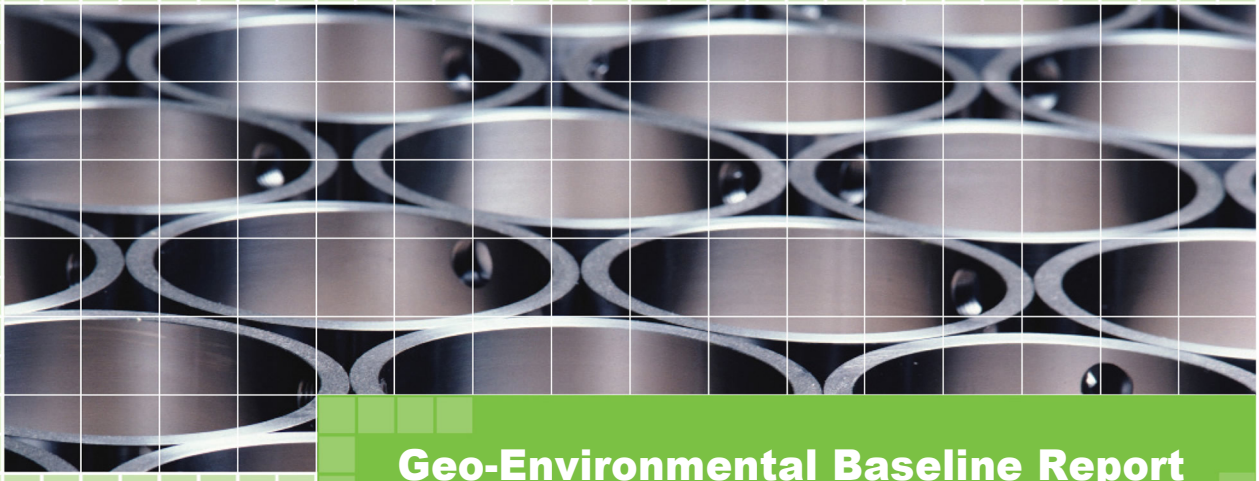

Geo-Environmental Baseline Report
Chatham Maritime Interface Land

SEEDA

May 2010

QM

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Contents

1 INTRODUCTION

1.1 AUTHORISATION

1.1.1 WSP Environment and Energy (WSPEE) was instructed by SEEDA (the Client) to undertake a Geo-Environmental Baseline Assessment of the Chatham Maritime Interface Land, Chatham, Kent (the Site).

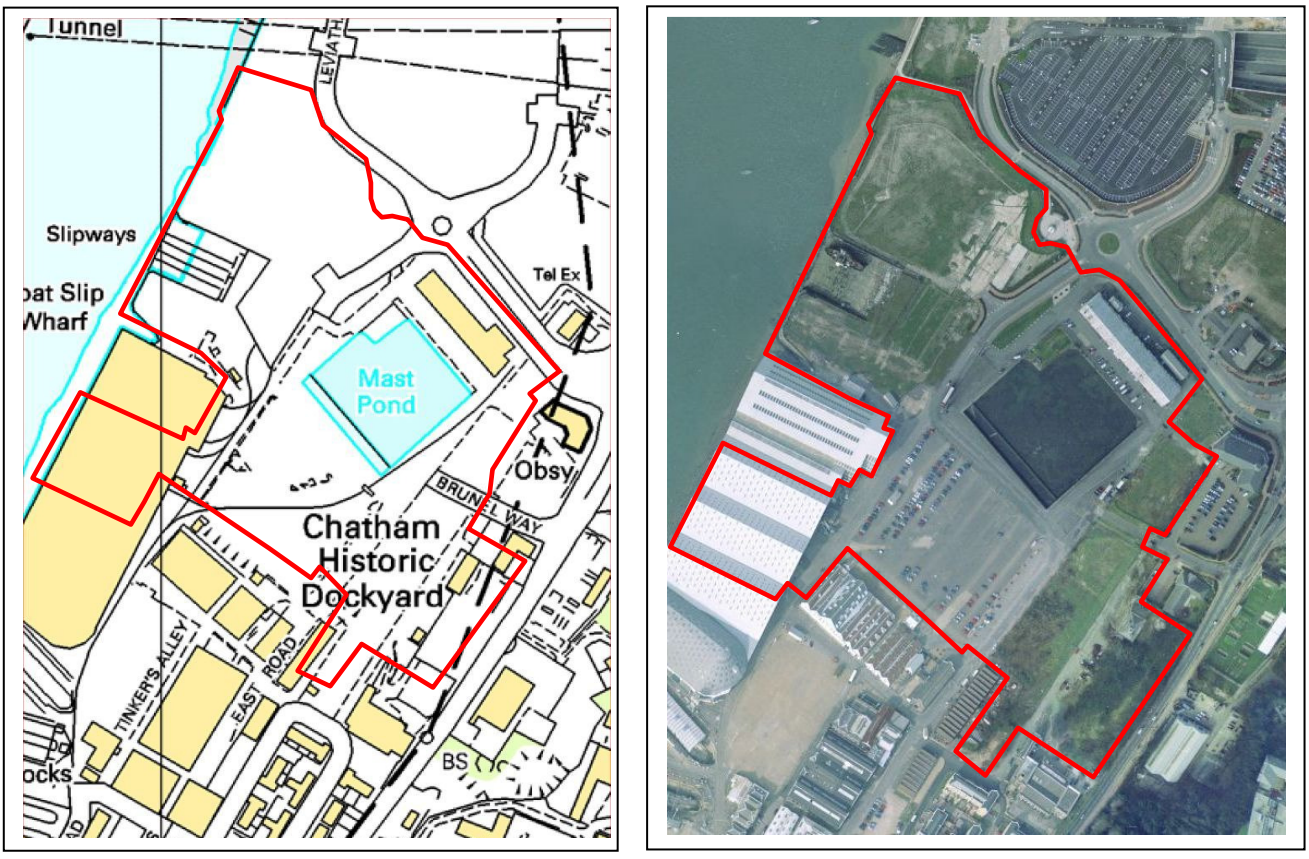
1.2 SCOPE OF WORKS

1.2.1 WSPEE have been instructed to provide Geo-Environmental baseline assessment to support a Supplementary Planning Document produced by Turley Associates for the South East England Development Agency (SEEDA), the report provides an overview of the ground, ground gas and groundwater conditions. In addition, provide a summary review of the provide an indication of potential development constraints.

1.3 SITE AREA AND BOUNDARY PLAN

1.3.1 The Site is understood to occupy approximately 12 Hectares and the site boundary has been taken from the CZWG Architects Preliminary Site Proposals Drawings, December 2009. Figure 1 below shows the current site layout and boundary plan:

Figure 1 Current Site Layout and Boundary Plan



1.4 PROPOSED DEVELOPMENT

1.4.1 The proposed development plan has been taken from the Supplementary Planning Document development zones which have been divided into; Riverside, North and South Mast Pond, Brunel Way and Pembroke Rise. The preliminary scheme details that the development is predominantly residential and is understood to comprise:

Zones	Land Use	Building Massing	Range of Storeys

Zones	Land Use	Building Massing	Range of Storeys
Riverside	Residential led mixed use including soft landscaping	Large to medium scale	Up to 10
North and South Mast Pond	Residential led mixed use and residential	Medium scale	Up to 2
Brunel Way	Commercial including soft landscaping	Medium scale	Up to 4
Pembroke Rise	Primarily residential including soft private gardens	Medium to small scale	Up to 3

1.4.2 It is understood that there is no proposed basement car parking, although under-croft could be possible.

2 SITE SETTING

2.1 SITE HISTORY

2.1.1 Chatham Dockyard was established in the 16th Century, and has undergone subsequent expansion and development until the 1980's when it ceased to be a Naval dockyard. The dockyard has been used for the storage, maintenance and construction of ships and submarines. It is reported that the area was bombed during the First World War and again during the Second World War, when 92 high explosive bombs were dropped on Chatham.

2.1.2 A reduction in productivity post 1945 took place until the construction of a nuclear submarine repair and refuelling complex between Dry Docks No.6 and 7 in the 1960's (Situated north of the site).The Dockyard finally closed in March 1984, when much of the Dockyard was demolished.

2.1.3 Historical maps indicate that the subject site was occupied by a Timber Stores and a Saw Mills / Houses (from circa 1772), and possibly a 'Works Department Office', and a Boat Store / House. It is also believed that a former defensive wall also ran through the site. Tramway crossed the site from pre 1932 until the Dockyard was demolished. North Mast Pond was featured on OS maps since circa 1720s. The south mast pond was excavated in the 1690's and filled c.1885.

2.2 GEOLOGY AND HYDROGEOLOGY

2.2.1 Geological Map Sheet no. 272, Chatham (Geological Survey of Great Britain, Scale 1:63,360), Drift edition, shows the following geological sequence:

Geological Unit	Aquifer Status*
Marine and Estuarine Alluvium – silty sandy clays	Secondary
River Terrace Gravels – silty sandy gravel	Secondary
White Chalk – white chalk with flints	Principal

*Environment Agency Groundwater Vulnerability Map

2.2.2 The site is not located within a groundwater source protection zone as designated by the Environment Agency.

2.3 HYDROLOGY

2.3.1 Surface water features in the vicinity of the subject site are as follows:

Surface Water Feature	Distance (m)	Direction
River Medway	Adjacent	North-western Boundary
North Mast Pond	On Site	N/A

2.3.2 No known surface water abstractions have been identified within a 1km radius of the subject site. In accordance with the Environment Agency website, the site is located in an area that is not protected by flood defences and there is a chance that the River Medway may flood the site at a frequency of 1% (1 in 100) or greater chance of happening each year

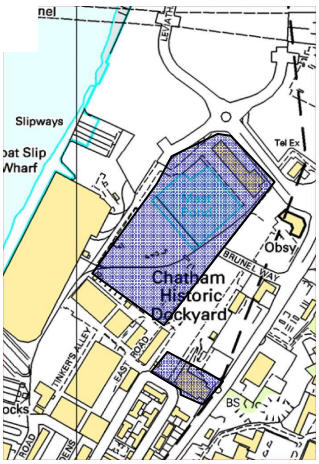
2.4 ENVIRONMENTAL SENSITIVITY

2.4.1 Overall, the site setting is considered to be of a **moderate to high** environmental sensitivity, due to the following reasons:

- The underlying Principal and Secondary Aquifer(s);
- The presence of an unprotected aquifer underlying the site.
- The presence of onsite and adjacent surface water features.
- The mixed residential and commercial use in the surrounding area.

3 DOCUMENT REVIEW

3.1 CAMPBELL REITH HILL, NOVEMBER 2003, CHATHAM MARITIME SITE APPRAISAL STUDIES, FINAL REPORT, INTERFACE LAND (FOR SEEDA). PROJECT NO: 6903/11.



3.1.1 This report provides information on two parts of the Site, predominantly in the central area of the site, although a small plot in the south east is also covered (see adjacent plan).

3.1.2 The report summarises a large range of information gathered from desk top studies, enquiries, surveys and investigations. A site investigation was undertaken on this part of the Site in April 2003. The following represents a summary of the information provided in the document

Site Description

- Area 1: This comprises the central area of the site, covers approximately 4 hectares and is occupied by the north mast pond, Old Boat House, and the former south mast pond which was reportedly filled, covered with gravel, and used as a car park. Occasional, disused railway tracks were also identified at the site.
- Area 2: This area is predominantly occupied by Brunel Saw Mill and is still used as a joiners shop and saw mill. It is understood that the saw mill does not form part of the Site.

Site History

Area 1:

3.1.3 The report identified that Area 1 has previously been the core of the historic dockyard and has been for hundreds of years. This area has historically been occupied by a fortified defensive wall, timber stores and sheds, kilns, mast houses and possibly an armoury. Two mast ponds and three small saw pits (now filled) were also located on the site. The south mast pond was excavated in the 1690's and filled c.1885. The north mast pond, present today, was constructed c.1720. An underground canal linking the mast pond to the Brunel Saw Mill was present on site, and this was later converted to a bunker during WWII. The buildings situated on the southern boundary were occupied by coal stores, pitch house, metal mill, joiners shop and a smithery.

3.1.4 The demolition of the site was identified as a potentially significant contaminative event as oil tanks etc. may have been drained on site before disposal, and hazardous materials (such as asbestos) may have been buried on site.

Area 2: (Brunel Saw Mill and Adjacent Land)

3.1.5 The saw mill was constructed in the early 1800's and comprised various parts of a production line. A timber reservoir, which was connected to the southern mast pond via an underground canal, was present to the north east of the mill, and was backfilled on the closure of the mill in the 1930's. The boiler house for the mill was subsequently occupied by a laundry.

Environmental Setting

Geology

3.1.6 The 'Area 1' is identified as being underlain by Alluvium and River Terrace Gravels (sandstone and flints) over White Chalk, although 'Area 2' is identified as being directly underlain by the White Chalk. It is understood that the Thanet Sands are absent beneath these areas. A substantial and variable thickness of Made Ground is also present on this area.

3.1.7 The northern part of the Site is identified as being underlain by the generally granular backfill of the casting basin for the Medway Tunnel.

Hydrogeology

3.1.8 The White Chalk is classified as a Principal Aquifer, which is described as 'highly permeable rock which has little ability to attenuate diffuse source pollutants and in which non-absorbed diffuse source pollutants and liquid discharges have the ability to move rapidly to underlying strata or to shallow groundwater'. The site is not situated in a Source Protection Zone1.

3.1.9 Although the groundwater beneath the site is likely to be tidally influenced, the Environment Agency identified groundwater to be approximately 1 metre Above Ordinance Datum (AOD). Tidal variations have been measured at 2.5m, and it is therefore likely that groundwater levels will reflect this.

3.1.10 The report identified, that based on historical site investigation data, the River Terrace Gravel aquifer and the White Chalk aquifer were in hydraulic continuity, which were overlain and potentially confined by Alluvium with a relatively low permeability. Perched groundwater is also believed to present within the Made Ground above the Alluvium.

Hydrology

3.1.11 The tidal River Medway, situated along the western boundary of the 'Site' is identified as the only large water course in the area.

Environmental Issues

Asbestos

3.1.12 Asbestos surveys of the Lower Boat House and Brunel Saw Mill were conducted in 2003, and these identified major occurrences of asbestos in the saw mill (specifically the basement) and the underlying tunnels.

Previous Site Investigations

3.1.13 Intrusive investigations have been undertaken on the Chatham Maritime area, although these were identified as being predominantly geotechnical. An investigation undertaken in 1997 immediately to the north of Area 1 identified significant depths of Made Ground containing various organic and inorganic contaminants including asbestos. Furthermore, organic contamination (including PAH's) was identified in the groundwater.

3.1.14 An investigation was undertaken in 1963 for a proposed bulk oil fuel storage store adjacent to the eastern boundary of 'Area 1' which traversed areas 'F4' and 'F5' on the 'Brunel Area'

Site Investigation Data

3.1.15 A ground investigation was conducted following the desk study review in April 2003. Prior to the intrusive investigation, an asbestos survey of surface soils was undertaken which revealed asbestos to be present in soils within the Site.

3.1.16 Areas 1 & 2 of the 'Interface Area' were investigated although, due to archaeological constraints; the filled South Mast Pond could not be investigated. Furthermore, no geotechnical work was undertaken.

3.1.17 Thirteen trial pits and seven boreholes were excavated, although five trial pits were abandoned at shallow depths due to obstructions.

3.1.18 Ground conditions at the site were identified as Made Ground comprising two layers, over Alluvium and in one borehole, River Terrace Gravel. The Made Ground was identified to thicken to the east of the site and contained sands, silts, clays, ash, chalk, slag, flint, wood chippings, timber and ironwork. Strong odours of creosote were also noted.

3.1.19 The analysis of soil samples indicated elevated levels of inorganic contaminants at various concentrations and locations across the site. Furthermore, organic contamination (PAH's) was also identified in the soils. Tit is unknown if hydrocarbon (TPH) analysis was undertaken.

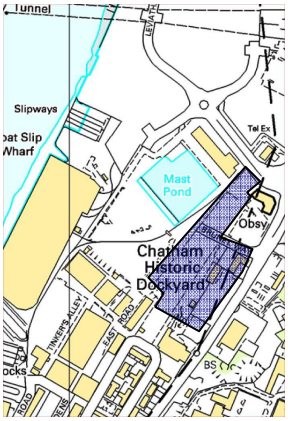
3.1.20 The report details that a trial pit which was excavated through the filled timber reservoir on the Brunel site shows Made Ground to comprise wood chippings, brick, gravel and slag becoming sandy clay and silt. The report infers that the reservoir walls are not permeable, and should any contamination exist, it is likely to be contained, although there is no supporting evidence for this.

[1] Environment Agency website, January 2006.

3.1.21 Analysis of groundwater samples indicated fluctuating levels of contaminants within the groundwater. The contaminants identified included metals and occasionally Volatile Organic Compounds (VOC's). One significantly elevated concentration (46mg/l) of bis (2ethylhexyl) phthalate was identified in borehole BH3 although the location plan showing this location has been omitted from the report supplied to WSP Environmental.

3.1.22 No significant gas issues were identified from the analysis of the soil gas within the five boreholes monitored.

3.2 CAMPBELL REITH HILL, SEPTEMBER 2002, CHATHAM MARITIME SITE APPRAISAL STUDIES, FINAL REPORT, BRUNEL AREA (FOR SEEDA). PROJECT NO: 6903/11



3.2.1 This report provides information on one part of the Site along the eastern boundary of the Site (see adjacent plan).

3.2.2 The report summarises a large range of information gathered from desk top studies, enquiries, surveys and investigations. A site investigation was undertaken on this part of the Site in October and November 2002.

3.2.3 The following represents a summary of the information provided in the document.

Site Description

3.2.4 The site is an irregular piece of land occupying approximately 2.6 hectares. For reporting purposes, the site was divided in to three areas, named as F2 to F4. The site is occupied by an old Police House in the north, with the remaining areas split over several levels, divided up by some retaining walls. Mature trees and dense shrubbery occupy much of the site. It is known that an underground tunnel is present in the southern area of the site, which linked the saw mill to the South Mast Pond to the west of this plot. A small underground chamber has also been identified to be present in the south west area of the plot. Some mounds of 'fly tipped' material were noted.

Site History

3.2.5 This area has historically been occupied by a fortified defensive wall, timber stores and sheds, kilns, mast houses and possibly an armoury. In later years a steam driven saw mill was constructed on the south eastern boundary, with the ancillary facilities constructed on the 'Brunel Area'. These included an overhead rail system and saw pits.

Environmental Setting

Geology

3.2.6 The 'Brunel' area is identified as being situated on the White Chalk and River Gravels which outcrop on the western area of the site. Trial pits on the 'Brunel Area' encountered significant thicknesses of wood shavings and sawdust. Furthermore, an investigation undertaken in 1966[2] on the south west area of the Brunel site indicated 3 metres of Made Ground, over sandy clay with stones and gravel. Chalk was identified at 8 metres below ground level. Previously, in 1963, another investigation in the North West of the Brunel area identified 3 metres of Made Ground over alluvial sandy clay and sandy gravels, with chalk encountered at 10 metres below ground level.

Hydrogeology

3.2.7 The hydrogeology of the site is the same as that described in the 'Interface Land' report, detailed in Section 2.2.

Hydrology

3.2.8 The tidal River Medway, situated along the western boundary of the 'Site' is identified as the only large water course in the area.

[2] Identified in the CRH report as '1996' although this is believed to be a typing error.

Environmental Issues

Asbestos

3.2.9 An 'Asbestos Status' report was referenced which identified that asbestos clearance work were undertaken across Chatham Maritime area including the Brunel Area in the late 1980's, although the records were reported to be incomplete.

3.2.10 Asbestos surveys of the Lower Boat House and Brunel Saw Mill were conducted in 2003, and these identified major occurrences of asbestos in the saw mill (specifically the basement) and the underlying tunnels. A 'walkover asbestos survey' of the Brunel site was undertaken and asbestos was identified in former structures and general building debris on the site.

3.2.11 A survey of ducts potentially containing asbestos material was also undertaken, although none was reported by CRH to be present in the ducts.

Previous Site Investigations

3.2.12 Intrusive investigation has been undertaken on the Chatham Maritime area, although these were identified as being predominantly geotechnical.

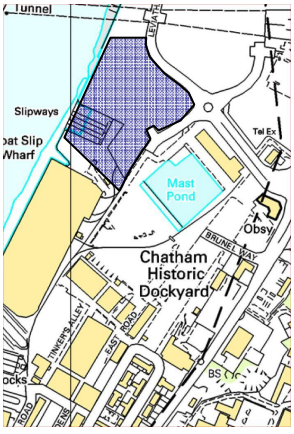
Site Investigation Data

3.2.13 Trial pits on the 'Brunel Area' encountered significant thicknesses of wood shavings and sawdust. Furthermore, an investigation undertaken in 1966 on the south west area of the Brunel site indicated 3 metres of Made Ground, over sandy clay with stones and gravel. Chalk was identified at 8 metres below ground level. Previously, in 1963, another investigation in the North West of the Brunel area identified 3 metres of Made Ground over alluvial sandy clay and sandy gravels, with chalk encountered at 10 metres below ground level. No contamination testing was undertaken during these investigations.

3.2.14 An investigation undertaken prior to the construction of the Observatory Building, on the north east boundary of the Brunel area indicated similar ground conditions to the Brunel site. The investigation identified elevated ground gases, including flammable gases and carbon dioxide.

3.2.15 Campbell Reith Hill undertook a site investigation in October and November 2000 comprising 53 trial pits to a depth of 4 metres below ground level. Numerous constraints including service ducts, trees and buildings were encountered during the investigation. No groundwater analysis or gas monitoring was undertaken as part of this investigation. Visual evidence of contamination, comprising suspected asbestos and ashy material was observed during the trial pitting. Analysis of the soil samples for various contaminants was undertaken and identified contamination of the soils to comprise metals and polycyclic aromatic hydrocarbons (PAH's). Furthermore, analysis confirmed the presence of asbestos in the form of cement sheeting, pipe fragments and some fibrous insulating panels.

3.3 CAMPBELL REITH HILL, JUNE 2001, CHATHAM MARITIME SITE APPRAISAL STUDIES, FINAL REPORT, WATERSIDE AREA (FOR SEEDA). PROJECT NO: 6903/11



3.3.1 This report provides information on one part of the Site along the north western boundary of the Site (see adjacent plan).

3.3.2 The report summarises a large range of information gathered from desk top studies, enquiries, surveys and investigations. A site investigation was undertaken on this part of the Site in November 2000.

3.3.3 The following represents a summary of the information provided in the document.

Site Description

3.3.4 The site occupies approximately 3 hectares and is generally hard covered although it appears that some soft standing exists. A boat slip is present along the western boundary adjoining the River Medway. The site was recently used as a

compound for contractors involved in the construction of Leviathan Way. A further boat slip was present in this area, but is believed to have been in filled as part of the construction of the Medway Tunnel.

Site History

3.3.5 Pre 1870's the main activity of the dockyard was located to the south of the Waterside area and was established there for hundreds of years. To the north of the Waterside area were alluvial marshlands. It is understood that in this part of the Site was occupied by housing, sheds a timber store and possibly an armoury.

Environmental Setting

Geology

3.3.6 The Waterside area is identified as being situated on a significant thickness of Made Ground over Alluvium then White Chalk. Trial pits in the area encountered a significant thickness of wood shavings and sawdust from former timber working.

Hydrogeology and Hydrology

3.3.7 The hydrogeology of the site is the same as that described in the 'Interface Land' report, detailed in Section 2.2. The tidal River Medway, situated along the western boundary of the 'Site' is identified as the only large water course in the area.

Environmental Issues

Asbestos

3.3.8 An 'Asbestos Status' report was referenced which identified that asbestos clearance work were undertaken across Chatham Maritime area including the Brunel Area in the late 1980's, although the records were reported to be incomplete.

3.3.9 A walkover survey conducted in May 2000 identified asbestos containing material, including cement board and cement pipe on the ground surface.

Previous Site Investigations

3.3.10 Intrusive investigation has been undertaken on the Chatham Maritime area, although these were identified as being predominantly geotechnical. Campbell Reith Hill undertook a site investigation in November 2000. The investigation comprised trial pitting and subsequent soil sampling and analysis. No groundwater or ground gas analysis was undertaken.

Site Investigation Data

3.3.11 Ground conditions were identified as thick variable horizons of Made Ground over Alluvium. The Made Ground generally comprised hardcore over sandy organic clay. Fragments of asbestos containing material such as cement pipes, tiles or bitumen coated cables were encountered. It is reported that asbestos materials were generally in concentrations below 0.01% by volume in bulk soil samples. Layers of dark black wood shavings which gave off a significant organic odour were also noted.

3.3.12 The analysis of soil samples indicated elevated levels of inorganic contaminants at various concentrations and locations across the site. A large area of this part of the Study Site was found to be 'saturated with hydrocarbons', although 'chemical results showed only a few trial pits had elevated levels of hydrocarbons'

4 ENVIRONMENTAL RISK ASSESSMENT

4.1 BACKGROUND

4.1.1 The objectives of the hazard assessment process are to:

- determine the sources of contamination (if present);
- identify specific chemicals of potential concern (if present);
- identify possible contaminant migration pathways;
- identify possible receptors (e.g. soil, groundwater, humans and third parties) which could be affected, including their relative potential sensitivity to contaminants given their nature of exposure; and,
- construct a conceptual model for the site which clarifies the mechanisms by which the site may present a risk, highlighting those sources of risk which will require further assessment and those which can be eliminated.

4.1.2 The conceptual model, which is revised and developed in light of investigation findings, provides a description of three elements i.e.

- the actual and probable nature, extent and location of contaminants, i.e. the SOURCE term;
- the potential existing and reasonably foreseeable future on-site and off-site RECEPTORS to contamination; and,
- the likely migration PATHWAYS by which contaminants may reach such receptors.

4.1.3 Such information enables the development of plausible POLLUTANT LINKAGES between sources of contamination and receptors, and thus an estimation of the risks that may be present.

4.1.4 The typical chemicals associated with these land uses have been identified within DEFRA R&D Publication CLR8 Potential Contaminants for the Assessment of Land and this information has been used to inform our conceptual site model.

4.2 CONCEPTUAL SITE MODEL

4.2.1 The pollutant linkages listed the tables below are considered to be plausible and could therefore potentially represent a significant risk of harm to human health and/or the pollution of Controlled Waters.

Potential contaminant Sources	Associated contaminants	Potential migration pathways	Sensitive receptors
Dockyard and Saw Mills (*Historical)* **Made Ground** (*Historical)*	**Potential Contaminants:** Range of metals, Oil/fuel hydrocarbons, Polycyclic Aromatic Hydrocarbons (PAH), and asbestos. Ground gases (methane and carbon dioxide).	*On-Site Human Health* Inhalation of volatile vapours/ ground gases. Direct contact with soil & groundwater. Ingestion of soil and dust. *Off-site* Migration through the underlying geology.	*On-Site Human Health* ■ Future residential and commercial occupants. ■ Construction & Maintenance Staff. ■ Potable water supply pipes. *Controlled Waters* ■ Principal and Secondary Aquifer. ■ River Medway. *Buildings*

5 DEVELOPMENT CONSTRAINTS

5.1.1 Based on the information reviewed to date, and the proposed development plan discussed earlier in this report, the following items have been identified as potential development risks.

5.1.2 WSPEE note that the re-use of site won materials will require careful consideration and completion of assessments such as an earthworks and/or material management plans.

5.1.3 It is also understood that the finished ground levels will be closely constrained by existing features such as the Mast Pond and access into the Historic Dockyard, which may mean that significant land raising may not be possible. However, the requirements which may be made to satisfy flood protection standards may conflict with this. Detailed level studies will be required to resolve that conflict.

5.2 CONTAMINATED LAND

5.2.1 WSPEE have noted the following development considerations and constraints:

Site Investigations

- Soil and groundwater analysis undertaken 9 years ago provides a reasonable indication of contaminants in certain areas, but the method of analysis and subsequent laboratory reporting undertaken at the time (specifically relating to organics) does not conform to current best practice, therefore further investigation, analysis and interpretation is required to assist in the assessment of risk at the site.
- Interpretation has been made using best practice adopted at the time, although in some instances the assessment methods have changed and therefore the data will have to be reassessed. Furthermore, the assessment will need to be specific to a development plan to assess the risks posed.
- Other contaminants potentially present at dockyard sites may not have been analysed for and may require further consideration during any additional site investigation.
- The previous investigation works is considered appropriate to identify some land quality issues. However, the classification of soils that may potentially be regarded as waste requiring disposal at landfill differs from land quality and other environmental risk evaluation criteria. From July 2005 wastes classified as hazardous have been required to comply with Waste Acceptance Criteria (WAC) and may also require further treatment prior to disposal at landfill. Due to these changes in legislation it will be necessary to undertake further evaluation of materials present at the study area for waste classification purposes.

Contamination

- Contaminants identified in the soil typically comprised metals, inorganic, asbestos and hydrocarbons including TPH and PAHs. Some of the contamination may classified as Hazardous Waste.
- During excavation works, there may be evidence of former basements, including concrete floors and walls, which may indicate highly variable ground conditions.
- Significant finds of asbestos materials, including fibrous insulating panels, cement sheeting and pipe fragments were noted in several areas of fill. Underground ducts potentially containing asbestos materials have been recorded to run across portions of the site.

Additional Assessment and Remedial Measures

- Although the foundation solution for the majority of the development would be piling, the exact method is unknown. Various complications are envisaged in relation to the piling. These include the restriction of use of driven piles to prevent excessive ground vibration near the Scheduled Ancient Monuments on site and other protected buildings. The preparation of a Foundation Works Risk Assessment Report and its examination by Environment Agency and Local Authority officers is likely to be required and is intended to assist planning authorities to meet their objectives described in Planning Policy Guidance (PPG) 23. It is likely that arisings from piling through Made Ground could be classified as Non Hazardous or Hazardous and the Natural Ground as Non Hazardous or Inert.

- Groundwater assessment is very limited across the site and further intrusive work is required to fully understand and assess the risks posed by any contamination which may be present. Some groundwater assessment undertaken in the central area of the site identified potentially significant contamination of the groundwater with Bis (2ethylhexyl) phthalate. The data provided indicates a potential risk although does not quantify the magnitude or extent of the risk. Further assessment and potentially remediation may be required.
- Potential dewatering of perched groundwater may be required during excavations. Groundwater contamination is present across the site and there may be a requirement to treat groundwater prior to disposal from dewatering.
- It has been identified on the architectural drawings that residential houses with private gardens and some areas of soft landscaping are incorporated in the development. Due to the increased exposure risks to residents in these properties, a more conservative assessment will be required for these development areas, and may require a greater amount of remediation than other areas of the site. Remedial measures may include treatment or excavation and disposal or capping to sever the potential pollutant linkages.
- Due to the nature of the Made Ground present beneath the site and potential contamination present, there is a significant risk of ground gas being generated at the site, and therefore gas protection measures may need to be incorporated into the development.
- There is a possibility that due to the contaminants identified in the soils beneath the site, suitable protection to potable water supply pipes may be required where pipe work is proposed to be installed in areas where contaminated soils are present (i.e. if soils are untreated). Consultation with the potable water supply company is recommended to identify if chemically suitable backfill is required to form 'clean' corridors or selection of appropriate pipe materials are needed.
- Persons undertaking works that penetrate below ground level need to consider the contamination recorded and appropriate health and safety and personal protective equipment is required.

5.3 GEOTECHNICAL

5.3.1 WSPEE have noted the following development considerations and constraints. The risks associated with the proposed development relate primarily to the nature of the underlying geology and the historical development at the site.

Ground Conditions and Potential for Settlement and Ground Movement

5.3.2 The thickness of the Made Ground varies considerably across the site. In general, the depth of Made Ground increases from 2m to 4m thick in the east of the site to at least 6m thick in the west of the site (adjacent to the River Medway). In the north-west corner of the site Made Ground up to 15m may be present; material that was excavated to form the casting basin for the Medway tunnel segments and backfilled upon completion. The composition of the Made Ground is variable but includes loose granular materials, soft to very soft cohesive deposits including organic material (possibly alluvial soils recovered from other areas of the dockyard) together with man made items.

5.3.3 Elsewhere in Chatham docks it is reported that Made Ground was found down to 9m bgl, although this was related to the development behind the more 19th Century Dockyard expansion.

5.3.4 The majority of Made Ground would have been deposited during the mid-nineteenth century expansion of the dockyards. Earthworks techniques at that time would have been crude and it is unlikely that a high state of compaction of the material would have been achieved. Although variable, the depth and composition of the Made Ground means that creep settlement may still be occurring. Although not currently indicated, the rate of this long term movement would be exacerbated by any raise in site levels as part of the development.

5.3.5 The impacts associated with any ongoing creep settlement of the Made Ground in terms of the proposed development are increased settlement of road pavements and hardstanding areas, movement of service connections where these enter structures and the requirement to install drainage at a deeper level to cater for anticipated long term movements. The reviewed information does not record any creep settlement of the Made Ground and it is considered unlikely that an assessment of this has been undertaken. Based on the lack of definitive information, creep settlement should be considered a potential risk to the proposed development. Further detailed investigation and assessment is required to assess the risks and degree of creep settlement to inform drainage design.

5.3.6 The Alluvium underlying the Made Ground is indicated to vary in thickness and composition across the site. The Alluvium also comprises loose granular materials, soft to very soft cohesive layers and layers of organic material (peat). Similarly to the Made Ground above, these deposits may still be undergoing settlement due to the weight of the overlying material (Made Ground) placed on it.

5.3.7 The following measures may be required to mitigate these risks:

- Additional thickness of pavement construction in roads and hardstanding areas. Due to the potentially poor performance of the Made Ground as a sub-grade material across the site this may be accounted for in the overall pavement design; or
- Depending on the composition and thickness of the Made Ground under pavement and hardstanding areas it may also be necessary to undertake ground improvement techniques e.g. excavation and re-compaction of upper layer of Made Ground, install vibro-replacement stone columns or add stabilisers (lime / cement);
- Provision of flexible service connections;
- Drainage laid at increased falls (requiring deeper service trenches) to offset long term movement across most of the site.
- Installation of band drains to accelerate settlement of the Alluvium. This would also accelerate settlement of the Made Ground;
- The requirement to support larger service ducts or drainage runs on piles to avoid excessive settlements and maintain serviceability. Supporting larger service ducts or drainage runs on piles may due to settlement of the ground around any buried services supported on piles possibly resulting in reflective cracking or differential movement at ground level. Allowance for additional ground treatment such as geo-grid reinforcement or vibro-replacement stone columns over the location of any piled services may be required to minimise differential settlement. It should be noted that some of the existing culverts at the site are reported to be supported on timber piles.

5.3.8 Due to the negligible bearing capacity of both the Made Ground and Alluvium and the nature of the development at the site it is likely that the majority of structures will be supported on piled foundations. Any settlement of the Made Ground and Alluvium will produce negative skin friction against the shaft of piles passing through these strata which will reduce the available superstructure load that may be carried on each pile.

5.3.9 The impact associated with settlement of the upper strata is the requirement for larger, longer or a greater number of piles. The amount of any negative skin friction would relate to the thickness of the Alluvium / Made Ground and in some areas e.g. the backfilled casting basin where the Made Ground is up to 15m deep, could be a significant proportion of pile capacity (depending on the pile dimensions and piling technique adopted). The potential for negative skin friction to occur at the site should be considered as significant, pending further investigation.

5.3.10 The effect of negative skin friction can be mitigated by sleeving piles over the depth of the compressible soils i.e. the Made Ground and Alluvium. This would restore the available working load of the pile for carrying structural loads only however this is unlikely to make a significant difference to the length of the pile likely to be used at the site. Alternatively, the effect of the negative skin friction can be taken into account in the foundation design and additional or larger piles installed to increase the superstructure load capable of being carried on each pile.

5.3.11 Buried river channel features could exist in the ground underlying the site area. These features within the River Terrace Gravels or Upper Chalk would have been infilled by the Alluvium when deposited and, if present, would represent localised areas with an increased thickness of alluvial material.

5.3.12 Any pile foundations within these features would therefore need to reach the underlying competent strata and the piles would be longer compared to piles in other areas. There may also be increased negative skin friction associated with the additional depth of Alluvium in these features.

5.3.13 Where any contaminated Made Ground is excavated, localised heave of the base of the excavation may occur. Settlement of the underlying soils would then take place following filling of the excavation. The impact of this settlement combined with any self settlement of the placed material could cause localised areas of increased / differential settlement compared with surrounding areas. This is assessed as being a minor risk at the site. It is considered that the earthworks techniques which will be required at the site will be suitable for mitigating the potential settlement issues detailed above.

5.3.14 It was noted that ground movement of up to 100mm was recorded during the dewatering operation for the construction of the Medway Tunnel. Following cessation of the dewatering in 1995 heave of the ground of around 5mm was recorded as water levels recovered. It is considered a very minor possibility that ground movements associated with construction of the Medway Tunnel could still be occurring. The soils at the site are susceptible to further settlement if other dewatering schemes are undertaken. Although subject to confirmation following further assessment it is likely that no additional construction costs will be associated with this issue.

Potential for Solution Features

5.3.15 Solution features could be present within the Upper Chalk. The impact associated with any solution features would be a possible greater thickness of Alluvium and an increased depth to a competent founding stratum (necessitating longer piles). If proved in any area of the site these features would need to be delineated. The issues associated with piling through increased depths of Alluvium would be as given previously above. The possible presence of a buried natural chalk headwall in the general site area has been noted in the information that has been reviewed. This may restrict the type of pile that could be adopted in these areas e.g. certain types of driven pile. Measures to mitigate this feature will however be dependant on whether it is present at the site and below the footprint of a proposed structure, additional investigative works should be undertaken to confirm (or otherwise) the location and extent of these features.

Groundwater

5.3.16 High groundwater levels (around 1.0m bgl) have been recorded at the site. Perched groundwater is likely to be present within the Made Ground at the site. Groundwater levels within the Made Ground are also likely to be variable due to the variable composition of the Made Ground, and also could present a risk from groundwater flooding. Any large excavations at the site are likely to require dewatering of excavations and / or the installation of sheet piles to provide a groundwater cut-off. It is recorded that a layer of clay was used to line the base of the casting basin excavation prior to backfilling which may result in perched groundwater at depth at this location. Depending on the nature of the backfill at that location collapse settlements due to inundation caused by a rise in the level of the perched water could occur. It is likely that mitigating measures adopted to control settlement of the Made Ground and Alluvium could also be adopted to offset the effects of any settlements resulting from inundation of deep areas of fill.

Risks Related to Historical Development at the Site

5.3.17 Obstructions relating to basements or foundations of former buildings are likely to be encountered where new structures are proposed on the site of former buildings.

5.3.18 The main impact associated with construction at the location of former buildings at the site comprises the potential for clashing of proposed foundations with relict foundations and other in-ground obstructions. This would cause delays and may require the redesign of some elements of the foundations or structure, potentially contributing to a substantial increase in construction costs.

5.3.19 The potential for relict foundations and in-ground obstructions should be considered as significant at this site given the nature of the historical development of the dockyard. Obstructions relating to buildings or features which are not marked on available historical maps should also be considered. Obstructions along proposed service runs as well as under the footprints of buildings should also be considered.

5.3.20 In order to mitigate the impact of potential obstructions in the ground the following measures should be undertaken:

- Proposed foundation or basement locations should be probed for the presence of obstructions. Alternatively, trial trenching could be undertaken. It is recommended that the foundation strategy for the site incorporates probing or trenching across the footprint of every proposed building at the site. This will provide a definitive record of the presence (or otherwise) of obstructions. Trial trenching is likely to provide the most rapid means of examining the site.
- Records indicate that the foundations of the existing buildings at the site comprise either strip or pad foundations bearing onto the River Terrace Gravels or timber piles. Other foundation techniques may also have been adopted. It should be considered that the floorslabs of existing buildings may also be supported on piles. Trial trenching should be undertaken across the location of foundations for proposed buildings at the site. It is estimated that 40m to 50m (linear) of 2.0m deep trenching could be undertaken per day (excluding breaking out of hard surfacing). Trenching along proposed service runs should also be undertaken at regular intervals.

- The most cost effective way of dealing with in-ground obstructions will be to position proposed foundations around them where possible. An allowance should be made for potential re-design of foundations to avoid in-ground obstructions. Where it is not possible to avoid obstructions, breaking them out and removing them may be required.
- In the case of retaining structures e.g. basement walls, slipway walls etc. it should be sufficient to demolish these structures to a given depth, typically 2.0m below finished ground levels. The likelihood that this will be required at the site is considered significant and provision for this should be allowed for.
- It is known that buried culverts and service ducts are present at the site and the position of these structures should be confirmed in order that they can be avoided by proposed foundations. Probing or trenching should be undertaken to confirm the location of known structures.

5.3.21 It should also be considered that substantial foundations could be associated with the travelling cranes adjacent to the boat slips, former aerial tramway and lifting gear. It is also possible that ground anchors may extend from the rear of the dock wall and / or boat slips which would need to be identified. Where proposed buildings are located near these (existing or historical) structures trial trenching should be undertaken to confirm the construction of these features.

5.3.22 Buildings / features which are being retained on site may have sterilized areas around them in which certain construction operations may be prohibited within a certain distance due to the sensitivity of the structure e.g. the dock wall or tunnel from the south mast pond to the sawmill or due to its historical status e.g. the mast ponds, boat house and saw mill which are registered as ancient monuments and / or listed buildings. In these areas, any restrictions in investigative works (e.g. site investigation, probing for obstructions) prior to construction could increase the risk of delays and cost overruns.

5.3.23 Given that most of the proposed buildings at the site will be located either near the dock wall, existing buildings to be retained or site features and the restrictions placed on previous ground investigations, there is a significant possibility that there will be restrictions to any further investigative works undertaken at the site. An allowance should be made for additional design and construction costs that may be required due to site restrictions.

5.3.24 Any structural features retained at the site as part of the redevelopment e.g. the dock wall and retaining wall towards the saw mill, for which construction details are not known will need to be checked for compliance with current design standards and to ensure that an adequate design life exists. If these structures are found to be non-compliant with current standards remedial measures may be required. No confirmation of the stability of these structures has been noted in the review undertaken to date. An allowance should be made for checking of these structures and possible remedial measures.

5.3.25 The contaminative nature of the Made Ground at the site means that foundation techniques which minimise the quantity of soil arisings would be beneficial. Piling through alluvial soils may however result in an increase in negative skin friction due to the reworking of the alluvial soils.

5.3.26 The impact of this would be a reduction in the available superstructure load that may be carried on each pile. Mitigating this impact would be as given before relating to negative skin friction.

5.3.27 Driven piling may not be suitable at certain locations across the site due to the risk of vibrations damaging some of the existing buildings or dock walls which are constructed from relatively fragile materials (timber, cast / wrought iron). Due to the sensitive nature of the soils within the Made Ground and Alluvium, vibrations from driven piling could also result in localised ground loss.

5.3.28 A preliminary assessment of the relative positions of proposed and retained structures at the site indicates that adopting driven piles for the majority of new buildings at the site could potentially damage retained structures. Whilst this aspect of the development will require further assessment, consideration should be given to adopting a vibrationless displacement piling technique such as continuous helical displacement (CHD). The limitations of this technique i.e. maximum pile diameter, pile length and capacity etc. should be considered.

5.3.29 Due to thickness of Made Ground and Alluvium underlying the site, it is unlikely that shallow foundations will be able to be adopted for any of the smaller proposed structures. Piled foundations should be assumed for all structures at the site subject to further assessment following an intrusive ground investigation. For the two storey terraced housing, it may be possible to adopted an alternative foundation solution such as vibro-concrete columns however this will be dependent on further investigation and contamination in these areas.

5.4 MISCELLANEOUS

5.4.1 The site has been identified as previously being bombed during WWI and WWII. WSPEE understand that no ordnance risk assessment has been undertaken to date and this should be considered prior to any ground work being undertaken. Furthermore, there may be a requirement for probing by a specialist ordnance location contractor prior to any piling work being undertaken.

5.4.2 WSPEE understand that the South Mast Pond is a Scheduled Ancient Monument, and as such, no site investigation work has been undertaken within the Pond. The Pond was in filled circa 1885, and the composition of material is unknown. In addition, two buildings are proposed in this area and will require considerations regarding installation of foundations etc in this area.