BURO HAPPOLD

The London Resort

Ground investigation scoping - Swanscombe Peninsula

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[redacted]

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1 Introduction

1.1 Purpose

The purpose of this report is to set out the plans for the proposed ground investigation associated with the development of the London Resort. This report deals with the investigations proposed on the area of the Swanscombe Peninsula. Investigations associated with the associated development at Tilbury and along the A2 and Highway Access part of the site are addressed separately. Marine investigations (in the River Thames) for the jetty structures at both Tilbury and Swanscombe are also subject to separate consideration.
Note: Reports to be prepared:

- Tilbury – Land based investigation [Buro Happold]
- Tilbury and Swanscombe Marine investigation [Buro Happold]
- A2 Access Road [WSP]

Previously (2016/17) an exploratory level ground investigation was undertaken on parts of the site when the details of the London Resort were not fully defined [1], [2]. There is also borehole data available from investigations carried out for HS1. Consequently, there are areas where little / no recent investigation has been undertaken, for example within areas of permitted landfills and areas outside of the Resort footprint, but where specific information on the ground conditions is required (e.g. in the areas of the proposed salt marsh enhancement etc.). The 2016/17 information with respect to groundwater, is currently being supplemented by a programme of site-wide groundwater monitoring / sampling from existing wells (being carried out over 2020 / 21).

This programme of ground investigation is therefore targeted to both the built elements of the Resort and also to other particular areas of the site (e.g. areas of particular constraint or sensitivity – such as landfills, chalk spines and areas of particular ecological and archaeological interest). Accordingly, the following text has been prepared in consultation with other relevant specialists [Archaeology - Wessex Archaeology, Ecology – EDP, Tunnelling – OTBe]. The investigations therefore have combined geotechnical, geoenvironmental, ecological and archaeological objectives and 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.

The ground investigation will include measures appropriate to mitigate the potential health, safety and hygiene risks associated with ground contamination, including unexploded ordnance (UXO).

1.2 Structure of report

The report first describes the site location and zoning (Chapter 2) and a summary of the current understanding of the ground model, in terms of its geology, hydrogeology and hydrology (Chapter 3). That understanding is based upon published information (British Geological Survey maps and borehole records for example) with very limited site specific ground investigation data from 2016/17. A summary of the current understanding of the proposed development is set out in Chapter 4. The various issues and constraints influencing the ground investigation are set out in Chapter 5 with the detail of the objectives and scope of the investigation works set out aspect by aspect in Chapter 6. A brief comment on phasing is presented in Chapter 7. The initial schedule (Phase A) of exploratory holes in a tabular format is provided as Appendix A with the proposed exploratory hole locations illustrated on a series of Drawings in Appendix B. These Drawings, including all the various information layers (e.g. proposed development layout) are available via the SharePoint link [Appendix B]

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2 Location and site description

The site is located on the Swanscombe Peninsula, Kent, on the south bank of the River Thames, and is approximately centred on National Grid Reference TQ 60657 76055. To facilitate assessment, the site is divided into five zones based on location, land use patterns and current ownership (see Table 1 and Figure 2-1 below)

Figure 2-1. Site zoning

Table 1. Summary description

Zone	Area	Description
Zone 1	48ha	Broadness Marsh. Forms the northernmost part of the Swanscombe Peninsula. River Thames adjacent to the north, north-west and north-east. Of undulating topography due to the historical infilling of Cement Kiln Dust (CKD). Generally covered with scrub vegetation.
Zone 2	54ha	North-western section of Swanscombe Peninsula. Highly varying topography due to presence of licensed CKD landfills. Vegetated with shrubs and trees.
Zone 3	35ha	Western part of the Peninsula east of Ingress Park residential development. Northern part (Zone 3A) is Blackduck Marsh. Zone 3B to the south comprises a more developed area with light commercial / industrial uses.
Zone 4	41ha	Eastern part of the Peninsula. Zones 4A and 4D currently marshland. Zone 4B is dissected by HS1 and is occupied by a series of industrial/commercial units, (Northfleet Industrial Estate, Kent Kraft Industrial Estate and eastern part of Manor Way Business Park).
Zone 5	18ha	Located in middle of the Peninsula immediately north of North Kent Line railway and west of HS1. Northern half (Zone 5A) includes the western part of Manor Way Business Park. Southern part (Zone 5B) is an open area part in-filled former chalk quarry (Craylands Lane Pit).

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3 Summary of initial ground model

3.1 Geology

Published mapping (BGS Sheet 271) and existing ground investigation data (mainly associated with HS1 but also 2016/17 data referred to above [1] [2]) indicates the Peninsula to be underlain by the following downward sequence and as illustrated in the cross section Figure 3-1. Additional detail on the superficial / alluvial deposits is provided by a geophysical survey carried out for geoarchaeological purposes [3].

Table 2. Summary of geological sequence

Stratum	Description	Observed Stratigraphy	
		Elevation of Top of Stratum (m OD)	Stratum Thickness (m)
Made Ground	Landfill comprising variable cement kiln dust, clayey gravel, and cobble-sized brick and concrete fragments	+12.5 to +0.0	7.5 to 17.5
Alluvium	Variable soft to firm clay and soft amorphous peat	+6.0 to -5.0	5.0 to 15.0
River Terrace Deposits	Medium dense sandy gravel	-10.0 to -15.0	1.0 to 7.5
Upper Chalk	Chalk with flints	-16.0 to -20	Not proven

The nature and thickness of the Made Ground varies across the Peninsula. In the north (Zone 1, Zone 2 and Zone 3B) it comprises cement kiln dust (CKD). In the south there are areas where chalk, clay, sand and gravels 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). There are some areas with a limited history of development where no / limited Made Ground is expected (Zone 3A, Zone 4A, Zone 4B). Alluvium (clay, silt, sand and peat) covers a large portion of the Peninsula north of Manor Way. Two prominent layers of peat occur 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 lenses of silt, clay or peat. The superficial deposits are underlain by Chalk bedrock, part of the White Chalk Subgroup (Seaford and Lewes Formations).

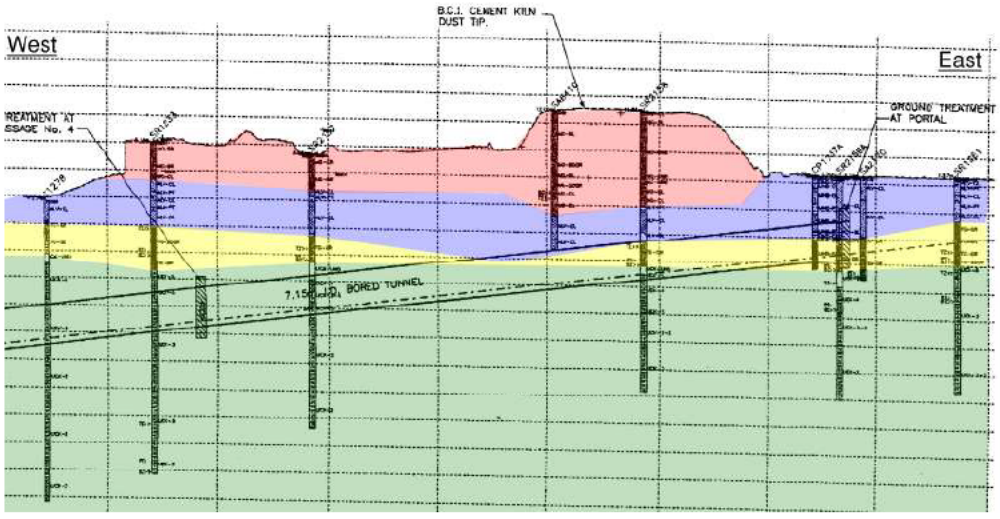

Figure 3-1. Cross section in vicinity of HS1 portal

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3.2 Geotechnics

Geotechnical parameters relevant to the evaluation of displacement and changes of stress are summarised below.

Table 2-1 Geotechnical Parameters

Stratum	Bulk Unit Weight, Y (kN/m^3)	Poisson's Ratio, μ		Undrained Shear Strength, c_u (kPa)	Young's Modulus, E (kPa)		Coefficient of Lateral Earth Pressure at Rest, k_o
		Short Term	Long Term		Short Term	Long Term	
Made Ground	18	0.2	0.2	--	15,000	15,000	0.6
Alluvium	16	0.5	0.2		500cu	300cu	0.6
River Terrace Deposits	20	0.2	0.2	--	35,000 (1)	35,000 (1)	0.4
Upper Chalk	20	0.2	0.2	--	300,000 (2)	300,000 (2)	1.0

Notes:

1. Young's Modulus for River Terrace is equal to 1,500 times SPT N value
2. CIRIA C574 suggests the secant modulus (E_S) for low density Grade B and C chalk to vary between 200 and 700MPa at 200kPa vertical stress . The corresponding E_S value for medium to high density Grade B / C chalk is noted to vary between 300 and 1,500MPa. For the purpose of this assessment, an E_S value of 300MPa is assumed.

3.3 Hydrogeology

Perched groundwater is present above low permeability bands in both the Made Ground and the Alluvium. Environment Agency Aquifer maps show the 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 although the nearest abstraction is about 1km east and on the northern side of the River (Tilbury Power Station).

There are limited records of groundwater strikes on BGS borehole records and groundwater levels on the northern part of the site will be influenced by the River Thames and associated tidal flows. 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 groundwater body is likely to be in continuity with the Chalk. Recent monitoring of wells installed in 2016/17 confirms site groundwater levels vary between about 0mOD to +4m OD, with the direction of groundwater flow being generally towards the north (the River Thames).

3.4 Hydrology

The Peninsula is located in a meander of the River Thames and is currently drained by a series of manmade drainage ditches and culverts to the River Thames. 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. South Pit Leachate Treatment Plant treats leachate from landfills within Zone 2. This effluent is discharged to the Southern Water foul system.

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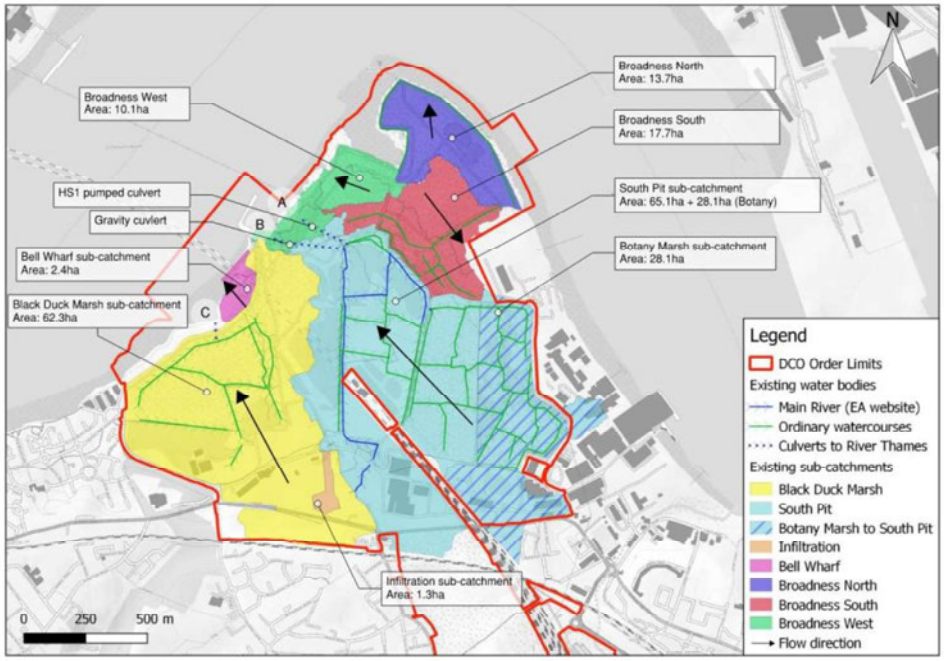

Figure 3-2 Existing catchments

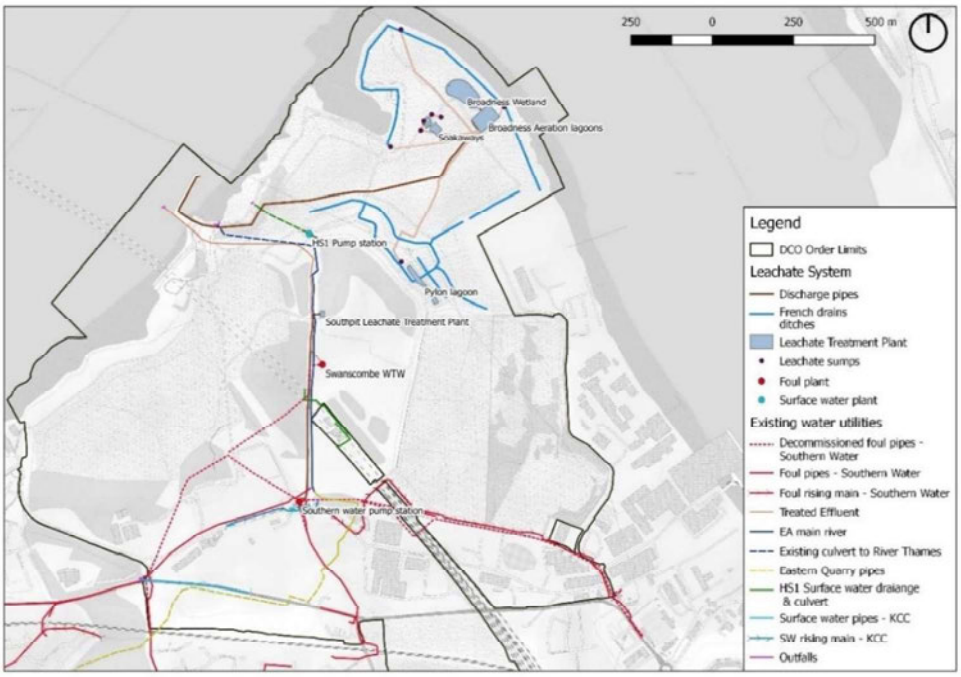

Figure 3-3 Existing water utilities systems

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3.5 Flood risk

The Swanscombe Peninsula has existing flood defences which range in crest level from 6.2m AOD along the north-western shore of the peninsula to 8.8m AOD along the northern shore. This flood defence level provides protection from flooding from tidal sources, which are considered to be the principal risk of flooding to the site, up to the present day 1 in 1000 year flood level. These flood defences comprise earth berms constructed largely around the perimeter of the peninsula, with cement kiln dust cores.

Figure 3-4. Existing flood defences

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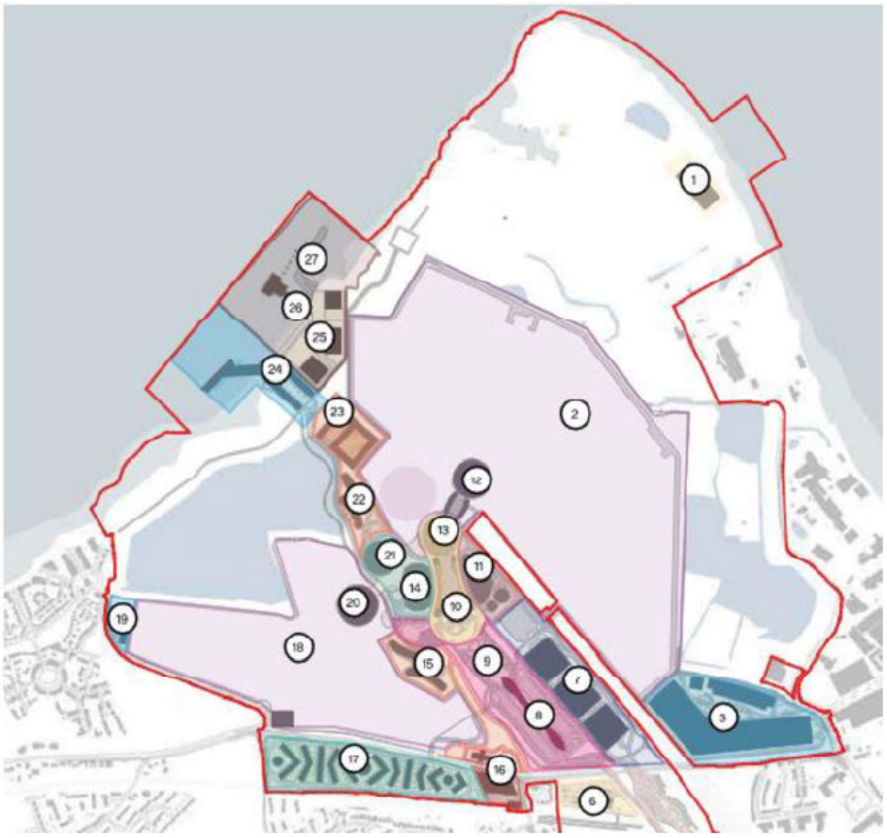
4 Summary of development

4.1 The resort

The Resort will be a nationally significant visitor attraction and leisure resort, built largely on brownfield land at Swanscombe Peninsula in Kent on the south bank of the River Thames and with supporting transport and visitor reception facilities on the northern side of the river in Essex. The focus of the Resort will be a 'Leisure Core' containing a range of events spaces, themed rides and attractions, entertainment venues, theatres and cinemas, developed in landscaped settings in two phases known as Gate One and Gate Two ('the Gates'). Outside the Gates will be a range of ancillary retail, dining and entertainment facilities in an area known as the Market.

The Resort will also include hotels, a water park connected to one of the hotels, a conference and convention centre known as a 'Conferention Centre', a Coliseum (capable of hosting e-Sports events), creative spaces, a transport interchange including car parking, 'back of house' service buildings, an energy centre, a wastewater treatment works and utilities required to operate the Resort. Related housing is also proposed to accommodate some of the Resort's employees.



1 Water Treatment Facility
2 Gate 1
3 Gate 1 Back of House
4 Ebbsfleet International Terminal (T2)
5 Bamber Pit Back of House
6 The Sports Ground Back of House
7 The London Resort Car Parks (CP1, CP2, CP3)
8 The London Resort Passenger Terminal (T1)
9 The London Resort Plaza
10 The London Resort Hotel (H1) & Boulevard
11 The Waterpark
12 Node 3 : Gate 1 Payline
13 Node 2 : The Market
14 The Conferention Centre
15 Hotel 3 (H3)
16 Visitor Centre and the London Resort Academy
17 Staff Accommodation
18 Gate 2
19 Gate 2 Back of House
20 Node 4 : Gate 2 Payline
21 The Coliseum
22 Hotel 4 (H4)
23 Hotel 2 (H2)
24 The London Resort Ferry Terminal (T3)
25 The London Resort Port
26 RoRo Facility
27 White's Jetty
28 The London Resort Tilbury Car Park (CP4)
29 The London Resort Tilbury Terminal (T4)

Figure 4-1. The proposed development

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4.2 Bridges and structures

The major civil structures are at the passenger terminal – an elevated people mover and cycle structure. The link bridges to the car park are also located here (see below). (the other major civil engineering structures are the tunnels through the Chalk spines (see section 5.12).

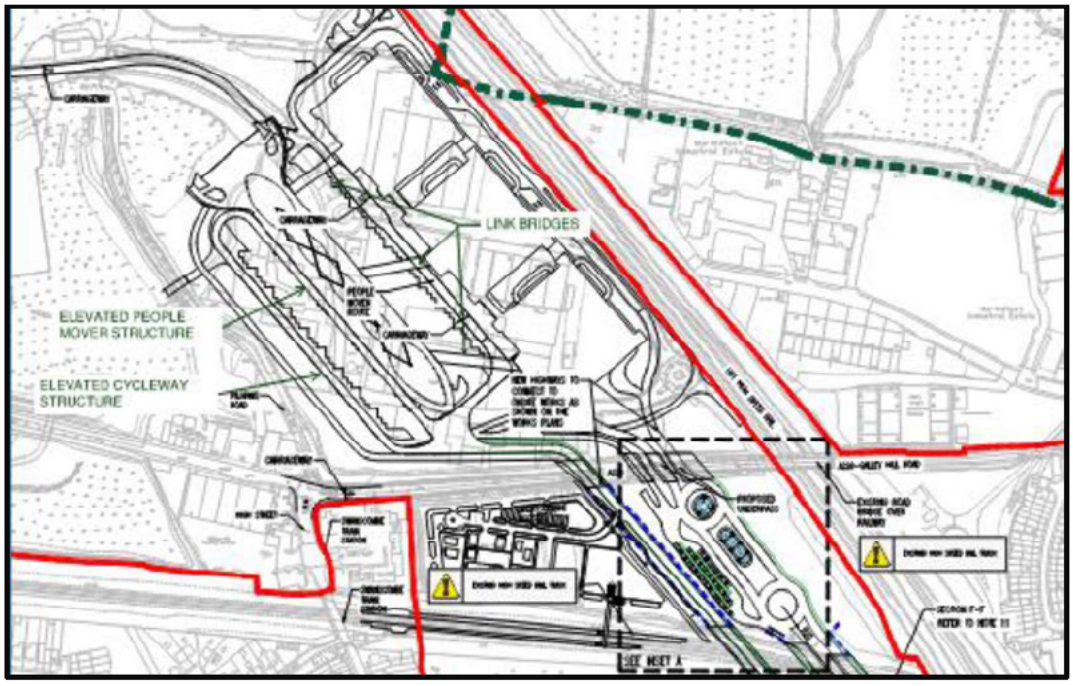

Figure 4-2 Bridges and civil structures

4.3 Flood defences

The following flood defence measures are currently anticipated;

- Black Duck Marsh - increase the formal flood defence crest level to 7.00mOD along the existing alignment.
- White's Jetty - replace the existing flood walls and flood gates with a flood embankment along a new alignment to the landward side of the White's Jetty with crest level will set to a minimum of 7.00m AOD
- Botany Marsh - a new secondary flood defence embankment along the north east perimeter (the west of Botany Marsh). This secondary flood defence crest level of the embankment will be set to 3.00m AOD.

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5 Issues and constraints

5.1 General

This section of the report aims to set out the several important issues and constraints that will influence the objectives and scope of the ground investigations.

5.2 HS1

The site is traversed south-east to north-west by a number of HS1 tunnel assets. These include a retained cutting, a cut-and-cover tunnel, and twin bored tunnels.

Figure 5-1 HS1 tunnel assets

Ground rules for development near CTRL infrastructure are provided in the Network Rail (High Speed) Asset Protection Development Handbook dated 2020. Minimum requirements are summarised as follows:

i. Existing tunnel infrastructure has been designed to accommodate a 50kPa increase of vertical stress at tunnel axis level. Any increase of vertical stress beyond this value will require an assessment of the tunnel lining capacity. Additional tunnel lining assessments will also be required where the tunnels are subject to a reduction of vertical stress at tunnel axis level.

ii. Where temporary dewatering works are required in connection with the proposed development, the impact of these activities on existing tunnel infrastructure will need to be considered.

iii. As part of the original CTRL development, HS1 was granted ownership of all subsoil located within three metres of the existing tunnels. Importantly, this ownership forms a rectangular section and includes the subsoil located between the twin bored tunnels.

iv. A license is required prior to undertaking any works within the HS1 subsoil ownership boundary. These licenses are unlikely to be granted for any piles located within three metres of existing tunnels.

v. All designs which have the potential to affect existing tunnel infrastructure will be subject to independent (Category 3) checking.

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vi. HS1 consultation is required in connection with any development within the HS1 'safeguarding' zone (See Section 4.3 of the Developers Handbook [4] and the sketch below (Figure 5-2).

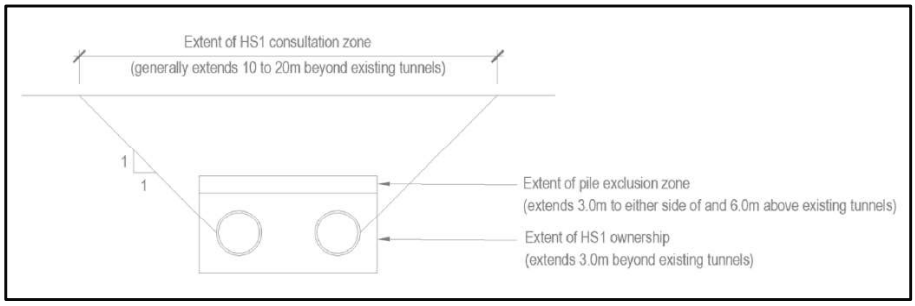

Figure 5-2 HS1 Safeguarding zone

5.3 Earthworks

Current preliminary estimates suggest that for the Resort (including both Gates but excluding any "marsh restoration" works) the total cut (volume of spoil arising from excavations) is approximately 860,000m^3 and the total requirement for fill is 490,000m^3. These initial and approximate volumes have been derived from modelling the existing and planned topographies of the site (Figure 5-3) where green coloured areas are areas of fill and red coloured areas, areas of cut. The overall aim of the development is to minimise the volumes of excavation (particularly relating to contaminated and permitted land) whilst also being consistent with various other aspects (such as flood risk, accessibility, landscape aesthetics etc). It is anticipated that a proportion of the spoil arisings will be directly suitable for re-use, a proportion will be suitable following treatment (on-site) and a proportion will not be suitable for re-use and would be disposed off-site to landfill. Currently a cautious assumption has been adopted that 40% of spoil arisings would be re-used on site (either directly or following treatment).

Figure 5-3. Preliminary earthworks plan

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5.4 Cement Kiln Dust

Available published information provides empirical based data for the use / reuse of CKD material and provides general characteristics of CKD which demonstrate potential benefits (technical, economic and environmental) of its use. The extent and properties (both physical and chemical) of the CKD in the several areas on the Swanscombe Peninsula is currently not well defined. The predominant use of the CKD material on site would be for the use as an earthworks fill material. There are also potential benefits in using any CKD spoil arisings as part of a soil stabilisation treatment. This potential for the reuse of CKD material for earthworks purposes, is subject to consideration and assessment of particular aspects, namely:

1. Consideration of mixing CKD with other materials / soil which may affect the leaching process based on the chemical properties of the materials (both CKD and soil / mixing agent).
2. Variance in concentrations of contaminants / chemicals within the individual CKD material
3. Potential for CKD to be used in the stabilisation of soft clayey soil (reducing its plasticity and increasing the optimum moisture content (OMC) and maximum dry density (MDD).
4. Treatment of the CKD material may be required prior to being used with other materials for earthworks

Trials into treatment and re-use may need to be carried out which will necessitate particular investigation and testing. Assessment will also be carried out into the need for and scope of any particular remedial measures necessary to prevent contamination of the natural environment from the CKD (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).

5.5 Ecological habitats

5.5.1 General description

There are a number of ecologically sensitive habitats on the Swanscombe Peninsula, parts of which recently notified by Natural England (March 2021) for designation as a Site of Special Scientific Interest (SSSI).

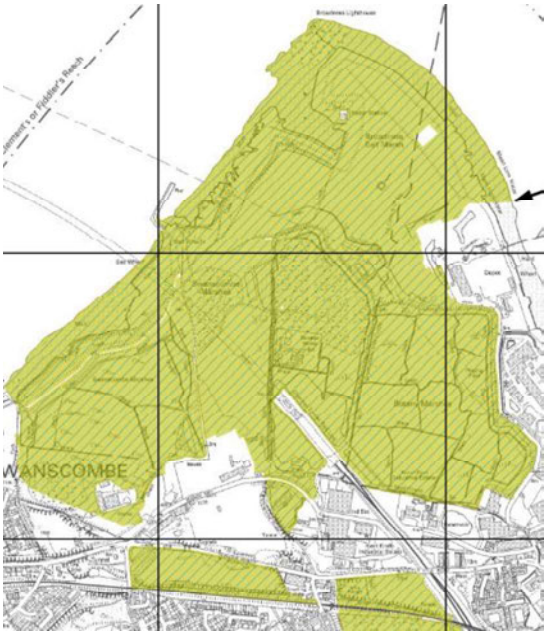

Figure 5-4. SSSI Summary map extract

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The planned development includes the creation and restoration of a series of habitats (including salt marsh, wetlands, scrub and grasslands on both Black Duck and Broadness Marshes. In the areas of ecological sensitivity (e.g. the marshes, grasslands, inter tidal habitats etc.) the design of the works will aim to reduce infiltration in areas underlain by hazardous soils materials (e.g. CKD) whilst also retaining the soils responsible for supporting the sensitive flora and flora. Such measures will include the creation of a topography and surface water drainage system, the incorporation of impermeable linings to standing water bodies (where appropriate), the incorporation of a suitable thickness of sub soil and topsoil particular to the relevant species.

The quality and amount of intertidal habitats will be increased by including salt marshes along the lower shoreline of the Thames. The existing salt marsh will be extended through the creation of a naturalised sloping bank and a series of creeks cut back approximately 20m into the adjacent bank (reducing levels in the adjacent area by approximately 1.5m). Scrape profiles will increase areas of salt marsh, small pools, rocks and shingle areas and reeds, sedges and grasses transitioning into open scrub mosaic vegetation. This planned creation of new intertidal habitat and extended salt marsh will require minimal long term management with capacity to respond to dynamic estuarine change. The extended salt marsh level is set to facilitate natural colonisation, with silts washed into the new creeks providing the growing medium. On the upper slopes, the salt marsh will transition to open scrub mosaic vegetation approximately 4m in height with pockets of woodland. The salt marsh level is set at approximately the Mean High Water Spring, level with the adjacent existing salt marsh. Earthworks in the vicinity of the River Thames (e.g. the creation of the extended areas of salt marsh) envisage a maximum 3m depth of excavation and will need to incorporate safeguards to prevent the pollution of the River by silts (particularly where comprised of CKD).

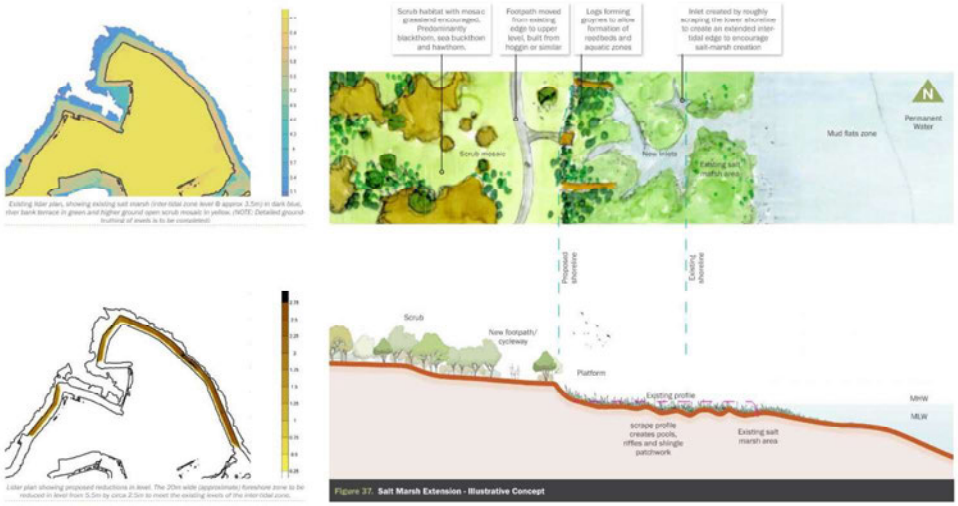

Figure 5-5. Illustration of salt marsh enhancement

5.5.2 Summary of current plans

5.5.2.1 Marshes

The design of the marshes (particularly Broadness Marsh) is subject to change depending upon discussions with Natural England and other relevant stakeholders.

Black Duck Marsh – raising of flood embankment and landscaping on it. Root protection to trees in proximity to prevent erosion of structure. Scrapes and minor excavations within the marsh to create more diverse ecological habitat. Boardwalk constructed. Potential re-profiling of levels on west side of marsh to form footpath connections in Ingress Park. Bridge connection to Ingress Park.

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Broadness Marsh – salt marsh embayments, Broadness Channel cutting (TBC), scrapes and minor excavations for ecological enhancement, leachate pond and ditch network, formation of new footpaths and roads, constructed wetland and ditch network.
Botany Marsh – Ditch clearance and digging of extended ditch network. Drainage works to form wet landscape to west side. Boardwalks constructed.
Gate 1 perimeter - Swales and planting alongside service road. Tie-in resort levels to marsh, perimeter swale within marsh landscape.
Gate 2 Perimeter – proposed to use fill material to extend into the marsh by approx.. 10m to form a woodland strip buffering the marsh from resort. Swales and planting alongside service road.

5.5.2.2 Landscaping

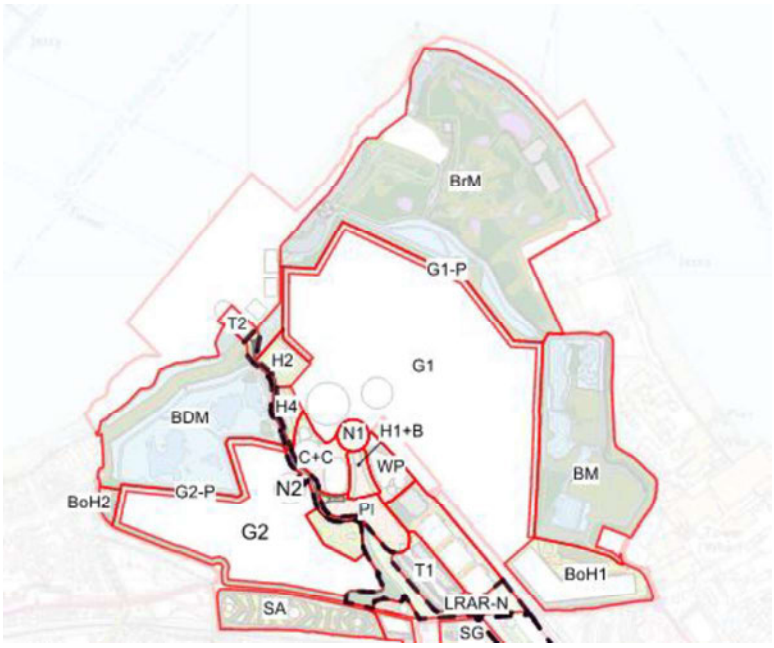

Figure 5-6 Key to landscape proposals

Terminal 1 (T1) - Engineered tree pits and raised planters (multi-level)

Terminal 2 (T2) – piling within salt marsh areas. Tree planting and feature landscape inside terminal.

Plaza and Spanish Steps (PI) – podium landscape (coordination with structural deck) engineered planting areas and tree pits, water features.

Coliseum and Conferention centre (C+C) and Nodes – as per Plaza comments

Hotels (H1, H2, H3, H4) – high-end landscapes including water-features, feature planting, terraces and gardens.

London Resort Access Road (North) (LRAR – N) Streetscapes to include formal tree planting in verges and naturalistic planting alongside marshes. Likely to include suds features around cliffs. Integration of new Swanscombe channel linking bottom of Pilgrims Way with BDM. Engineered trees pits and raised planters in public realm areas.

Back of House 1 (BOH 1) –tree planting, pond and SUDS.

Back of House 2 (BOH2) – tree planting in soft landscape areas

Staff Accommodation (SA) – tree planting, gardens, SUDS. Sports Ground Pit (SG) - Tree planting and feature landscape at plaza to station.

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5.6 Archaeology

5.6.1 Geoarchaeological Background

This section is an edited version of detailed text presented in a Wessex Archaeology report [5] to which appropriate cross reference is recommended. The superficial geology comprises a sequence of Holocene and Pleistocene deposits. An area of Pleistocene Head deposits is mapped in the southwest corner of the site, surrounding an infilled chalk pit. Head deposits in the area have produced Middle Palaeolithic (240-160 kya) archaeology.

Geoarchaeological investigations were undertaken within the southern and central area of the peninsula in advance of construction of the Channel Tunnel Rail Link (CTRL) and identified a sequence of late Pleistocene Gravels, overlain by Holocene deposits (alluvium, peat and organic-rich muds) accumulated over the last 11,500 years. Work along the line of the CTRL identified two peat horizons interbedded in alluvium, with radiocarbon dates producing a late Mesolithic date on the basal peat (6610-5520 BC) and a Neolithic to early Bronze Age date for the upper peat (3970-1500 BC).

A geophysical (ERT) survey was carried out on 2017 to characterise the landscape in terms of archaeologically relevant topographic features. It identified significant variation in the upper surface of the river terrace sands and gravels (the location of former channels) with the surface of the gravels higher in the centre of the peninsula (c. -5mOD) compared to c. -10mOD elsewhere. Made Ground is present across the peninsula including two large (4 to 6m) mounds of cement kiln dust (CKD). The deposits of alluvium and peat vary significantly in thickness across the peninsula and are generally thinnest (<4m) towards the north-eastern and central-southern parts of the peninsula, with >6m recorded at the northernmost point.

5.6.2 Geoarchaeological Potential of Deposits

Peat

There are multiple peat beds within the alluvium with the potential to date variously to the Mesolithic to Bronze/Iron Age. These peat deposits can vary in thickness from a few centimetres to over a metre or more, forming laterally and horizontally variable but extensive deposits. The peats vary in composition, from structureless peats lacking visible plant remains to herbaceous and wood peats (from wet carr-woodlands through to drier woodlands). The peats are geoarchaeologically significant, representing phases of reduced and/or stable sea-levels during which semi-terrestrial plant communities replaced mud flats and saltmarsh, providing a range of environmental niches for human and animal exploitation. Peat deposits contain a range of palaeoenvironmental remains and material suitable for scientific dating, providing evidence on past vegetation, environmental change and human land-use within the wetland and associated dry ground. Where thicker peat layers are encountered, they have increased potential to contain archaeology, including waterlogged wooden structures and artefacts. Timber trackways have been unearthed in peat at a number of locations with the Thames floodplain of East London (e.g. Erith and Rainham Marshes).

Alluvium

Alluvial clays, silts and sands form the primary component of the Holocene alluvial sequences along the floodplain of the Thames Estuary. These deposits represent sediment accumulating in mud flats and salt marsh environments within the succeeding extensive intertidal floodplains. The geoarchaeological potential of the alluvium is low, although it still has the potential to contain or partially mask archaeology. Although alluvium contains paleoenvironmental remains such as pollen and plant macrofossils, these are often poorly preserved and of uncertain source area. Alluvium also lacks suitable material of secure context for radiocarbon dating. However, targeted investigation of microfaunal remains (e.g. diatoms, foraminifera and ostracods) can be useful for understanding the balance between marine and freshwater environments.

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Organic Rich Muds

Organic rich muds have been recorded amongst alluvial deposits in the Thames Estuary and tributaries. These deposits, like peat, are highly variable in extent, forming at stages in low energy environments. Where associated with peat, organic muds may represent part of a succession from freshwater swamps through to peat-forming tall herb swamp and carr-woodland communities. Lenses or bands of organic muds within peat could also reflect the development of freshwater pools within floodplain woodland habitats, sporadic or short-term flooding and fluctuating water-levels. The geoarchaeological potential of organic rich deposits is high and comparable to peat, containing a range of palaeoenvironmental remains and material suitable for radiocarbon dating.

5.7 Residual contamination

The potential sources of residual contamination across the Swanscombe Peninsula are summarised below.

Zone	Contamination profile
Zone 1	Landfill comprising the majority of the marsh that was previously used for the deposition of CKD and river dredgings. Leachate collection and treatment from the areas of CKD landfilling.
Zone 2	North Pit landfill, South Pit and Surge Pile (Phases 1 and 3), all infilled with CKD. Leachate from the CKD landfills collected and discharged to foul sewer. Other sources include; derelict sewage works, 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. Former gasworks.
Zone 3A	Swanscombe Marshes. Hazardous ground gas from underlying alluvium and marshland.
Zone 3B	Current and historical uses: cement works, welding works, Glass Recovery facility, whiting works (with tanks and silos), electricity substation and conveyors. Swanscombe Cement Landfill (infilled with CKD and other wastes?). Hazardous ground gas from underlying alluvium and marshland.
Zone 4A	Hazardous ground gas from underlying alluvium and marshland.
Zone 4B	Historic: Thames Tar Distillery, paper mills, chemical works, tramways, electricity substations and pipeline. Current: Northfleet Industrial Estate. Partial infilling of lagoon.
Zone 4C	Firing range. Historical infilling
Zone 4D	Warehouse / Depot. Hazardous ground gas from underlying alluvium and marshland. Gas migration from adjacent Botany Rd Landfill.
Zone 5A	Cement works, whiting works, tramway tracks, conveyors and railway sidings. Tank and electricity substation. Infilled land (Pilgrims Pit), licensed waste treatment / management sites.
Zone 5B	Industrial sites (tanks and a conveyor). Infilled former chalk quarry.

5.8 Permitted areas

There are several areas of this part of the site that are subject to Environmental Permits (former Waste Management Licences). Most of these areas have been subject to landfilling, but there are also permitted areas where no disposal has taken place. The Permits have particular implications for both ground investigation and Resort development:

- The development must not compromise the permit holder's ability to manage and monitor the 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

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- 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.

The landfill areas (both licensed and non licensed) are illustrated below.

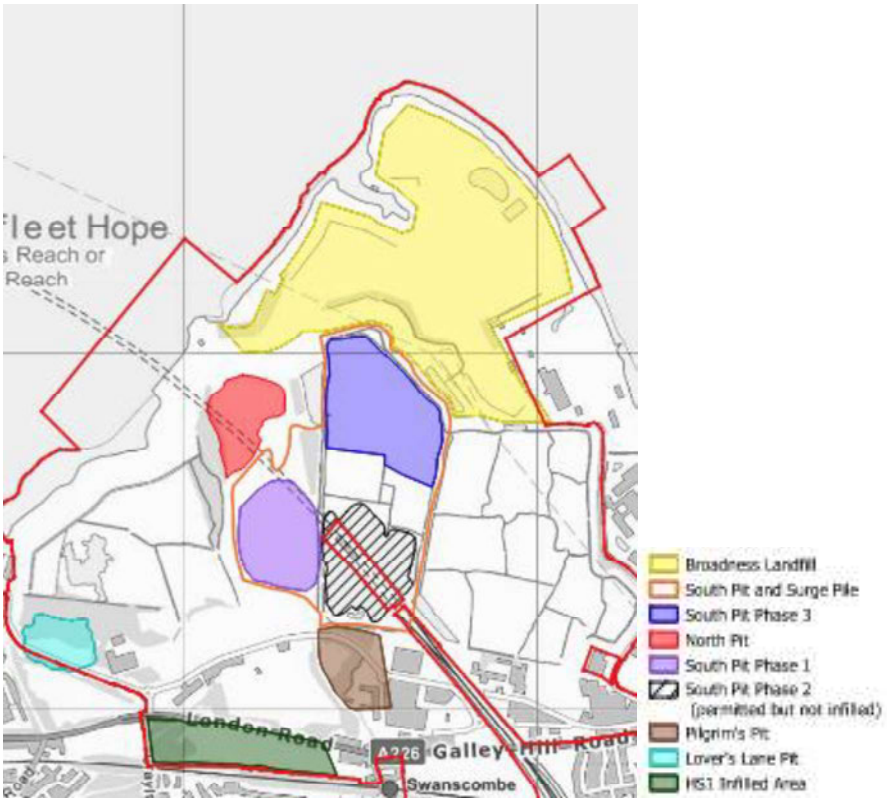

Figure 5-7. Landfill / licensed areas

5.9 Leachate management system

The existing leachate collection and management system on the Swanscombe Peninsula is complex but relatively well understood (Figure 5-8). This existing system is not functioning well and substantial elements of it will be disrupted / removed by the Resort. Currently it is anticipated that the leachate treatment plant that serves the Broadness Marsh area 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 and pumped to the upgraded plant.

The leachate treatment plant currently located within the South Pit area will be relocated. The most appropriate location for the plant and the required treatment levels are subject to further consideration, including the option of pumping the leachate from the South Pit area to the upgraded Broadness Marsh leachate treatment plant.

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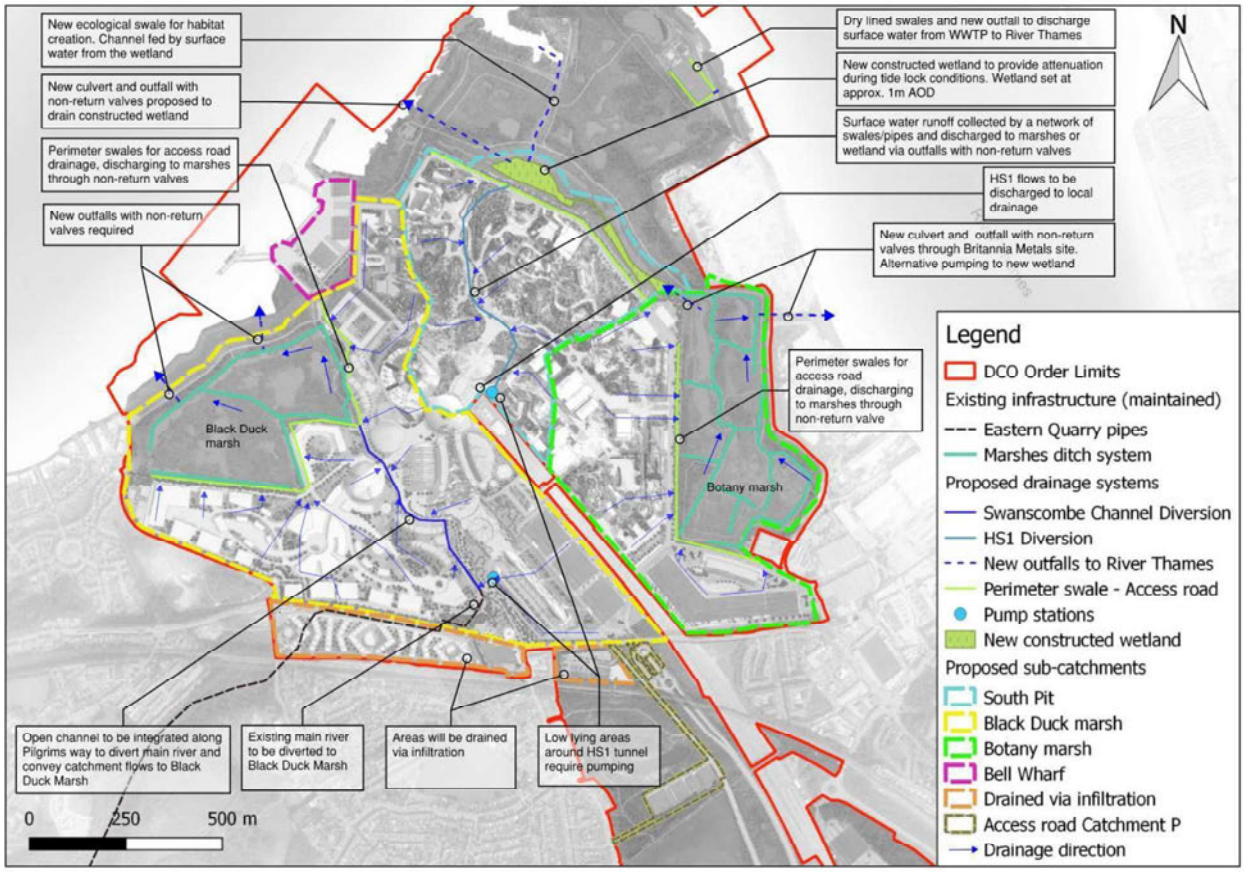

Figure 5-8. Existing leachate / drainage infrastructure

5.10 Hazardous ground gas

There are potential sources of hazardous ground gas associated with some of the natural soils on the site, the Made Ground and also some of the landfilled materials/ infilled lagoons etc. Currently there is very limited data on the ground gas regime across the site and that which is available is not reliable. There is therefore a potential for hazardous ground gas to migrate and accumulate in confined spaces in buildings to hazardous concentrations. That potential will be mitigated by the incorporation of gas protection systems commensurate with the site specific ground gas regime determined by the programme of ground investigations, subsequent earthworks and the nature of the building. Any such gas protection system will be designed, constructed and verified in accordance with the relevant British Standard and good practice guidance respectively.

5.11 Unexploded Ordnance (UXO)

The overall risk associated with encountering UXO on the Swanscombe Peninsula is assessed as 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 (Ref Report). These risks can be mitigated by one or a number from a range of measures as appropriate (discussed in Chapter 6) that will reflect both the location and the nature and extent of the below ground works (including ground investigation).

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5.12 Chalk spines / topography

The most significant topographic features that affect the site (and that will impact upon both the ground investigation and the subsequent development) are the chalk spines which cross the southern part of the site approximately east-west and carrying major road [A226 London Road] and rail [North Kent Line] links. The spines range from a minimum of about 6m above surrounding ground (near Manor Way Business Park) to some 20m above surrounding ground in the eastern part (Zone5).

Access to the resort will require reinstatement/ refurbishment of the historic tunnel adit and for additional tunnels to be constructed through these chalk spines (one such location into the Bamber Pit landfill). Investigations are likely to have particular constraints and may require particular permissions from the road and rail authorities. If possible, investigations should be planned to avoid the need for approval, e.g. by locating trial holes outside the railway boundary.

The topography across the majority of the Peninsula is relatively gentle although there are some areas of steeper gradient, typically associated with the tip areas and the river boundary.

5.13 Land ownership, existing infrastructure and buildings

Currently access to all areas of the site is not unfettered and permissions to enter and to carry out ground investigation will be required. In addition to the existing rail and road links referred to above (and HS1) there are several areas of the site that have been subject to previous, recent and/ or current commercial / industrial activity which will have resulted in the presence of buildings, hardstanding and below ground infrastructure and obstructions.

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6 Ground investigation – objectives and scope

6.1 General

6.1.1 Health, safety and the environment

Consideration of issues relating to Health, Safety and the Environment will be given prime consideration during the London Resort project, including during the ground investigation. The key pieces of legislation that are recognised as relevant to Health and Safety on development projects, including the ground investigation phase are The Health and Safety at Work Act and The Construction (Design & Management) Regulations 2015. Because of the scale of the ground investigation, the works are notifiable.

The Client has appointed Buro Happold Limited to act as Principal Designer for the initial phases of the project. The intent will be to appoint a Principal Designer during the course of 2021, as the detailed design of the project is developed. The London Resort project is deemed to be a part of the workplace and as such the finished design and future Client obligations will comply with the Workplace (Health, Safety and Welfare) Regulations 1992.

Every person involved in the ground investigation will undergo specific project induction training. Induction training will provide an introduction to the project and site context, a description of the project risks and (for site operatives and supervision staff) a review of the individual's competency.

Site Establishment, including welfare facilities will be provided for all personnel working within the ground investigation. The cleanliness of the facilities will be maintained to a high standard to ensure good hygiene. The site welfare will meet the required standards under Schedule 2 of the CDM Regulations 2015.

There are potential risks to all personnel involved in the ground investigation associated with the potential ground contamination sources from former uses of the Project Sites (Made Ground / Fill from past and recent industrial and commercial activities), landfill and industrial process wastes and hazardous ground gas. The site would be classed as a Red site under the BDA site designation. There is also a potential for unexploded ordnance (see below).

One of the key concerns during the construction phases of the development (including the ground investigation) will be the potential to pollute the environment. Activities that poses a risk of introducing pollutants into the environment and/ or disturbing pollutants already sitting within the ground shall be identified and subject to an approved risk assessment. Any potential environmental impacts are to be controlled sufficiently and dynamically monitored in order to eliminate significant impacts on the environment and the local community.

6.1.2 Unexploded ordnance

The results of the current UXO risk assessments have indicated that there are potential risks related to UXO on the Site. These risks can be mitigated by one or a number from a range of measures as appropriate, that will reflect both the location and the nature and extent of the below ground works. This range of measures includes:

- The preparation of a ground investigation operational UXO risk management plan
- UXO safety and awareness briefing for all personnel involved in below ground works;
- The availability/ presence of an "on call" explosive ordnance disposal (EOD) engineer Information requirements
- Magnetometer survey ahead of intrusive boreholes [to be confirmed].

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6.2 Data management

6.2.1 Objectives

1. To ensure compilation and retention of factual ground investigation data in a project database that enables rapid accurate retrieval and use by all relevant users

6.2.2 Scope

a. Definition of a data management plan
b. All exploratory holes to have unique identifiers that assist users
c. All data to be provided in AGS 4.1 data format
d. Design, construction and maintenance of project database

6.3 Resort buildings

6.3.1 Objectives

1. To define the geological profile and geotechnical parameters of the strata sufficient to inform foundation design
2. To identify the physical and chemical characteristics of near surface soils and deeper geology
3. To define the groundwater regime (shallow and deep)
4. To define the ground gas regime
5. To inform tunnel impact assessment of HS1 (for buildings in vicinity)

6.3.2 Scope

a. Geophysical survey (To supplement existing data [3])
b. Cable percussion and cable percussion with rotary follow on holes [Appropriate spacing / location for each building, with the borehole extending at least 5m below the longest pile anticipated].
c. Static cone penetration tests (SCPTs)
d. In situ testing [Permeability, strength, density etc.].
e. Installation of groundwater and gas monitoring standpipes and piezometers
f. Sampling of soils during drilling for geotechnical and geochemical testing
g. Window sampling and trial pitting – sampling of shallow soils for geotechnical and geochemical testing
h. Geotechnical testing of soils and rock
i. Monitoring of hazardous ground gas and groundwater regimes
j. Chemical analysis of soils, groundwater and hazardous ground gas

6.4 Resort bridges, tunnels and structures

6.4.1 Objectives

1. To define the geological profile and geotechnical parameters of the strata sufficient to inform foundation/ construction design
2. To define the groundwater regime (shallow and deep).

6.4.2 Scope

a. Detailed topographical surveys at specific locations

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b. Geophysical survey (To supplement existing data [3])
c. Trial pit/trench investigations [specific to bridge structures and to locate the position of the historic adit tunnel beneath the Network Rail Chalk spine].
d. Face mapping of the exposed chalk face – undertaken with a high access MEWP to avoid roped access and railway possessions.
e. Cable percussion and cable percussion with rotary follow on holes [Appropriate spacing / location and depth for each bridge, tunnel, tunnel portal or structure].
f. Cable percussion with rotary follow on holes in vicinity of HS1 portal and tunnel. In situ testing [downhole geophysics and/or pressuremeter testing possible] and installation of monitoring instrumentation
g. In situ testing [Permeability, strength, density].
h. Installation of groundwater standpipes and piezometers
i. Sampling of soils during drilling for geotechnical and geochemical testing
j. Geotechnical testing of soils and rock
k. Monitoring of groundwater regimes
l. Chemical analysis of soils and groundwater

6.4.3 Particular constraints

- Approvals from Network Rail (High Speed) in relevant area.
- Approvals from Network Rail and KCC Highways re Chalk spines.

6.5 Earthworks (inc re-use) and marsh enhancements

6.5.1 Objectives

1. To define the presence, location and nature of the near surface soils (natural and anthropogenic) likely to be subject to exaction/ transport / re-use or disposal
2. To define the physical characteristics and geotechnical parameters of these strata sufficient to inform earthworks design and potential for re-use of all potential arisings [Made Ground , CKD, Alluvium etc.]
3. To identify the chemical characteristics of near surface soils
4. To define the shallow groundwater regime

6.5.2 Scope

a. Geophysical survey (To supplement existing data [3])
b. Shallow cable percussion / window sampler holes
c. In situ testing [Permeability, strength, density].
d. Installation of groundwater standpipes
e. Trial pitting
f. Sampling of soils and shallow groundwater
g. Monitoring of groundwater regimes
h. Chemical analysis of soils and groundwater
i. Chemical and horticultural analysis of topsoil / potential topsoil materials
j. Treatment trials (CKD)

6.5.3 Particular constraints

- Areas subject to environmental permits / licences [Environment Agency and natural England]

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- Marsh areas / adjacent to River / shallow groundwater and water ingress

6.6 Utilities infrastructure

6.6.1 Objectives

1. To define the presence, location and nature of soils/ strata at locations of below ground structures (existing and planned), leachate treatment plant(s), conveyance channels and ponds etc.
2. To define the physical characteristics and geotechnical parameters of these strata sufficient to inform earthworks design / stability etc
3. To define the shallow groundwater regime
4. To determine the potential for infiltration drainage at relevant locations

6.6.2 Scope

a. Shallow cable percussion / window sampler holes
b. In situ testing [Permeability, strength, density, CBR].
c. Installation of groundwater standpipes
d. Trial pitting
e. Infiltration tests
f. Sampling of soils and shallow groundwater
g. Monitoring of shallow groundwater and ground gas regimes
h. Chemical analysis of soils and groundwater

6.6.3 Particular constraints

- Maintenance of existing infrastructure / systems
- Consents from asset owners of existing below ground services

6.7 Flood protection

6.7.1 Objectives

1. To define the presence, location and nature of soils/ strata at locations of existing flood defences
2. To define the presence, location and nature of soils/ strata at locations of new earth embankment flood defences
3. To determine the condition of existing river walls (in vicinity of jetty) and suitability for use during construction
4. To define the physical characteristics and geotechnical parameters of these strata sufficient to inform suitability / design
5. To define the shallow groundwater regime

6.7.2 Scope

a. cable percussion / window sampler holes
b. In situ testing [Permeability, strength, density, downhole geophysics].
c. Installation of groundwater standpipes
d. Trial pitting
e. Sampling, geotechnical and chemical testing of soils

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f. Monitoring, sampling and chemical testing of groundwater
g. Structural investigations [non-intrusive and intrusive] on conditions of existing river walls

6.8 Residual Contamination [not already incorporated above]

6.8.1 Objectives

1. To define the presence, location and nature of residual contamination (solid, liquid and gas) across the peninsula in areas not addressed above [including areas not subject to built development which could present environmental liability)
2. To determine waste characteristics and the potential for segregation, treatment and re-use in areas not addressed above
3. To determine the ground gas regime in sensitive areas (e.g. neighbouring land with sensitive uses and potential for migration)

6.8.2 Scope

a. Shallow cable percussion / window sampler holes
b. Installation of groundwater/ gas standpipes
c. Trial pitting
d. Sampling of soils and shallow groundwater
e. Monitoring of groundwater and ground gas regimes
f. Chemical analysis of soils, groundwater and hazardous ground gas.

6.8.3 Particular constraints

- Existing Environmental Permits
- Gross / mobile contamination requiring particular H,S & E precautionary measures.

6.9 Archaeology

Ref: Wessex Archaeology. London Resort. Written scheme of investigation for geoarchaeological borehole survey. 106575.01. December 2020.

6.9.1 Objectives

1. To identify the presence of sequences of alluvium, peat and former land surfaces;
2. Obtain representative samples through deposits
3. Assess the geoarchaeological and archaeological significance of deposits
4. Use the information collected to feed into the geoarchaeological deposit model, along with the geoarchaeological boreholes proposed to ground truth the ERT and EMI survey

6.9.2 Scope

a. On site presence / inspection/monitoring and recording of all ground investigation exploratory holes (particularly trial pits)

6.9.3 Particular constraints

- Currently limited information regarding the possible archaeological assets on the Peninsula

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7 Phasing

7.1 Phase A - Exploratory

The initial phase of the ground investigation will be designed to provide a broad coverage of the ground conditions across the whole of the Peninsula site. All of the Phase A exploratory works are summarised in the Schedule in Appendix A with locations shown on the plans (Zone by Zone) in Appendix B.

i. Some exploratory holes will be targeted to specific locations (e.g. of key structures/ buildings). Others will be located to provide information relevant to wider areas of the site or aspects of the development.
ii. The priority for the Phase A exploratory works will be discussed and agreed with the Environment Agency and local authority regulators (and other relevant stakeholders).
iii. Permissions for exploratory works will influence prioritisation / phasing
iv. Geophysical survey to define ground condition profiles across relevant parts of the site [To be subject to further consideration].
v. In situ testing, sampling, monitoring and laboratory testing / analysis will be intensive in order to provide maximum early information. Initial entry of all data into the data management system.
vi. Early reporting to identify key gaps and uncertainties to be addressed in Phase B.

The need for and scope of the investigations in Phase B will be determined during / at the conclusion of Phase A.

7.2 Phase B - Main

The main phase the investigation will further define the ground conditions initially sketched out by Phase A to provide design level information for all buildings, structures and earthworks. For budgetary purposes only, an indication of the potential number and type of exploratory holes in the Phase B investigation is shown in the Schedule (Appendix A) in italicised text.

i. Exploratory holes will be targeted to particular structures and also constructed on appropriately spaced grids.
ii. Likely to include locations where obtaining permissions is protracted
iii. Pilot / field trial testing of soil treatment for re-use (e.g. for CKD).
iv. Testing schedules (geotechnical and geochemical) will be refined to reflect initial data

7.3 Phase C – Detailed / Targeted

The detailed phase of the investigation will apply to particular / key elements of the development. For example;

i. probing in areas of below ground obstructions
ii. along the lines / within areas of deep excavation
iii. where the main investigation has identified uncertainties / rapidly varying ground conditions

The need for and scope of the investigations in Phase C will be determined during / at the conclusion of Phase B.

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[6] BSI, BS 8485:2015+A1:2019. Code of practice for the design of protective measures for methane and carbon dioxide ground gases for new buildings, 2019.

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Appendix A Schedule of Phase A exploratory holes

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SCHEDULE 1: EXPLORATORY WORKS FOR THE LONDON RESORT

Table1: Schedule of Exploratory Works

Ex hole ref.	Location				Objectives	Methodology	Known constraints	Depth (m)	Installations	Sampling. In-situ & ex situ testing	
	Zone	Building / structure	Easting	Northing						Geotechnical	Geoenvironmental & Geoarchaeological
CP101 CP102 CP103 CP104 CP105 CP106	Zone 1	Saltmarsh enhancement [Approx 1.1km along NW & NE perimeter]	560277 560382 560556 560651 560875 561016	176253 176418 176562 176708 176566 176373	1. To define presence, location and nature of near surface soils (natural and anthropogenic) likely to be subject to excavation/ transport / re-use or disposal 2. To assess geoarchaeological significance of deposits 3. To define physical characteristics and geotechnical parameters to inform earthworks design/stability /potential for re-use [Made Ground, CKD, Alluvium] 4. To identify chemical characteristics of strata 5. To define shallow groundwater regime	6 No Cable Percussion boreholes (CP) @250m spacing along enhancement line	SSSI – NE consent UXO risk Unlicensed landfill (CKD) Existing water management infrastructure Existing watercourses	5m into Chalk. Approx. 20mbgl.	Standpipe piezo. Response zone – Alluvium & River Terrace Gravels	SPTs at 1m intervals in made ground, granular alluvium and terrace gravels SPTs at 1m interval in the chalk. U100 in cohesive soils and weathered chalk at 1m to 1.5m centres, for chalk classification. Large bulk samples of CKD from trial pits (treatment trials) Laboratory: Index / classification, strength, consolidation, earthworks and permeability tests.	**Soils [Made Ground]** Samples @ 0.5, 1.0 and 1.2 from starter pit then @0.5m intervals. **Soils [Natural strata]** Sample at top of natural strata and @ 0.5m intervals if visual/ olfactory evidence of contamination. No further samples of non contaminated **Chemical analyses** Selected samples of MG for Suite E and 10% for Suite H. Allow 10% samples for analysis by VOCs, SVOCs, TPHCWG, asbestos quantification. **Geoarchaeological** Samples of alluvial clay / peat, wood / artefacts (to be taken / directed by on-site archaeologist) **Groundwater (not TPs)** 2 No samples from monitoring wells approx 1 month apart. Analytical suite
TP101 TP102 TP103 TP104 TP105 TP106 TP107 TP108			560331 560373 560574 560712 560823 560896 560987 561051	176312 176389 176638 176680 176619 176544 176446 176295		8No Trial pits (TP) @100m centres along enhancement line		Base of alluvium / 4mbgl	None		
CP107 CP108 CP109 CP110 CP111 CP112		Swales and water bodies Earthworks [Approx 850m]	560671 560596 560763 560884 560323 560402	176362 176105 175957 175829 176098 176181	1. To define presence, location and nature of soils/ strata in areas of excavation. 2. To assess geoarchaeological significance of deposits 3. To define physical characteristics and geotechnical parameters to inform earthworks design/stability	5No CPs @250m spacing - see line of deep excavation		1m below base of excavation or 10mbgl	Standpipe piezo. Response zone – Alluvium & River Terrace Gravels	As above	As above

Ex hole ref.	Location				Objectives	Methodology	Known constraints	Depth (m)	Installations	Sampling. In-situ & ex situ testing	
	Zone	Building / structure	Easting	Northing						Geotechnical	Geoenvironmental & Geoarchaeological
TP109 TP110 TP111 TP112 TP113 TP114 TP115 TP116 TP117		(Drainage Strategy & Earthworks Drgs)	560670 560621 560649 560786 560830 560532 560428 560254 560350	176318 176186 176034 175923 175860 176132 176101 176063 176184	/potential for re-use [Made Ground, CKD, Alluvium] 4. To identify chemical characteristics of strata 5. To define shallow groundwater regime	9 No TPs @100m centres along line of deep excavation		1m below base of excavation/ TP to 4mbgl	None		
CP103 CP104 CP105 CP106		New outfalls (NE & NW banks). Existing & new WWTP	As for Saltmarsh above	As for Saltmarsh above	1. To define presence, location and nature of soils/ strata at location of culverts, outfalls and WWTPs 2. To assess geoarchaeological significance of deposits 3. To define physical characteristics and geotechnical parameters to inform earthworks design / stability 4. To define shallow groundwater regime 5. To determine hazardous ground gas regime (at WWTP)	1No CP @ outfall and 2No CP @150m intervals along culvert		10m / 5m into competent strata (Allow 20m bgl)	GW Standpipe. Response zone – Alluvium & River Terrace Gravels Standpipe + gas tap. Response zone above swl at WWTP	As above	As above
TP103 TP104 TP105 TP106 TP107 TP108			As for Saltmarsh above	As for Saltmarsh above		4No TPs @100m centres along line of culvert		TP to 4mbgl	None		
CP101 CP102 CP103 CP104 CP105 CP106		Flood defence berms (See Fig 3.4) 1.8km (850m in Saltmarsh)	560277 560382 560556 560651 560875 561016	176253 176418 176562 176708 176566 176373	1. To define presence, location and nature of soils/ strata along line of existing / planned flood defences 2. To assess geoarchaeological significance of deposits 3. To define physical characteristics and geotechnical parameters to	4No CPs @250m spacing along line of flood defences (avoid duplication with saltmarsh)		10m / 5m into competent strata (Allow 20m bgl)	GW Standpipe. Response zone – Alluvium & River Terrace Gravels	As above	As above

Ex hole ref.	Location				Objectives	Methodology	Known constraints	Depth (m)	Installations	Sampling. In-situ & ex situ testing	
	Zone	Building / structure	Easting	Northing						Geotechnical	Geoenvironmental & Geoarchaeological
TP101 TP102 TP103 TP104 TP105 TP106 TP107 TP108 TP118 TP119			560331 560373 560574 560712 560823 560896 560987 561051 560497 560600	176312 176389 176638 176680 176619 176544 176446 176295 176400 176483	inform earthworks design / stability 4. To define shallow groundwater regime	10No TPs @100m spacing along line of flood defences (avoid duplication with saltmarsh)		TP to 4mbgl	None		
SCPT101 SCPT102 SCPT103 SCPT104 SCPT105 SCPT106 SCPT107 SCPT108			560331 560373 560574 560712 560823 560896 560987 561051	176312 176389 176638 176680 176619 176544 176446 176295		SCPTs at 100m spacing along line of flood defences (not at TP locations) (piezocone)		SCPT 15m to 20m		Dissipation tests in 25% of SCPTs in alluvium	None
	Zone 2	Earthworks Main areas of cut S and W of HS1. Includes South Pit Phase 3. Approx 5ha with cut of 5-10m. Nb duplication with some structures in Zone 2			1. To define the presence, location and nature of the near surface soils (natural and anthropogenic) likely to be subject to exaction/ transport / re-use or disposal 2. To define the physical characteristics and geotechnical parameters of these strata sufficient to inform earthworks design and potential for re-use of all potential arisings [Made Ground , CKD, Alluvium etc.] 3. To identify the chemical characteristics of near surface soils	5no CP [1/ha] 10 No TPs [2/ha]	SSSI – NE consent UXO risk Landfill permits (South Pit and North Pit) CKD and other wastes Existing water management infrastructure	CP to 20m TP to 4m	Standpipe piezos. Response zones for GW and HGG	SPTs at 1m intervals in made ground, granular alluvium and terrace gravels SPTs at 1m interval in the chalk. U100 in cohesive soils and weathered chalk at 1m to 1.5m centres, for chalk classification. Large bulk samples of CKD from trial pits (treatment trials) Laboratory: Index / classification, strength, consolidation and permeability tests.	**Soils [Made Ground]** Samples @ 0.5, 1.0 and 1.2 from starter pit then @0.5m intervals. **Soils [Natural strata]** Sample at top of natural strata and @ 0.5m intervals if visual/ olfactory evidence of contamination. No further samples of non contaminated **Chemical analyses** Selected samples of MG for Suite E and 10% for Suite H. Allow 10% samples for analysis by VOCs, SVOCs, TPHCWG, asbestos quantification. **Geoarchaeological** Samples of alluvial clay / peat, wood / artefacts (to be taken / directed by on-site archaeologist) **Groundwater**

Ex hole ref.	Location				Objectives	Methodology	Known constraints	Depth (m)	Installations	Sampling. In-situ & ex situ testing	
	Zone	Building / structure	Easting	Northing						Geotechnical	Geoenvironmental & Geoarchaeological
		(See Earthworks Drg)			4. To define the shallow groundwater regime		Existing watercourses				2 No samples from monitoring wells approx 1 month apart. Analytical suite: General inorganics – pH, electrical conductivity, cyanide (total), sulphate (as SO_4), chloride, ammonia, ammonium, nitrate, nitrite, total nitrogen, dissolved oxygen, hardness, total dissolved solids. Organics – USEPA 16 PAHs, TPH CWG, BTEX including MTBE, phenol. Metals and metalloids – CLEA metals, mercury. **Ground gas** Monitored at weekly intervals for 6 weeks. Selected samples submitted for analysis – Suite G
		HS1			1. To define the physical characteristics and geotechnical parameters of the strata to inform a preliminary assessment of the impact of the proposed design on the HS1 tunnel. 2. Define the groundwater regime	3 No CPs with rotary follow on.	HS 1 tunnels and exclusion zones associated with tunnels + loading/stress & movement limits	2No to 75m[1] 1No to 50m[1]	Piezometers: At 3 levels in the chalk to determine effect of under drainage	SPTs at 1m intervals in made ground, granular alluvium and terrace gravels SPTs at 1m interval in the chalk, until depth rotary follow on commences. U100 in cohesive soils and weathered chalk at 1m to 1.5m centres, for chalk classification. Pressuremeter tests within the chalk at 5m intervals. Laboratory: Index / classification, strength, consolidation and permeability tests.	As above
CP201 CP202 CP203 CP204 TP205 TP206 WS201 WS202 WS203 WS204 WS205 WS206 WS207		2. Gate 1 20ha approx. Layout / structures not known. Generic exploratory ground investigation	560496 560262 560583 560266 560310 560198 560143 560398 560575 560592 560560 560692 560517	175654 175676 175513 175883 175615 175551 175971 176019 175979 175862 175753 175644 175573	1. To define the geological profile and geotechnical parameters of the strata sufficient to inform foundation design 2. To identify the physical and chemical characteristics of near surface soils and deeper geology 3. To define the groundwater regime (shallow and deep) 4. To define the ground gas regime 5. Provide design parameters to model the effect of the development on HS 1 running tunnels	4no CP boreholes [1/5ha] 10No Window Sampler holes (WS) [1/2ha] 10 No TPs [1/2ha]	SSSI – NE consent UXO risk Landfill permits (South Pit Phase 3 and North Pit) CKD and other wastes Existing water management infrastructure Existing watercourses Swanscombe WTW &South Pit Leachate	2No CP to 50m 2No CP to 25m WS to 5m TPs to 4m.	Standpipe piezos. Response zones for GW and HGG Gas monitoring standpipes in WS.	As above plus: Large bulk disturbed samples at 1m intervals in trial pits and at change in strata type. Infiltration tests in 7No Trial Pits at 1m, 2m and 3m depth. Provide trench box to support sides	As above

Ex hole ref.	Location				Objectives	Methodology	Known constraints	Depth (m)	Installations	Sampling. In-situ & ex situ testing	
	Zone	Building / structure	Easting	Northing						Geotechnical	Geoenvironmental & Geoarchaeological
WS208 WS209 WS210 WS215 CP209			560346 560180 560381 560255 560256	175665 175614 175837 175516 175578			Treatment Plant HS1 Pump Station & safeguarding				
CP205 CP206 TP201 TP202 TP203 WS211 WS212 WS213		10. Hotel H1(145 x 18m) Height 47m & Boulevard (190 x 75m) Height 6m	560376 560336 560338 560373 560387 560350 560400 560357	175393 175311 175400 175330 175282 175368 175312 175254	1. To define the geological profile and geotechnical parameters of the strata sufficient to inform foundation design 2. To identify the physical and chemical characteristics of near surface soils and deeper geology 3. To define the groundwater regime (shallow and deep) 4. To define the ground gas regime	2 No CP with rotary follow on *[Phase 2 - add 3No CP]* 3No Window Sampler holes (WS) [1/50m grid] *[Phase 2 - add 2No WS]* 3 No TPs	SSSI – NE consent UXO risk Landfill permit (South Pit Phase 3) CKD and other wastes Existing water management infrastructure Existing watercourses	CP to 50m WS to 5m TPs to 4m	Piezometers in CPs At 3 levels in the made ground, terrace deposits and chalk. Determine presence of perched water tables Gas monitoring standpipes in WS.	As above (exc infiltration tests)	As above
TP236 TP237 WS237 WS238 CP225		Car Park 9 (90 x 70m) Height 52m	560531 560541 560569 560536 560501	175289 175250 175248 175220 175260	1. To define the geological profile and geotechnical parameters of the strata sufficient to inform foundation design 2. To identify the physical and chemical characteristics of near surface soils and deeper geology 3. To define the groundwater regime (shallow and deep) To define the ground gas regime	1No CP holes with rotary follow on. *[Phase 2 - add 3No CP]* 2No WS *[Phase 2 – add 3No WS]* 2No TPs	SSSI – NE consent UXO risk Landfill permit (South Pit Phase 2). Not implemented Existing water management infrastructure Existing watercourses	1 No to 50m	Standpipe piezo with GW & HGG response zones	As above	As above

Ex hole ref.	Location				Objectives	Methodology	Known constraints	Depth (m)	Installations	Sampling. In-situ & ex situ testing	
	Zone	Building / structure	Easting	Northing						Geotechnical	Geoenvironmental & Geoarchaeological
CP207		11. Waterpark 37m high skeleton structure over Park at ground level	560442	175362	1. To define the geological profile and geotechnical parameters of the strata sufficient to inform foundation design 2. To identify the physical and chemical characteristics of near surface soils and deeper geology 3. To define the groundwater regime (shallow and deep) 4. To inform tunnel impact assessment of HS1	1 No CP borehole with rotary follow on *[Phase 2 - add 2No CP]*	SSSI – NE consent UXO risk Landfill permit (South Pit Phase 2). Not implemented Existing watercourse HS1 Safeguarding	CP to 50m	**Piezometers** At 3 levels in the made ground, alluvium, deposits and chalk.	As above	As above
TP204 WS214 CP208		12. Node 3. Gate 1 Payline 7.5m high platform and 87m high structure Note: Connecting platform from The Market spans HS1 tunnel	560384 560430 560417	175591 175651 175611	1. To define the geological profile and geotechnical parameters of the strata sufficient to inform foundation design 2. To identify the physical and chemical characteristics of near surface soils and deeper geology 3. To define the groundwater regime (shallow and deep) 4. To define the ground gas regime 5. To inform tunnel impact assessment of HS1 (for buildings in vicinity)	1 No CP borehole with rotary follow on 1No WS 1 No TP	SSSI – NE consent UXO risk Landfill permit (South Pit Phase 2). Not implemented Existing watercourse HS1 Safeguarding Swanscombe WTW	1No to 75m WS to 5m TPs to 4m	**Piezometers** Standpipe piezo with GW & HGG response zones. At 2 levels in the river terrace and chalk to determine water pressures on the HS1 retained cut. Gas monitoring standpipe in WS.	As above.	As above
CP226 TP238 TP239 WS239		13. Node 2. Market (100m dia) 7.5m high platform. Note: Connecting platform from Gate 2 Payline spans HS1 tunnel	560314 560319 560341 560376	175456 175511 175469 175473	1. To define the geological profile and geotechnical parameters of the strata sufficient to inform foundation design 2. To identify the physical and chemical characteristics of near surface soils and deeper geology 3. To define the groundwater regime (shallow and deep) 4. To define the ground gas regime	1 No CP borehole with rotary follow on *[Phase 2 - add 4No CP]* 1No WS *[Phase 2 - add 4No WS]* 2No Trial Pits	SSSI – NE consent UXO risk Landfill permits (South Pit Phase 2 &3) CKD and other wastes	CP to 50m WS to 5m TPs to 4m	Standpipe piezo with GW & HGG response zones Gas monitoring standpipes in WS.	As above plus: Infiltration tests in 1No Trial Pit at 1m, 2m and 3m depth. Provide trench box to support sides	As above

Ex hole ref.	Location				Objectives	Methodology	Known constraints	Depth (m)	Installations	Sampling. In-situ & ex situ testing	
	Zone	Building / structure	Easting	Northing						Geotechnical	Geoenvironmental & Geoarchaeological
					5. To inform tunnel impact assessment of HS1 (for buildings in vicinity)		Existing water management infrastructure Existing watercourses HS1 Safeguarding				
TP207 TP208 TP209 WS216 WS217 WS218 CP210 CP211		14. Conferention Centre (115 x 70m) Height 41m	560304 560252 560298 560261 560280 560299 560299 560258	175361 175344 175319 175372 175333 175296 175383 175302	1. To define the geological profile and geotechnical parameters of the strata sufficient to inform foundation design 2. To identify the physical and chemical characteristics of near surface soils and deeper geology 3. To define the groundwater regime (shallow and deep) 4. To define the ground gas regime	2 No CP borehole with rotary follow on *[Phase 2 - add 5No CP]* 3No WS *[Phase 2 - add 4No WS]* 3No Trial Pits	SSSI – NE consent UXO risk Landfill permit (South Pit Phase 3) CKD and other wastes Existing water management infrastructure Existing watercourses	CP to 60m WS to 5m TPs to 4m	Standpipe piezo with GW & HGG response zones Gas monitoring standpipes in WS.	As above	As above
CP212 CP214 TP210 TP211 TP212 TP213 TP214 TP215 WS219 WS220 WS221		18. Gate 2 Location of Soil Hospital Nominal 4ha	559971 559924 559668 559737 559835 560193 560076 560006 559595 559848 560108	175428 175084 175277 175133 175250 175227 175355 175227 175199 175180 175203	1. To define the geological profile and geotechnical parameters of the strata sufficient to inform foundation design 2. To identify the physical and chemical characteristics of near surface soils and deeper geology 3. To define the groundwater regime (shallow and deep) 4. To define the ground gas regime	3 No CP boreholes 3No WS 6 TPs	SSSI – NE consent UXO risk Existing water management infrastructure Existing watercourses	CP to 20m WS to 5m TP to 4m	Standpipe piezo with GW & HGG response zones Gas monitoring standpipes in WS.	As above plus: Infiltration Test in 1 No TP at 1m, 2m and 3m depth. Provide trench box to support sides	As above

Ex hole ref.	Location				Objectives	Methodology	Known constraints	Depth (m)	Installations	Sampling. In-situ & ex situ testing	
	Zone	Building / structure	Easting	Northing						Geotechnical	Geoenvironmental & Geoarchaeological
TP216 TP217 TP218 WS222 WS223 WS224 CP215		21. Coliseum (85m Dia) Height 41m	560183 560217 560165 560154 560218 560192 560187	175449 175400 175392 175431 175443 175381 175414	1. To define the geological profile and geotechnical parameters of the strata sufficient to inform foundation design 2. To identify the physical and chemical characteristics of near surface soils and deeper geology 3. To define the groundwater regime (shallow and deep) 4. To define the ground gas regime	1 No CP borehole with rotary follow on *[Phase 2 - add 3No CP]* 3No WS *[Phase 2 - add 4No WS]* *3No TPs*	SSSI – NE consent UXO risk Landfill permits (South Pit Phase 3) CKD and other wastes	CP to 60m (*Shared with structure 14*) WS to 5m TPs to 4m	Standpipe piezo with GW & HGG response zones Gas monitoring standpipes in WS.	As above	As above
TP219 TP220 TP221 WS225 WS226 WS227 CP216		22. Hotel H4 (90 x 18m) Height 54m	560096 560155 560135 560101 560134 560107 560130	175595 175542 175467 175622 175570 175548 175502	1. To define the geological profile and geotechnical parameters of the strata sufficient to inform foundation design 2. To identify the physical and chemical characteristics of near surface soils and deeper geology 3. To define the groundwater regime (shallow and deep) 4. To define the ground gas regime	1 No CP hole with rotary follow on. *[Phase 2 - add 2No CP]* 3 No WS 3No TPs	SSSI – NE consent UXO risk Landfill permits (South Pit 3 and North Pit) CKD and other wastes	CP to 75m WS to 5m TPs to 4m	Standpipe piezo with GW & HGG response zones Gas monitoring standpipes in WS.	As above	As above
TP222 TP223 TP224 WS228 WS229 WS230 CP217 CP218 CP219		23. Hotel H2 (125 x 95m) Height 54m	560104 560050 560112 560128 560050 560133 560171 560085 560084	175721 175769 175791 175748 175721 175675 175711 175691 175772	1. To define the geological profile and geotechnical parameters of the strata sufficient to inform foundation design 2. To inform tunnel impact assessment of HS1 3. To identify the physical and chemical characteristics of near surface soils and deeper geology 4. To define the groundwater regime (shallow and deep) 5. To define the ground gas regime	3 No CP borehole with rotary follow on *[Phase 2 - add 5No CP]* 3No WS *[Phase 2 - add 4No WS]* 3No TPs	SSSI – NE consent UXO risk HS1 Safeguarding Landfill permit (North Pit) CKD and other wastes Existing watercourses	1No CP to 75m 2No CP to 60m WS to 5m TPs to 4m	Standpipe piezo with GW & HGG response zones Gas monitoring standpipes in WS.	As above	As above

Ex hole ref.	Location				Objectives	Methodology	Known constraints	Depth (m)	Installations	Sampling. In-situ & ex situ testing	
	Zone	Building / structure	Easting	Northing						Geotechnical	Geoenvironmental & Geoarchaeological
TP226 TP227 WS232 WS233 CP220 SCPT201 SCPT202 SCPT203 SCPT204		24. Ferry Terminal (T3) (150 x 55m) Height 10m	559986 559978 559948 559940 559989 559905 559957 559961 560012	175803 175874 175898 175832 175847 175868 175877 175817 175824	1. To define the geological profile and geotechnical parameters of the strata sufficient to inform foundation design 2. To identify the physical and chemical characteristics of near surface soils and deeper geology 3. To define the groundwater regime (shallow and deep) 4. To define the ground gas regime 5. To inform tunnel impact assessment of HS1 6. To provide data on strength of alluvium, terrace gravels and weathered chalk (SCPTs) and on alluvial silt/sand/clay laminations (Piezocone)	1 No CP hole with rotary follow on. *[Phase 2 - add 2No CP]* 4 No SCPTs 3No WS 3No TPs	SSSI – NE consent UXO risk CKD and other wastes HS1 Safeguarding	CP to 75m SCPTs to 20m from on foreshore area. WS to 5m TPs to 4m	Standpipe piezo with GW & HGG response zones Gas monitoring standpipes in WS.	As above [Note: SCPT: piezocone, truck mounted if possible, foreshore area to assessed, may require heavy crawler mounted rig 10 tonne min, preferably 20 tonnes]	As above
TP225 TP228 TP229 TP230 WS231 WS234 WS235 WS236 CP221 SCPT205 SCPT206 SCPT207 SCPT208		25. Port (160 x 55m) Height 10 – 20m.	560017 560030 560086 560058 560024 560085 560081 560054 560071 560003 560034 559980 560032	175903 175965 175959 176066 175861 176073 175989 175931 176035 175952 175990 175913 175922	1. To define the geological profile and geotechnical parameters of the strata sufficient to inform foundation design 2. To identify the physical and chemical characteristics of near surface soils and deeper geology 3. To define the groundwater regime (shallow and deep) 4. To define the ground gas regime 5. To inform tunnel impact assessment of HS1 6. To provide data on strength of alluvium, terrace gravels and weathered chalk (SCPTs) and on alluvial silt/sand/clay laminations (Piezocone)	1 No CP hole with rotary follow on. 4 No SCPTs 3No WS 3No TPs	SSSI – NE consent UXO risk CKD and other wastes Existing water management infrastructure HS1 Safeguarding	1No to 60m 4 No SCPTs to 20m from on foreshore area. WS to 5m TPs to 4m	Standpipe piezo with GW & HGG response zones	As above [Note: SCPT: piezocone, truck mounted if possible, foreshore area to assessed, may require heavy crawler mounted rig 10 tonne min, preferably 20 tonnes]	As above
		26. Ro Ro Facility (55 x 45m) Height 10m			1. To define the geological profile and geotechnical parameters of the strata sufficient to inform foundation design	See structures 23 & 24	SSSI – NE consent UXO risk	See structures 23 & 24		See structures 23 & 24	As above

Ex hole ref.	Location				Objectives	Methodology	Known constraints	Depth (m)	Installations	Sampling. In-situ & ex situ testing	
	Zone	Building / structure	Easting	Northing						Geotechnical	Geoenvironmental & Geoarchaeological
		Exclude marine			2. To identify the physical and chemical characteristics of near surface soils and deeper geology 3. To define the groundwater regime (shallow and deep) 4. To define the ground gas regime		CKD and other wastes Existing water management infrastructure				
		27. Whites Jetty	Marine structure. Not included at this stage								
CP 220 CP 221 TP 225 TP 226 TP 227 TP 228 TP 229		Flood defences / infrastructure Increase height of flood berm from 6.3 to 7.0mOD. 300m length	See other structures in Zone above	See other structures in Zone above	1. To define the geological profile and geotechnical parameters of the strata sufficient to inform foundation design 2. To identify the physical and chemical characteristics of near surface soils 3. To define the groundwater regime (shallow)	3 No CP holes (250m spacing) 5No TPs [150m spacing] 6 No SCPT at 100m spacing	SSSI – NE consent UXO risk Existing water management infrastructure	CP to 10m TP to 4m SCPTs to 20m, or prove the River Terrace by 3m	Standpipe piezo with GW response zone	SPTs at 1m intervals in made ground, and granular alluvium and terrace gravels SPTs at 1m interval in the chalk, until depth rotary follow commences. U100 in cohesive soils and weathered chalk at 1m to 1.5m centres, for chalk classification Piezocone dissipations tests at 1m intervals in the alluvium	As above
CP222 CP223 CP224 TP231 TP232 TP233 TP234 TP235 SCPT209 SCPT210 SCPT211 SCPT212 SCPT213 SCPT214	**Zone 3A**	Flood defences Increase height of flood berm from 6.3 to 7.0mOD. 450m length	559948 559746 559540 559910 559812 559712 559623 559529 559916 559855 559768 559740 559631 559573	175733 175635 175481 175693 175668 175604 175541 175456 175724 175651 175683 175590 175576 175479	1. To define the geological profile and geotechnical parameters of the strata sufficient to inform foundation design 2. To identify the physical and chemical characteristics of near surface soils 3. To define the groundwater regime (shallow)	3 No CP holes (250m spacing) 5No TPs [150m spacing] 6 No SCPT at 100m spacing	SSSI – NE consent UXO risk Existing water management infrastructure	CP to 10m TP to 4m SCPTs to 20m, or prove the River Terrace by 3m	Standpipe piezo with GW response zone	SPTs at 1m intervals in made ground, and granular alluvium and terrace gravels SPTs at 1m interval in the chalk, until depth rotary follow commences. U100 in cohesive soils and weathered chalk at 1m to 1.5m centres, for chalk classification Piezocone dissipations tests at 1m intervals in the alluvium	As above

Ex hole ref.	Location				Objectives	Methodology	Known constraints	Depth (m)	Installations	Sampling. In-situ & ex situ testing	
	Zone	Building / structure	Easting	Northing						Geotechnical	Geoenvironmental & Geoarchaeological
		20. Node 4. Gate 2 Payline	Included in Zone 2								
		18. Gate 2	Included in Zone 2								
		22. Hotel H4 (90 x 18m)	Included in Zone 2								
TP301 TP302 TP303 WS301 WS302 WS303 CP301	**Zone 3B**	19. Gate 2 Back of house (45 x 18m – largest building) Height 16m	559532 559522 559558 559567 559528 559541 559549	175312 175246 175233 175290 175273 175204 175256	1. To define the geological profile and geotechnical parameters of the strata sufficient to inform foundation design 2. To identify the physical and chemical characteristics of near surface soils and deeper geology 3. To define the groundwater regime (shallow and deep) 4. To define the ground gas regime	1 No CP borehole with rotary follow on. *[Phase 2 – add 1No CP]* 3No WS *[Phase 2 – add 3No WS]* 3No TPs	UXO risk Lover's Lane Pit [Permit ???] Also known as Swanscombe Cement Works Landfill Outside SSSI	1 No to 40m WS to 5m TP to 4m	Standpipe piezo with GW & HGG response zones Gas monitoring standpipes in WS.	SPTs at 1m intervals in made ground, and granular alluvium and terrace gravels SPTs at 1m interval in the chalk, until depth rotary follow commences. U100 in cohesive soils and weathered chalk at 1m to 1.5m centres, for chalk classification. Large bulk disturbed samples at 1m intervals in trial pits and at change in strata type. Pressuremeter tests within the chalk at 5m intervals. Laboratory: Index / classification, strength, consolidation and permeability tests.	**Soils [Made Ground]** Samples @ 0.5, 1.0 and 1.2 from starter pit then @0.5m intervals. **Soils [Natural strata]** Sample at top of natural strata and @ 0.5m intervals if visual/ olfactory evidence of contamination. No further samples of non contaminated **Chemical analyses** Selected samples of MG for Suite E and 10% for Suite H. Allow 10% samples for analysis by VOCs, SVOCs, TPHCWG, asbestos quantification.
		18. Gate 2	Included in Zone 2								
	Zone 4A	Gate 1	Included in Zone 1								
TP401 TP402 TP403 TP404 TP405 TP406 WS401 WS402	**Zone 4B**	7. Car Parks (CP1, CP2, CP3 (Each 90 x 90m) Height 52m	560564 560568 560714 560751 560798 560711 560641 560579	175209 175150 175122 175079 174961 174954 175196 175115	4. To define the geological profile and geotechnical parameters of the strata sufficient to inform foundation design 5. To identify the physical and chemical characteristics of near surface soils and deeper geology 6. To define the groundwater regime (shallow and deep) 7. To define the ground gas regime	3No CP holes with rotary follow on. *[Phase 2 - add 3No CP]* 6No WS *[Phase 2 – add 3No WS]* 6No TPs	UXO risk Pilgrims Pit Landfill (?) Outside SSSI Existing water management infrastructure	1 No to 75m, 2 No to 50m	Standpipe piezo with GW & HGG response zones	SPTs at 1m intervals in made ground, and granular alluvium and terrace gravels SPTs at 1m interval in the chalk, until depth rotary follow commences. U100 in cohesive soils and weathered chalk at 1m to 1.5m centres, for chalk classification Large bulk disturbed samples at 1m intervals in trial pits and at change in strata type. Pressuremeter tests within the chalk at 5m intervals.	**Soils [Made Ground]** Samples @ 0.5, 1.0 and 1.2 from starter pit then @0.5m intervals. **Soils [Natural strata]** Sample at top of natural strata and @ 0.5m intervals if visual/ olfactory evidence of contamination. No further samples of non contaminated **Chemical analyses** Selected samples of MG for Suite E and 10% for Suite H. Allow 10% samples for analysis by VOCs, SVOCs, TPHCWG, asbestos quantification.

Ex hole ref.	Location				Objectives	Methodology	Known constraints	Depth (m)	Installations	Sampling. In-situ & ex situ testing	
	Zone	Building / structure	Easting	Northing						Geotechnical	Geoenvironmental & Geoarchaeological
WS403 WS404 WS405 WS406 CP401 CP402 CP403			560673 560711 560768 560765 560682 560803 560570	175013 175088 175037 174970 175092 174985 175179						Laboratory: Index / classification, strength, consolidation and permeability tests.	
CP404 CP405		8. Passenger Terminal (T1) (245 x 35m) Height 23m	560517 560650	175087 174926	1. To define the geological profile and geotechnical parameters of the strata sufficient to inform foundation design 2. To identify the physical and chemical characteristics of near surface soils and deeper geology 3. To define the groundwater regime (shallow and deep)	2No CP holes with rotary follow on. *[Phase 2 - add 2No CP]*	UXO risk Pilgrims Pit Landfill (?) Outside SSSI Existing water management infrastructure	2No to 40m	Standpipe piezo with GW & HGG response zones	As above	As above
TP407 TP408 TP409 TP410 TP411 WS407 WS408 WS409 CP406 CP407		3.Back of House 1.1 (170 x 35m) Height 25m Earthworks (cut – east)	561017 561095 561216 561069 560970 560956 561027 561109 561008 561149	175069 175027 175043 175089 175118 175096 175027 175068 175099 175048	1. To define the geological profile and geotechnical parameters of the strata sufficient to inform foundation design and potential for spoil re-use 2. To identify the physical and chemical characteristics of near surface soils and deeper geology 3. To define the groundwater regime (shallow and deep) 4. To define the ground gas regime	2 No CP holes with rotary follow on. *[Phase 2 - add 2No CP]* 3No WS *[Phase 2 add 3No WS]* 5 No TPs.	UXO risk Outside SSSI	2 No to 50m TPs to 3m.	Standpipe piezo with GW & HGG response zones Gas monitoring standpipes in WS.	As above	As above
TP412 TP413 TP414 WS410 WS411		3. Back of House 1.2 (415 x 85m – largest extents) Heights 27 – 49m	560968 561096 561170 560910 561068	175018 174943 174990 175007 174989	1. To define the geological profile and geotechnical parameters of the strata sufficient to inform foundation design and potential for spoil re-use	3 No CP holes with rotary follow on. *[Phase 2 - add 3No CP]* 3No WS	UXO risk Outside SSSI	3 No CP to 50m WS to 5m TPs to 4m.	Standpipe piezo with GW & HGG response zones Gas monitoring standpipes in WS.	As above	As above

Ex hole ref.	Location				Objectives	Methodology	Known constraints	Depth (m)	Installations	Sampling. In-situ & ex situ testing	
	Zone	Building / structure	Easting	Northing						Geotechnical	Geoenvironmental & Geoarchaeological
WS412 CP408 CP409 CP410		Earthworks (cut – east)	561198 560899 560985 561230	174941 175078 174941 175007	2.To identify the physical and chemical characteristics of near surface soils and deeper geology 3.To define the groundwater regime (shallow and deep) 4.To define the ground gas regime	*[Phase 2 add 3No WS]* 3 No TPs.					
TP415 TP416 TP417 WS413 WS414 WS415 WS416 WS417 WS418 CP411 CP412 CP413 CP414		16. Visitor Centre (145 x 55m) & Academy (100 x 50m) Height 17m	560441 560485 560514 560422 560461 560503 560450 560506 560487 560443 560526 560431 560523	174919 174918 174903 174920 174915 174923 174839 174876 174837 174936 174911 174881 174833	1.To define the geological profile and geotechnical parameters of the strata sufficient to inform foundation design and potential for spoil re-use 2.To identify the physical and chemical characteristics of near surface soils and deeper geology 3.To define the groundwater regime (shallow and deep) 4.To define the ground gas regime	4 No CP holes with rotary follow on. *[Phase 2 - add 3No CP]* 6No WS *[Phase 2 add 3No WS]* 3 No TPs.	UXO risk Adjacent HS1 Infill Area? Outside SSSI	4 No to 50m WS to 5m TPs to 3m.	Standpipe piezo with GW & HGG response zones Gas monitoring standpipes in WS.	As above plus: Infiltration Tests in 2 No TP at 1m, 2m and 3m depth. Provide trench box to support sides	As above
		Galley Hill Rd Underpass Adjoin Zone 4C			1. To define the geological profile and geotechnical parameters of the strata sufficient to inform foundation/ construction design	Geological mapping	UXO risk				
CP416 CP417		Elevated People Mover (inc. 4C)	560830 560931	174847 174765	1.To define the geological profile and geotechnical parameters of the strata sufficient to inform foundation/ construction design 2.To define the groundwater regime (shallow and deep)	2 No CP holes with rotary follow on. *[Phase 2 - add 1No CP]*	UXO risk Outside SSSI	2 No to 25m	Standpipe piezo with GW & HGG response zones	As above	As above

Ex hole ref.	Location				Objectives	Methodology	Known constraints	Depth (m)	Installations	Sampling. In-situ & ex situ testing	
	Zone	Building / structure	Easting	Northing						Geotechnical	Geoenvironmental & Geoarchaeological
CP415		Elevated Cycleway (inc. 4C)	560807	174914	1. To define the geological profile and geotechnical parameters of the strata sufficient to inform foundation/ construction design	1 No CP holes with rotary follow on. *[Phase 2 - add 1No CP]*	UXO risk Outside SSSI	1 No to 25m	Standpipe piezo with GW & HGG response zones	As above	As above
CP418 CP419 CP420		Link Bridges	560550 560582 560694	175124 175048 174970	1. To define the geological profile and geotechnical parameters of the strata sufficient to inform foundation/ construction design	3 No CP holes with rotary follow on.	UXO risk Outside SSSI	3 No to 40m	Standpipe piezo with GW & HGG response zones	As above	As above
TP418 TP419 TP420 TP421 WS419 WS420 WS421 WS422 CP421 CP422 CP423 CP424	**Zone 4C**	Back of House SG (130 x 75m various buildings) Height 28m	560738 560674 560642 560690 560775 560726 560660 560718 560757 560697 560639 560685	174843 174850 174811 174819 174837 174859 174833 174808 174860 174843 174848 174799	1. To define the geological profile and geotechnical parameters of the strata sufficient to inform foundation design and potential for spoil re-use 2. To identify the physical and chemical characteristics of near surface soils and deeper geology 3. To define the groundwater regime (shallow and deep) 4. To define the ground gas regime	2 No CP holes with rotary follow on. *[Phase 2 - add 2No CP]* 3No WS *[Phase 2 add 3No WS]* 3 No TPs.	SSSI – NE consent UXO risk	2 No CP to 50m WS to 5m TPs to 4m.	Standpipe piezo with GW & HGG response zones Gas monitoring standpipes in WS.	SPTs at 1m intervals in made ground, and granular alluvium and terrace gravels SPTs at 1m interval in the chalk, until depth rotary follow commences. U100 in cohesive soils and weathered chalk at 1m to 1.5m centres, for chalk classification Large bulk disturbed samples at 1m intervals in trial pits and at change in strata type. Pressuremeter tests within the chalk at 5m intervals. Laboratory: Index / classification, strength, consolidation and permeability tests.	Samples @ 0.5, 1.0 and 1.2 from starter pit then @0.5m intervals. **Soils [Natural strata]** Sample at top of natural strata and @ 0.5m intervals if visual/ olfactory evidence of contamination. No further samples of non contaminated **Chemical analyses** Selected samples of MG for Suite E and 10% for Suite H. Allow 10% samples for analysis by VOCs, SVOCs, TPHCWG, asbestos quantification.
TP422 TP423 WS423 WS424 CP425 CP426		Energy Centre EC1 (105 x 40m) Height 28m	560744 560785 560771 560800 560746 560821	174792 174801 174782 174811 174817 174781	1. To define the geological profile and geotechnical parameters of the strata sufficient to inform foundation design and potential for spoil re-use 2. To identify the physical and chemical characteristics of near surface soils and deeper geology 3. To define the groundwater regime (shallow and deep) 4. To define the ground gas regime	3 No CP holes with rotary follow on. *[Phase 2 - add 2No CP]* 3No WS *[Phase 2 add 3No WS]* 3 No TPs.	SSSI – NE consent UXO risk	3 No CP to 50m WS to 5m TPs to 4m.	Standpipe piezo with GW & HGG response zones Gas monitoring standpipes in WS.	As above	As above

Ex hole ref.	Location				Objectives	Methodology	Known constraints	Depth (m)	Installations	Sampling. In-situ & ex situ testing	
	Zone	Building / structure	Easting	Northing						Geotechnical	Geoenvironmental & Geoarchaeological
	Zone 4D	Marsh No works proposed									
TP501 TP502 TP503 WS501 WS502 WS503 CP501	**Zone 5A**	15. Hotel (H3) (130 x18m) Height 60m	560323 560304 560264 560253 560248 560336 560293	175176 175129 175158 175175 175132 175108 175159	1. To define the geological profile and geotechnical parameters of the strata sufficient to inform foundation design 2. To identify the physical and chemical characteristics of near surface soils and deeper geology 3. To define the groundwater regime (shallow and deep) 4. To define the ground gas regime	1No CP holes with rotary follow on. *[Phase 2 - add 3No CP]* 3 No WS 3 No TPs	UXO risk Outside SSSI	CP to 75m WS to 5m TPs to 4m	Standpipe piezo with GW & HGG response zones Gas monitoring standpipes in WS.	As above plus: Infiltration Test in 1 No TP at 1m, 2m and 3m depth. Provide trench box to support sides	As above
TP504 TP505 TP506 WS504 WS505 WS506 CP502		9. Plaza (70m dia) Platform Height 16m Mast Structure Height 127m	560441 560464 560410 560421 560471 560425 560434	175207 175153 175180 175199 175181 175144 175171	1. To define the geological profile and geotechnical parameters of the strata sufficient to inform foundation/ construction design 2. To define the groundwater regime (shallow and deep)	1No CP holes with rotary follow on. *[Phase 2 - add 3No CP]* 3 No WS 3 No TPs	UXO risk Outside SSSI	CP to 75m	Standpipe piezo with GW response zone Gas monitoring standpipes in WS.	As above plus: Infiltration Test in 1 No TP at 1m, 2m and 3m depth. Provide trench box to support sides	As above
TP507 TP508 TP509 TP510 TP511 WS507 WS508 WS509 WS510 WS511	**Zone 5B**	17.Staff Accommodation (90 x 15m – building shapes vary) 40m high	559924 560057 560162 560264 560389 559987 560060 560200 560253 560310	174881 174930 174869 174895 174836 174909 174888 174910 174850 174884	1. To define the geological profile and geotechnical parameters of the strata sufficient to inform foundation design 2. To identify the physical and chemical characteristics of near surface soils and deeper geology 3. To define the groundwater regime (shallow and deep) 4. To define the ground gas regime	3No CP holes with rotary follow on. *[Phase 2 - add 3No CP]* 5 No WS *[Phase 2 - add 3No WS]* 5 No TPs	SSSI – NE consent UXO risk Eastern Quarry pipes	1 No CP to 50m. 2 No to 40m. WS to 5m TPs to 4m	Standpipe piezo with GW & HGG response zones Gas monitoring standpipes in WS.	As above plus: Infiltration Test in 1 No TP at 1m, 2m and 3m depth. Provide trench box to support sides	As above

Ex hole ref.	Location				Objectives	Methodology	Known constraints	Depth (m)	Installations	Sampling. In-situ & ex situ testing	
	Zone	Building / structure	Easting	Northing						Geotechnical	Geoenvironmental & Geoarchaeological
CP503			559943	174946							
CP504			560133	174911							
CP505			560352	174866							

Appendix B Exploratory Hole Plans

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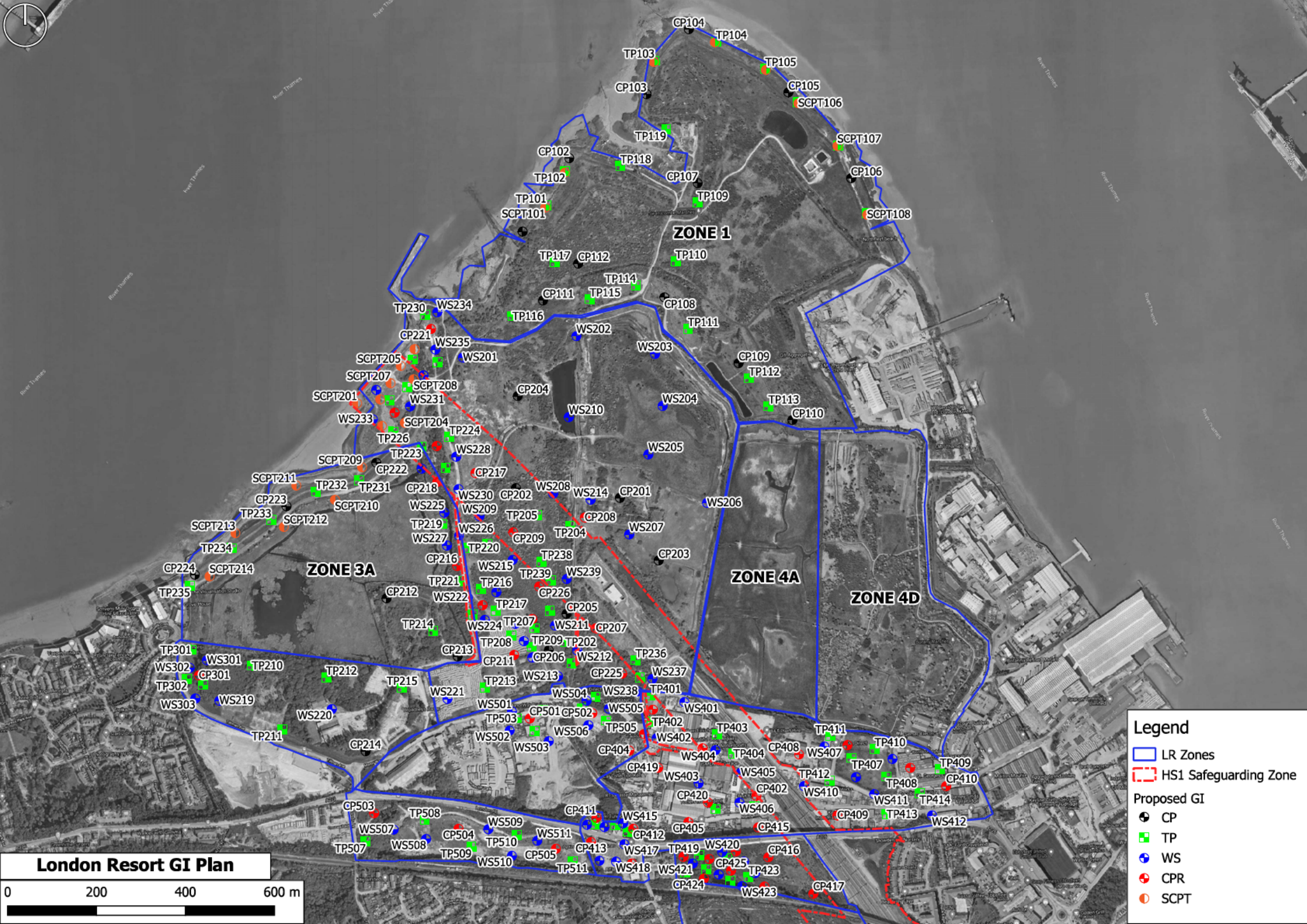
ZONE 1
ZONE 3A
ZONE 4A
ZONE 4D
CP104
TP104
TP103
TP105
CP103
CP105
SCPT106
TP119
SCPT107
CP102
TP118
CP106
TP102
CP107
TP109
TP101
SCPT101
SCPT108
TP117
CP112
TP110
TP114
CP111
TP115
CP108
TP230
WS234
TP116
TP111
CP221
WS202
WS235
WS203
SCPT205
WS201
CP109
SCPT207
TP112
SCPT208
CP204
SCPT201
WS231
WS204
TP113
WS210
CP110
WS233
SCPT204
TP224
TP226
WS205
WS228
TP223
SCPT209
CP222
CP217
SCPT211
TP232
TP231
CP218
WS208
WS214
CP201
WS230
CP202
WS206
CP223
WS225
WS209
TP205
CP208
TP233
SCPT212
SCPT210
SCPT213
TP219
WS226
WS207
WS227
TP204
CP209
TP234
TP220
CP203
CP216
TP238
WS215
CP224
SCPT214
TP239
WS239
TP221
TP216
TP235
CP212
WS222
CP226
TP217
CP205
TP214
WS224
TP207
WS211
CP207
TP208
TP209
TP202
TP301
CP213
WS301
CP211
CP206
WS212
TP236
WS302
TP210
CP301
CP225
WS237
TP212
TP215
TP213
WS213
TP401
TP302
WS221
WS504
WS238
WS303
WS219
WS501
WS505
WS401
CP501
CP502
WS220
TP503
TP505
TP402
TP403
TP411
TP211
WS506
WS502
WS402
TP410
CP214
WS503
CP404
CP408
WS407
TP404
WS404
TP407
TP409
CP419
WS405
TP412
WS403
CP410
TP408
CP420
CP402
WS410
WS411
TP414
CP503
WS406
CP409
TP413
TP508
CP411
WS415
WS412
WS509
CP405
CP415
WS507
CP504
WS511
CP412
TP510
CP416
TP507
WS508
CP413
WS417
TP419
WS420
CP505
TP509
CP425
TP423
WS510
TP511
WS418
WS421
CP424
WS423
CP417
London Resort GI Plan
0
200
400
600 m
Legend
LR Zones
HS1 Safeguarding Zone
Proposed GI
CP
TP
WS
CPR
SCPT

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