e.g. areas of CKD landfill). The contractor will provide a CEMP secured through a DCO requirement, which will set out procedures for the protection of human health, controlled waters and flora and fauna. To mitigate the effects from the migration of contaminants to site neighbours, the CEMP will set out procedures for the protection of adjacent sites including dust suppression activities. This will include use of dedicated haul routes, strictly enforced speed limits, limiting drop heights (set out in Chapter 16, Air quality) and control of surface water run-off (set out in Chapter 17, Water resources and flood risk).

18.190 The ground investigations carried out to date have provided relatively localised / limited characterisation of the contamination profile of the Project Site (as described in the description of baselines above). Further investigations are proposed (as described above), but nevertheless there is always a possibility that an area of relatively localised contaminated soil or groundwater (of particularly difficult determinands or highly elevated concentrations) could be encountered during the below ground works that is not identified by ground investigation. In the event that an area of the unexpected heavily contaminated soils or groundwater is encountered, implementation of the Contaminated Land Management Strategy (Appendix 18.9) which will be secured through a requirement in the DCO, will ensure that the contamination will be sampled and assessed as soon as practicable. Should such an area of contamination require specific remedial action, or should it alter the overall risk assessment, the local planning authorities (for the Kent Project Site and / or Essex Project Site) and/or Environment Agency regulators will be informed as appropriate, and a supplementary risk assessment prepared, submitted for approval and appropriate remedial action agreed and taken.

### **Mitigation of demolition and construction effects**

18.191 Implementing the general measures (summarised in Table 18.21 below) will be required to aid in mitigating the potentially significant (moderate/major) adverse effects that have been identified across the Project Site during the demolition and construction phase. These measures will also further reduce potential minor adverse effects. Incorporation of mitigation such as personal protective equipment (PPE) and implementation of the health and safety regime, defined and secured in a Construction Environmental Management Plan (CEMP) (document reference 8.20), which will be secured through a requirement in the DCO, will address the main potential adverse effects across much of the Proposed Development. All of the mitigation measures listed in Table 18.20 will be implemented prior to and during construction. However, there are particular areas where additional, specific mitigation measures will be required (for example, during construction works in areas of landfilling or in areas where flora and fauna are particularly sensitive). Those additional specific measures are described under the heading for the relevant element of the Proposed Development - Essex Project Site, Swanscombe Peninsula (Kent Project Site)

or A2 Highway Works (Kent Project Site).

**Table 18.21: Summary of general mitigation measures during demolition and construction.**

<b>Receptor</b>	<b>Adverse effect</b>	<b>Mitigation measure</b>	<b>Means of implementation</b>
Construction workers	Direct contact, inhalation or ingestion.	Construction Environmental Management Plan (CEMP) (document reference 8.20) to include appropriate health, safety and welfare provision relevant to below ground works. Including; induction, awareness training, PPE and provision for unforeseen contamination (including Unexploded Ordnance, UXO). Ground investigations to include sampling / testing for acute risks and monitoring of groundwater and ground gas / vapour.	CEMP to be secured via a DCO requirement and managed by contractor. Scope of investigations to be secured via a DCO requirement.
Site neighbours	Dust emissions, migration of gas / vapour	CEMP (document reference 8.20) to include dust suppression measures such as dampening, and wheel washing. Ground investigations to include sampling / testing for acute and chronic risks and monitoring of groundwater and ground gas / vapour.	CEMP to be secured via a DCO requirement and implemented by contractor. Scope of investigations to be secured via a DCO requirement.
Secondary Aquifer Principal Aquifer Surface waters (River Thames, River Ebbsfleet)	Infiltration, leaching and migration, run- off	CEMP (document reference 8.20) to include measures to limit un-sealed surfaces and contain / manage infiltration and surface water run-off. Ground investigations to include monitoring of groundwater and risk assessment. Foundation Works Risk Assessment (undertaken as part of detailed design) to inform foundation solution and ensure mitigation of risk. Remediation Strategy (to be prepared in general accordance with	CEMP to be secured via a DCO requirement and implemented by contractor. Scope of investigations to be secured via a DCO requirement.



Receptor	Adverse effect	Mitigation measure	Means of implementation
		the Contaminated Land Management Strategy, Appendix 18.9) to include removal / treatment of any gross contamination. Control of groundwater during excavation.	
Flora and fauna	Impeded health and growth of plants and animals	CEMP (document reference 8.20) to include particular measures for the protection of flora and fauna, as set out in Chapter 12 (Terrestrial and freshwater ecology and biodiversity)	CEMP to be secured via a DCO requirement and implemented by contractor.

### **Operation**

18.192 As described above, pre-commencement site activities will include ground investigations designed to allow assessment of potential risks / adverse effects identified within the Desk Studies, which have also informed the assessment presented here. This will be undertaken in accordance with Land Contamination: Risk Management (LC:RM), relevant British Standards (BS 10175:2011+A2:2017, BS EN ISO 21365:2020, BS 5930:2015+A1:2020) and other good practice guidance (as outlined in the 'Law, policy and guidance' section). The findings of these investigations will be reported and will include risk assessment and waste characterisation. This information will subsequently lead to the development and preparation of a Remediation Strategy (which will be prepared in general accordance with the Contaminated Land Management Strategy, Appendix 18.9) for the Proposed Development. The specific measures necessary to mitigate potential adverse effects will be set out and described in the Remediation Strategy, which will be secured via a DCO requirement.

18.193 This Remediation Strategy will be implemented at the construction stage, but it will also have addressed the potential operational risks. For completeness and ease of reference, the remedial measures incorporated into the construction phase and which also mitigate the potential operational risks are summarised in Table 18.22. The evidence for the successful completion of these works will be presented in a Verification or Completion Report (also secured via a DCO requirement). Due to the complexities of the Project Site, including areas of permitted landfill, additional specific mitigation measures will be required, as set out in the following subsection.

**Table 18.22: Summary of operational general mitigation measures.**

<b>Receptor</b>	<b>Adverse effect</b>	<b>Mitigation measure</b>	<b>Means of implementation</b>
Site visitors and workers	Human contact with soils	Topsoil specification to meet relevant British Standard (BS 3882:2015) / human health criteria. Materials Management Plan (to be prepared post-DCO submission) will set out the end use criteria for the re-use / treatment of soils.	Set out in Remediation Strategy, secured via DCO requirement.
Flora and fauna	Impeded health and growth of plants and animals (inc. SSSI)		
Site visitors and workers	Migration and accumulation of ground gas to hazardous concentrations in confined spaces	Gas protection systems to buildings.	Set out in Remediation Strategy, secured via DCO requirement.
Built environment		Gas protection systems to prevent off-site migration	
Neighbours			
Secondary Aquifer	Derogation of quality by leaching and migration.	Infiltration and surface water run- off reduced and controlled by development and drainage system.	Set out in Remediation Strategy, secured via DCO requirement.
Principal Aquifer	Derogation of quality by leaching and migration.	Piled foundations in accordance with recommendations of Foundation Works Risk Assessment (FWRA).	Foundation solution described in FWRA and Remediation Strategy, secured via DCO requirement.
Surface waters (River Thames, River Ebbsfleet)	Derogation of quality by contaminant migration via permeable strata, run-off, drainage.	Infiltration and surface water run- off reduced and controlled by development and drainage system.	Set out in Remediation Strategy, secured via DCO requirement.
Built environment	Aggressive attack on below ground concrete	Design to meet requirements of ground conditions and Building Research Establishment (BRE) recommendations.	Set out in Remediation Strategy, secured via DCO requirement.

Receptor	Adverse effect	Mitigation measure	Means of implementation
	Permeation of potable water supply pipes	Design to meet requirements of ground conditions and recommendations of UK Water Industry Research <sup>29</sup> (UKWIR).	

### Additional specific mitigation measures

#### *Essex Project Site*

18.194 The nature of the ground conditions and of the nature of the Proposed Development on the Essex Project Site is such that no site specific remediation / mitigation measures additional to the measures set out in the site-wide remediation strategy summarised above and presented in detail in the Contaminated Land Management Strategy (Appendix 18.9) will be required.

#### *Kent Project Site – Swanscombe Peninsula (Zones 1 to 5)*

18.195 On the Swanscombe Peninsula part of the Kent Project Site there are three elements that require particular measures to be implemented in addition to the site-wide remediation strategy summarised above and presented in detail in the Contaminated Land Management Strategy (Appendix 18.9). These are:

- The widespread occurrence of CKD;
- The presence of a leachate collection and management system over particular areas of the Kent Project Site;
- The presence of areas designated as part of the Swanscombe Peninsula SSSI, and
- The presence of areas subject to Environmental Permits.

18.196 The extent and properties (both physical and chemical) of the CKD in the several areas on the Peninsula is currently not well defined. Some initial research has been carried out and a note on that is included within the Contaminated Land Management Strategy (Appendix 18.9). The programme of ground investigation referred to above will address this current paucity of data and will inform both the potential for treatment / beneficial re-use of CKD

<sup>29</sup> UK Water Industry Research (2011) Guidance for the Selection of Water Supply Pipes to be used in Brownfield Sites (Ref 10/WM/03/21)

spoil arising from the earthworks, but also the need for and scope of any particular remedial measures necessary to prevent contamination of the natural environment (whilst also recognising that in the restored salt marsh area, these ground conditions have contributed to the particular ecological value of that part of the Peninsula).

- 18.197 The existing leachate collection and management system on the Peninsula is complex but relatively well understood. This current understanding is described in Chapter 17 (Water resources and flood risk) and Surface Water Drainage Strategy (document reference LR DC BUR REP 403.1). This existing system is not functioning as well as it could do and furthermore substantial elements of it will be disrupted / destroyed during construction of the Proposed Development and will require re-instatement and reconstruction as well as the construction of enhanced capacity.
- 18.198 Further investigations of the existing system are planned and these (together with consideration of the Proposed Development) will inform the detailed design of the new and improved leachate collection, management and treatment system. Currently it is anticipated that the leachate treatment plant that serves the Broadness Marsh area (Zone 1) will be adapted and upgraded to increase its treatment capacity. The conveyance channels around the Broadness Marsh area will be formalised and enlarged to capture the leachate and surface water runoff. The flows will be conveyed to open lined detention ponds within and pumped to the upgraded plant.
- 18.199 The leachate treatment plant currently located within the South Pit area (Zone 2) will be relocated to enable the Proposed Development. The most appropriate location for the plant and the required treatment levels will be considered during design development, including the option of pumping the leachate from the South Pit area to the upgraded Broadness Marsh leachate treatment plant.
- 18.200 For areas that fall within the Swanscombe Peninsula SSSI, Natural England must be notified (and approve) any proposals for ground investigation and / or remedial design or action in these areas.
- 18.201 There are several areas of this part of the Kent Project Site that are subject to Environmental Permits (former Waste Management Licences), illustrated by Figure 18.6. Most of these have been subject to landfilling, but there are also permitted areas where no disposal has taken place. Provided that the permits remain in force (and are not surrendered prior to construction) their existence has particular implications that will be taken into account and secured through a requirement in the DCO, namely:
- The Proposed Development must not compromise the permit holder's ability to manage and monitor the Project Site in accordance with the permit and to continue to comply with the permit conditions;

- The Environment Agency must be notified (and approve) any proposals for ground investigation on these landfills; and
- The Environment Agency must be notified (and approve) the construction of any infrastructure on the permitted landfill which could affect the landfill cap, its profile and its management and monitoring regime.

### ***Kent Project Site – A2 Highway Works (Zones 6 to 9)***

18.202 On the A2 Highway Works part of the Kent Project Site the presence of licensed landfills and the Swanscombe Peninsula SSSI again presents elements that require particular measures to be implemented in addition to the Contaminated Land Management Strategy summarised above and included as Appendix 18.9. The regulatory / management constraints presented by the presence of licensed landfills and the SSSI and the particular mitigation measures needed to address them described above with respect to the Swanscombe Peninsula are equally applicable to this part of the Kent Project site (areas within the SSSI as well as Bamber Pit, Northfleet Landfill and Southfleet Landfill) and will also be secured through a requirement in the DCO.

18.203 Particular mitigation will be applicable to Bamber Pit and Northfleet landfill. The construction of the Access Road and the people mover across Bamber Pit will involve the construction of a substantial cutting through the Inert wastes of the southern flank of the pit and through the commercial / industrial wastes of the northern flank. This excavation will generate substantial volumes of spoil (much likely to be Hazardous Waste) but will also affect the existing leachate regime (there is no current collection / treatment system) and the landfill gas management system. The programme of ground investigation referred to above will address the need to provide site specific data (on the nature of the waste and the leachate and gas regimes) and will inform the need for and scope of any particular remedial design / construction measures necessary to prevent contamination of the natural environment and enable safe design and construction.

18.204 Similarly, the construction of the Access Road and the people mover across Northfleet Landfill will involve earthworks, although the design has aimed to minimise excavation and also to avoid interference with the existing landfill cap and the leachate and gas management and monitoring regimes on the Project Site as far as possible. This does have consequent impacts upon the Baker's Hole SSSI (see Chapter 14, Cultural heritage and archaeology). The location of the existing landfill infrastructure is well defined but will be supplemented by the programme of ground investigation referred to above and will address the need to provide supplementary data. The results will inform the need for and scope of any particular remedial design / construction measures necessary to prevent contamination of the natural environment, reinstate any existing control systems and enable safe design and construction and will also be secured through a requirement in the DCO.

## RESIDUAL ENVIRONMENTAL EFFECTS

### General

- 18.205 A number of potential significant adverse effects to people and the environment associated with the Proposed Development and ground conditions were identified during the demolition and construction phase. A more limited number of further potential adverse effects were identified once the Proposed Development is operational. As described above, all of these potential adverse effects are capable of mitigation. Such measures, informed by ground investigations and defined in a Remediation Strategy (to be prepared in general accordance with the Contaminated Land Management Strategy, once further ground investigation has been undertaken) and CEMP that are secured via DCO requirements will ensure appropriate design and construction during development.
- 18.206 With mitigation, the vast majority of potential effects during demolition and construction and once in operation are negligible. The residual effect to the River Thames during operation on the Swanscombe Peninsula (Kent Project Site) will be minor beneficial. This is because the upgraded leachate treatment plants and improved surface water drainage system will resolve known issues where existing drainage ditches containing leachate overtop during high rainfall events, with consequent untreated discharge directly to the River Thames.
- 18.207 This assessment is presented in a series of tables below. Table 18.23, Table 18.24 and Table 18.25 present the assessment of residual effects during demolition and construction for the Essex Project Site, Swanscombe Peninsula (Kent Project Site) and A2 Highway Works (Kent Project Site) areas, respectively. Table 18.26, Table 18.27 and Table 18.28 then present the assessment of residual effects, once operational, for the same areas of the Proposed Development and in the same order.

### Demolition and Construction Effects

#### *Essex Project Site*

- 18.208 Table 18.23 provides a summary of the residual effects for the Essex Project Site during demolition and construction.

**Table 18.23: Summary of residual effects during demolition and construction (Essex Project Site).**

Receptor	Description of effect	Significance before mitigation	Mitigation measures	Residual effect significance
Construction workers	Contact with contaminated materials	Moderate adverse	Implementation of health and safety regime, set out in CEMP, informed by ground investigation and secured via DCO requirement.	Negligible
Neighbours	Inhalation of contaminated dusts	Minor adverse	Implementation of good construction practice, set out in CEMP, informed by ground investigation and secured via DCO requirement.	Negligible
	Migration and accumulation of ground gas to hazardous concentrations			Negligible
Secondary Aquifer	Derogation of quality by leaching and migration of contamination	Moderate adverse	Limit un-sealed surfaces, contain / manage infiltration and surface water run-off. Groundwater monitoring. Remove / treat gross contamination. Groundwater control.	Negligible
Principal Aquifer	Derogation of quality by leaching and migration of contamination	Moderate adverse	Foundation Works Risk Assessment (prepared during detailed design) informed by ground investigation. Scope of investigations agreed and secured via DCO requirement.	Negligible
River Thames	Derogation of quality by contaminant migration via permeable strata, run-off, drainage.	Moderate adverse	Limit un-sealed surfaces, contain / manage infiltration and surface water run-off. Groundwater monitoring. Remove / treat gross contamination. Groundwater control.	Negligible
Flora and fauna	Impeded health and growth of plants and animals	Minor adverse	Implementation of good construction practice, set out in CEMP, informed by ground investigation and secured via DCO requirement.	Negligible

**Kent Project Site – Swanscombe Peninsula (Zones 1 to 5)**

18.209 Table 18.24 provides a summary of the residual effects for the Swanscombe Peninsula (Kent Project Site) during demolition and construction.

**Table 18.24: Summary of residual effects during demolition and construction on the Swanscombe Peninsula (Kent Project Site).**

Receptor	Description of effect	Significance before mitigation	Mitigation measures	Residual effect significance
Construction workers	Contact with contaminated materials	Major adverse	Implementation of health and safety regime, set out in CEMP. Ground investigation to be approved by Environment Agency in licensed areas, secured via DCO requirement.	Negligible
Neighbours	Inhalation of contaminated dusts	Major adverse	Implementation of good construction practice, set out in CEMP. Ground investigation to be approved by Environment Agency in licensed areas, secured via DCO requirement.	Negligible
	Migration and accumulation of ground gas to hazardous concentrations	Major adverse		Negligible
Secondary Aquifer	Derogation of quality by leaching and migration of contamination	Moderate adverse	Construction works to take into account presence of existing leachate treatment plants, with Environment Agency approval for works in licensed areas, secured via DCO requirement. Limit un-sealed surfaces, contain / manage infiltration and surface water run-off. Groundwater monitoring. Remove / treat gross contamination. Groundwater control.	Negligible
Principal	Derogation of	Major	Foundation Works Risk	Negligible



Receptor	Description of effect	Significance before mitigation	Mitigation measures	Residual effect significance
Aquifer	quality by leaching and migration of contamination	adverse	Assessment (prepared during detailed design) informed by ground investigation. Ground investigation to be approved by Environment Agency in licensed areas, secured via DCO requirement.	
River Thames	Derogation of quality by contaminant migration via permeable strata, run-off, drainage.	Major adverse	Construction works to take into account presence of existing leachate treatment plants. Limit un-sealed surfaces, contain / manage infiltration and surface water run-off. Groundwater monitoring. Remove / treat gross contamination. Groundwater control.	Negligible
Flora and fauna	Impeded health and growth of plants and animals	Major adverse	Implementation of good construction practice, set out in CEMP. Ground investigation and remediation to be approved by Natural England in SSSI areas and by the Environment Agency in environmental permitted areas, secured via DCO requirement.	Negligible

***Kent Project Site – A2 Highway Works (Zones 6 to 9)***

18.210 Table 18.25 provides a summary of the residual effects for the A2 Highway Works area (Kent Project Site) during demolition and construction.

**Table 18.25: Summary of residual effects during demolition and construction within the A2 Highway Works area (Kent Project Site).**

Receptor	Description of effect	Significance before mitigation	Mitigation measures	Residual effect significance
Construction workers	Contact with contaminated materials	Major adverse	Implementation of health and safety regime, set out in CEMP. Environment Agency approval will be gained for works in licensed areas, secured via DCO requirement.	Negligible
Neighbours	Inhalation of contaminated dusts and / or gases	Major adverse	Implementation of good construction practice, set out in CEMP, informed by ground investigation. Environment Agency approval will be gained for works in licensed areas, secured via DCO requirement.	Negligible
	Migration and accumulation of ground gas to hazardous concentrations	Major adverse		Negligible
Secondary Aquifer	Derogation of quality by leaching and migration of contamination	Minor adverse	Environment Agency approval will be gained for works in licensed areas, secured via DCO requirement. Limit un-sealed surfaces, contain / manage infiltration and surface water run-off. Groundwater monitoring. Remove / treat gross contamination. Groundwater control.	Negligible
Principal Aquifer		Major adverse	Environment Agency approval will be gained for works in licensed areas. Foundation Works Risk Assessment (prepared during detailed design) informed by ground investigation. Scope of investigations agreed and secured via DCO	Negligible

Receptor	Description of effect	Significance before mitigation	Mitigation measures	Residual effect significance
			requirement.	
River Ebbsfleet	Derogation of quality by contaminant migration via permeable strata, run-off, drainage.	Minor adverse	Limit un-sealed surfaces, contain / manage infiltration and surface water run-off. Groundwater monitoring. Remove / treat gross contamination. Groundwater control.	Negligible
Flora and fauna	Impeded health and growth of plants and animals	Major adverse	Implementation of good construction practice, set out in CEMP. Natural England approval will be gained in SSSI areas and Environment Agency approval will be gained for works in environmental permitted areas, secured via DCO requirement.	Negligible

## Operational Effects

### *Essex Project Site*

18.211 Table 18.26 provides a summary of the residual effects for the Essex Project Site, once operational.

**Table 18.26: Summary of residual effects during operation (Essex Project Site).**

Receptor	Description of effect	Significance before mitigation	Mitigation measures	Residual effect significance
Site visitors and workers	Contact with contaminated soils	Minor adverse	Import appropriate thickness of suitable soils.	Negligible
	Accumulation of ground gas to hazardous concentrations in	Moderate / minor adverse	Gas protection systems to buildings	Negligible
Gas protection systems			Negligible	
Neighbours				

Receptor	Description of effect	Significance before mitigation	Mitigation measures	Residual effect significance
	confined spaces			
Secondary Aquifer	Derogation of quality by leaching and migration.	Minor adverse	Infiltration and surface water run-off reduced and controlled by development and drainage system	Negligible
Principal Aquifer		Minor adverse	Piled foundations in accordance with recommendations of Foundation Works Risk Assessment (prepared during detailed design).	Negligible
River Thames	Derogation of quality by contaminant migration via permeable strata, run-off, drainage.	Minor adverse	Infiltration, migration via shallow aquifer, surface water run-off reduced and controlled by development and drainage system	Negligible
Flora and fauna	Impeded health and growth of plants	Negligible adverse	Import appropriate thickness of suitable soils.	Negligible
Built environment	Aggressive attack on below ground infrastructure	Minor adverse	Design to meet requirements of ground conditions and relevant standards (BRE)	Negligible
	Accumulation of ground gas to hazardous concentrations in confined spaces	Minor adverse	Design to meet requirements of ground conditions and relevant standards (UKWIR)	Negligible

**Kent Project Site – Swanscombe Peninsula (Zones 1 to 5)**

18.212 Table 18.27 provides a summary of the residual effects for the Swanscombe Peninsula (Kent Project Site), once operational.

**Table 18.27: Summary of residual effects during operation on the Swanscombe Peninsula (Kent Project Site).**

Receptor	Description of effect	Significance before mitigation	Mitigation measures	Residual effect significance
Site visitors and workers	Contact with contaminated soils	Minor adverse	Characterisation of soils and inform treatment / beneficial re-use. Import appropriate thickness of suitable soils	Negligible
	Accumulation of ground gas to hazardous concentrations in confined spaces	Major adverse	Gas protection systems to buildings	Negligible
Neighbours	Gas protection systems		Negligible	
Secondary Aquifer	Derogation of quality by leaching and migration.	Minor adverse	Upgrade to leachate treatment plants. Infiltration and surface water run-off reduced and controlled by development and drainage system	Negligible
Principal Aquifer		Minor adverse	Piled foundations in accordance with recommendations of Foundation Works Risk Assessment (prepared during detailed design)	Negligible
River Thames	Derogation of quality by contaminant migration via permeable strata, run-off, drainage.	Minor adverse	Upgrade to leachate treatment plants. Infiltration, migration via shallow aquifer, surface water run-off reduced and controlled by development and drainage system	Minor beneficial
Flora and fauna	Impeded health and growth of plants and animals	Moderate / Minor adverse	Characterisation of soils and inform treatment / beneficial re-use. Import appropriate thickness of suitable soils.	Negligible

Receptor	Description of effect	Significance before mitigation	Mitigation measures	Residual effect significance
Built environment	Aggressive attack on below ground infrastructure	Moderate adverse	Design to meet requirements of ground conditions and relevant standards (BRE)	Negligible
	Accumulation of ground gas to hazardous concentrations in confined spaces	Moderate adverse	Design to meet requirements of ground conditions and relevant standards (UKWIR)	Negligible

**Kent Project Site – A2 Highway Works (Zones 6 to 9)**

18.213 Table 18.28 provides a summary of the residual effects for the A2 Highway Works area (Kent Project Site), once operational.

**Table 18.28: Summary of residual effects during operation within the A2 Highway Works area (Kent Project Site).**

Receptor	Description of effect	Significance without mitigation	Mitigation measures	Residual effect significance
Site visitors and workers	Contact with contaminated materials	Negligible	Characterisation of soils and inform treatment / beneficial re-use. Import appropriate thickness of suitable soils.	Negligible
Site neighbours	Accumulation of ground gas to hazardous concentrations in confined spaces	Major adverse	Gas protection systems	Negligible
Secondary Aquifer Secondary Aquifer	Derogation of quality by leaching and migration.	Minor adverse	Infiltration and surface water run-off reduced and controlled by development and drainage system	Negligible
Principal	Derogation of	Moderate /	Piled foundations in	Negligible

Receptor	Description of effect	Significance without mitigation	Mitigation measures	Residual effect significance
Aquifer	quality by leaching and migration.	minor adverse	accordance with recommendations of Foundation Works Risk Assessment (prepared during detailed design)	
River Ebbsfleet	Derogation of quality by contaminant migration via permeable strata, run-off, drainage.	Negligible	Infiltration, migration via shallow aquifer, surface water run-off reduced and controlled by development and drainage system	Negligible
Flora and fauna	Impeded health and growth of plants and animals	Negligible	Characterisation of soils and inform treatment / beneficial re-use. Import appropriate thickness of suitable soils.	Negligible
Built environment	Aggressive attack on below ground concrete	Negligible	Design to meet requirements of ground conditions and relevant standards (UKWIR)	Negligible

## CLIMATE CHANGE

18.214 It is accepted that the climate is changing and that this will affect future weather patterns.

Such changes to weather patterns in the UK may include: an increase in warmer weather; an increase in the frequency and intensity of rainfall events; and an increase in the duration or frequency of dry spells in the summer. Such events are also likely to become more extreme. There is the potential for these scenarios to impact upon potential contaminant migration pathways in particular with respect to both hazardous ground gas and contaminated groundwater via permeable strata, during both construction and in operation.

18.215 Increased temperatures and drier summers could, for example, increase the depth of desiccation in a landfill cap or clay confining layer, or cause a drop in groundwater levels. This could expose or enhance a pathway for the migration of hazardous ground gas. Increased rainfall will increase flood risk (fluvial or groundwater). This will influence the extent and duration of ground saturation accordingly, and also cause rise in groundwater levels. Such events may result in increased infiltration and therefore mobilisation of contamination, with potential to impact upon sensitive aquifers or surface waters.

Changes to the degree of saturation in soils may also affect pathways for ground gas migration, for example, water may displace ground gas in soil pores, causing release at the ground surface with potential to accumulate within buildings / confined spaces.

- 18.216 There is the potential for such weather events to affect the Proposed Development during both construction and operation. In particular, during construction (including remediation), significant rainfall events or flooding may overwhelm normal site surface water controls, and lead to mobilisation of contamination within exposed soils (e.g. landfilled CKD wastes etc.). Measures set out in a “standard” CEMP produced in the past are not likely to account for these extreme weather events. Accordingly, to mitigate the potential impact of such events, detailed incident management plans, including responses to extreme weather events, will be a part of the CEMP and site management documents once a contractor is appointed for the London Resort and these remain live for the duration of construction period.
- 18.217 During operation, the above potential effects can and will be mitigated by undertaking appropriate monitoring and design. In particular, monitoring of hazardous ground gas and groundwater (both levels and chemistry) will be undertaken over sufficient duration, spread and depth to determine variation in parameters over seasons and therefore inform the prediction of potential changes during extreme weather events. Accordingly, the designed Surface Water Drainage Strategy (LR DC BUR REP 403.1), Flood Risk Management Strategy (0042936\_LR\_BUR\_DCO\_FRM\_1004) (both of which will contribute to the integrated approach to remediation) and ground gas protection systems will be resilient to the effects of climate change and extreme events.

### CUMULATIVE, IN-COMBINATION AND TRANSBOUNDARY EFFECTS

- 18.218 The potential zone of influence for cumulative effects with regards to Chapter 18 (Soils, hydrogeology and ground conditions) is 1km. This reflects the maximum extent of ground conditions / hydrogeology on neighbouring land that could plausibly be affected by sources of contamination on the Project Site. It similarly reflects the maximum extent of the neighbouring land where sources of contamination could plausibly affect the ground conditions / hydrogeology within the Project Site. The schemes (a mixture of DCO applications and planning applications) from the Cumulative Effects Assessment shortlist that are located within the zone of influence of the Project Site are summarised in Table 18.28.
- 18.219 As summarised in Table 18.28, no significant cumulative effects are anticipated related to ground conditions. This is because the identified schemes are subject to the NPPF or Planning Act 2008, where the purpose of both is to ensure that the schemes are suitable for their proposed use. If consent for a development is granted, that suitability is ensured by the attachment of planning conditions or DCO requirements to the consent. Schemes with potentially significant adverse effects to receptors relevant to this chapter will not be



granted planning permission / consent.

18.220 Given the nature of the other schemes and their location / distance from the Proposed Development there are no plausible effects related to ground contamination that could combine with the effects assessed for the scheme to become significant. For example, it is not plausible that non-significant effects on groundwater on surrounding sites could become significant because that would require unrealistic groundwater migration flow which is contrary to the regional groundwater flow. Similarly, it is not plausible that non-significant effects on people (construction workers, visitors and neighbours) could combine to become significant because this would require unrealistic patterns of contaminant migration (e.g. as dusts via air). However, there is a potential for such effects that are indirectly associated with ground contamination, for example with respect to waste (Chapter 19), water (Chapter 17) and transport (Chapter 9) and that potential is assessed in those chapters.

**Table 18.28: Summary of potential cumulative effects with other schemes.**

Application name and reference	Distance from Project Site	Determined by / status	Potential cumulative effects	
			Construction	Operation
Tilbury2 Port Expansion, TR030003	820m east of Essex Project Site	NSIP – Development Consent Order granted	The developments are subject to the NPPF or Planning Act 2008 which will ensure that the schemes are suitable for their intended use. Accordingly, mitigation and control measures will be adopted during the construction phase to mitigate effects to the identified receptors. Consent for schemes with potentially significant adverse effects (related to ground conditions) during construction would not be granted.  Given the nature and location of the other	It is assumed that the developments that are brought forward will be operated in accordance with the granted consents and that planning conditions / DCO requirements, that ensure that a scheme is suitable for its intended use, will be met or discharged. Consent for schemes with potentially significant adverse effects (related to ground conditions) during operation would not be granted.  Given the nature and location of the other schemes there is no
Thurrock Flexible Generation Plant, EN010092	400m east of Essex Project Site	NSIP – Application for development consent has been accepted for examination		
The Pier, 17/01814/FUL	Directly adjacent to western boundary of Kent Project Site	Dartford Borough Council Awaiting decision (checked 29/10/2020)		
Land West of Springhead Road, 20150155   EDC	Adjacent to southern boundary of Kent Project Site	Ebbsfleet Development Corporation Permission granted, to be		

Application name and reference	Distance from Project Site	Determined by / status	Potential cumulative effects	
			Construction	Operation
		delivered in phases	schemes there is no plausible potential for effects to combine with the non-significant effects during construction of the Proposed development to become significant.  Therefore, no significant cumulative effects are anticipated.	plausible potential for effects to combine with the non-significant effects during operation of the Proposed development to become significant.  Therefore, no significant cumulative effects are anticipated.
Land West of Springhead Road, EDC/18/009	Adjacent to southern boundary of Kent Project Site	Ebbsfleet Development Corporation Permission granted		
Land at former Northfleet Cement Works, EDC/16/004	600m east of Kent Project Site	Ebbsfleet Development Corporation Approved subject to section 106		
Former Croxton and Garry Site	Adjacent to southern boundary of Kent Project Site	Ebbsfleet Development Corporation Approved subject to section 106		
Northfleet Works, the Shore	830m east of Kent Site	Gravesham Borough Council Approved		

18.221 Construction of the Proposed Development and those schemes / developments in the surrounding area will accord with the granted consents and relevant DCO requirements or planning conditions. On land where contamination may be present, there will be a requirement to undertake intrusive investigation, carry out risk assessment and devise an appropriate Remediation Strategy, secured via standard planning conditions / DCO requirement. Associated with such a strategy, a site-specific CEMP would be required which secures mitigation measures to avoid detrimental effects to sensitive receptors during construction. Where significant pollutant linkages are identified for a site, the implementation of the appropriate and agreed Remediation Strategy will result in a negligible or minor beneficial effect on ground conditions in the area. There will be a requirement to demonstrate successful remediation by the publication of a Verification Report, which will be required to discharge planning conditions or satisfy DCO requirements.

18.222 In operation, as described above and considering the Proposed Development and surrounding land uses, no significant cumulative effects are anticipated relating to ground

conditions after mitigation measures are implemented. The cumulative impact of site-specific remediation will improve general ground conditions at the local scale, leading to a negligible to minor beneficial effect in both the demolition and construction phase and during the operation of the Proposed Development. However, the location and scale of the identified potential cumulative schemes is such that significant beneficial effects are not likely to occur.

## SUMMARY AND CONCLUSIONS

18.223 This chapter presents an assessment of the information on ground conditions (available up to July 2021) in relation to the soils, hydrogeology and ground condition impacts with respect to the Proposed Development at the Project Site. The Proposed Development is assessed against the baseline of the Project Site by developing a Conceptual Site Model that describes the environmental features and expected interaction of potential contamination sources.

18.224 To facilitate the assessment, the Essex Project Site and Kent Project Site have been considered separately. To understand potential contaminating land uses (both current and historical), the Kent Project Site is divided into a number of zones (Zones 1 to 9). The baseline geological, hydrological, hydrogeological and the geoenvironmental conditions (including issues associated with soil gases, chemicals within soils and groundwater) are described, and an assessment undertaken utilising a Source – Pathway – Receptor analysis. Conceptual Site Models have been developed for three distinct areas: the Essex Project Site, the Swanscombe Peninsula (Zones 1-5) (Kent Project Site) and the A2 Highway Works area (Zones 6-9) (Kent Project Site).

18.225 A number of potential significant adverse effects have been identified during demolition and construction without mitigation. A limited number of further potential adverse effects exist during operation. The majority of these significant adverse effects exist on the Kent Project Site, reflective of the scale of works proposed in the area, the particular challenges of the current / former land use, and the sensitivity of the identified receptors.

18.226 All of the potential likely significant adverse effects can be mitigated. A range of general mitigation measures have been identified that apply to the whole of the Proposed Development, namely the need for ground investigations to define a Remediation Strategy and contractor's health and safety method statements, all secured via DCO requirements, to ensure appropriate design and construction of the Proposed Development.

18.227 Additional specific mitigation measures are required on the Kent Project Site, in particular in areas designated as a part of the Swanscombe Peninsula SSSI and also where Environmental Permits apply. In those areas, Natural England and / or, the Environment Agency, respectively, must be notified and approve proposals for ground investigation and

any construction that could affect landfill infrastructure, its management or reporting regime. Appropriate characterisation of soils (including deposited wastes such as CKD) will be required to ensure its beneficial re-use, treatment or disposal. This further characterisation will be obtained from the planned programme of ground investigations which will be secured through a requirement in the DCO.

- 18.228 With the additional specific mitigation measures applied, the vast majority of potential effects have been assessed as negligible. The residual effect to the River Thames during operation on the Swanscombe Peninsula (Kent Project Site) will be minor beneficial. This is because the upgraded leachate treatment plants and improved surface water drainage system will resolve known issues where existing drainage ditches containing leachate overtop during high rainfall events, with consequent untreated discharge directly to the River Thames.
- 18.229 Ground conditions at the Project Site may be vulnerable to extreme weather events or climate change during the demolition / construction phase. For example, significant rainfall could overwhelm normal site surface water controls and lead to mobilisation of contamination within site soils. This can be mitigated by the provision of detailed incident management plans, to be defined within the CEMP and site management documents once a contractor has been appointed for the works. The ground investigations will include monitoring (for example, of hazardous ground gas emissions, groundwater level and chemistry) over sufficient duration to enable design that is resilient to climate change once the Proposed Development is in operation.
- 18.230 The list of developments considered in the assessment of cumulative, in-combination and transboundary effects is presented in Chapter 22 of this ES. Consideration was given to the location, nature and scale of the identified developments in determining whether any of these could result in potential cumulative, in-combination or transboundary effects relevant to ground conditions. It was determined that no significant effects related to ground conditions are likely to occur. This is on the basis that any development will be subject to standard planning conditions / DCO requirements (requiring ground investigation and geoenvironmental risk assessment, preparation of a Remediation Strategy and CEMP, and a Verification Report to demonstrate their successful implementation) that will ensure that none of the developments result in significant adverse effects. Given the nature of the other schemes and their location / distance from the Proposed Development there are no plausible effects related to ground contamination that could combine with the effects assessed for the scheme to become significant. Similarly, the schemes are such that significant beneficial effects are not likely to occur.