Riverside Energy Park

Flood Risk Assessment

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CORY
RIVERSIDE ENERGY

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Executive Summary

This Flood Risk Assessment (FRA) has been prepared by Peter Brett Associates LLP (PBA) to support a Development Consent Order (DCO) application relating to the construction, operation and maintenance of an Energy Park, to be known as Riverside Energy Park (REP), located within the London Borough of Bexley (the 'Proposed Development'). The Proposed Development comprises an integrated range of technologies including waste energy recovery, waste anaerobic digestion, solar panels and battery storage with an electrical output of up to 96 megawatts (MWe), together with an associated Electrical Connection (underground) to export power to the electricity network.

The decision on the development consent application for the Proposed Development will be taken in accordance with the Overarching National Policy Statement for Energy (NPS EN-1) (July 2011); the National Policy Statement for Renewable Energy Infrastructure (NPS EN-3) (July 2011); and the National Policy Statement for Electricity Networks Infrastructure (NPS EN-5) (July 2011). Section 5.7 of NPS EN-1 refers to specific policies in respect of the assessment of flood risk and sets out the decision making principles that will be applied. NPS EN-1 refers to Planning Policy Statement 25 (PPS 25) which provides guidance regarding the scope of flood risk assessment to be undertaken by Applicants. PPS 25 has now been superseded by the revised National Planning Policy Framework (NPPF), published in July 2018.

In accordance with the fundamental objectives of the NPPF, this FRA demonstrates that:

(i) The Proposed Development is safe;

(ii) The Proposed Development does not increase flood risk; and,

(iii) The Proposed Development does not detrimentally affect third parties.

The Environment Agency (EA) Flood Zone map shows that the REP site lies within Flood Zone 3 'High Probability' of the River Thames (as defined in Planning Practice Guidance (PPG) 'Flood Risk and Coastal Change' Table 1, Paragraph: 065 Reference ID: 7-065-20140306). The REP site is located within an area benefitting from flood defences, with a standard of protection of 1 in 1,000 years.

Flood Zone 3 'High Probability' (greater than 1 in 200 (0.5%) annual probability of sea flooding)

The REP site lies within the Belvedere region of the London Borough of Bexley (LBB), an area designated for employment growth within the Bexley Core Strategy (Policy CS12), the plan-making process having been informed by a Strategic Flood Risk Assessment, as required by the NPPF. In addition, the Belvedere region lies within (i) the Thames Gateway (designated for growth within the Thames Gateway Delivery Plan (2007)) and (ii) a designated London Plan Opportunity Area (comprising brownfield land and offering significant capacity for growth).

On this basis, in accordance with Paragraph 162 of the revised NPPF (July 2018), as the REP site is located within an area allocated for development in development plans, it is not necessary to apply the sequential test again.

The Proposed Development constitutes 'Essential Infrastructure' land use, which is considered appropriate within Flood Zone 3a (reference PPG Tables 2 (Paragraph: 066 Reference ID: 7-066-20140306) and 3 (Paragraph: 067 Reference ID: 7-067-20140306)) subject to passing the Exception Test. This FRA answers the second part of the Exception Test, with the wider sustainability benefits of the Proposed Development providing sufficient evidence to pass the first part of the Exception Test.

The flood risk mitigation strategy for the Proposed Development consists of the following elements:

- The proposed finished floor level (FFL) for the ground floor would be set at a minimum of 2.97 m AOD, providing freeboard to above the 1 in 200 year 2100 breach flood level, with flood sensitive equipment set a minimum of 400 mm above the FFL to provide additional resilience;

- REP is located in an area benefitting from flood defences, with a standard of protection of 1 in 1,000 years, and therefore safe access is readily provided. The principal source of (residual) flood risk at this location relates to a breach of the tidal flood defences and, should a breach occur, safe refuge will be provided for operational staff and visitors within the buildings located above the flood level with an appropriate flood incident management plan in place for the Proposed Development.

In summary, the FRA demonstrates that the Proposed Development is safe and in accordance with the requirements of national, regional and local planning policy.

1 Introduction

1.1 Scope of Flood Risk Assessment (FRA)

1.1.1 Peter Brett Associates LLP (PBA) has been appointed by Cory Environmental Holdings Limited (Cory) (The Applicant) to prepare a Flood Risk Assessment (FRA) in support of an application for a Development Consent Order (DCO) relating to the construction and operation (including maintenance) of an Energy Park, to be known as Riverside Energy Park (REP). The Proposed Development comprises energy generating equipment, with an electrical output of up to 96 megawatts (MWe), together with an associated Electrical Connection (underground) to export power to the electricity network.

1.1.2 The FRA addresses the following:

- Identification of potential sources of flooding at the site (i.e. fluvial, tidal, pluvial, groundwater, surface water);
- Assessment of existing flood risk at the site; and
- Consideration of the potential impact of the proposals, taking into account the predicted impacts of climate change over the lifetime of the development, and the identification of measures to mitigate flood risk.

1.1.3 A full glossary of defined terms and abbreviations is presented in the Project Glossary (**Document Reference 1.6**).

1.2 Sources of Information

1.2.1 The FRA has been prepared with reference to the following sources of flood risk information:

- Environment Agency (EA) online flood maps (https://flood-map-for-planning.service.gov.uk and https://flood-warning-information.service.gov.uk/long-term-flood-risk);
- Natural England MAGiC mapping**;**

  http://www.natureonthemap.naturalengland.org.uk/MagicMap.aspx;
- Cranfield University Land Information System;

  http://www.landis.org.uk;
- London Borough of Bexley, Erith Marshes Ditches and Dykes Study (Surface Water Management Final Report) (2009);
- London Borough of Bexley, Erith Marshes Ditches and Dykes (Hydrology Phase 2) (2010);

- London Borough of Bexley, Bexley Strategic Flood Risk Assessment (SFRA) Level 1 (2010);
- London Borough of Bexley, SFRA Level 2 (2014);
- London Borough of Bexley, Preliminary Flood Risk Assessment (PFRA) (2011);
- London Borough of Bexley, Local Flood Risk Management Strategy (2017);
- Kent Thameside Delivery Board, Strategic Flood Risk Assessment of Kent Thameside (2005);
- Kent Thameside Regeneration Partnership, Kent Thameside Water Cycle Study Phase 1 (2009), incorporating update of the Strategic Flood Risk Assessment of Kent Thameside (2005);
- Dartford Borough Council, PPS25 Flood Risk Sequential Test – Dartford's Borough-Wide Assessment (2010);
- Kent County Council, PFRA (2011);
- Kent County Council, Kent Local Flood Risk Management Strategy 2017-2023;
- Kent County Council, Drainage and Planning Policy Statement (2017);
- Kent County Council, Dartford Surface Water Management Plan Stage 2 (2016);
- Doran Consulting, Floor Level Strategy Report (2018);
- Doran Consulting, Drainage Design Strategy (2018); and
- Tony Gee and Partners LLP, River Wall Condition Survey (2018).

1.3 Policy Context and Guidance

1.3.1 The Overarching National Policy Statement for Energy (NPS EN-1) (2011), published by the Department of Energy and Climate Change, provides the primary basis for decisions by the Secretary of State on Nationally Significant Infrastructure Projects (NSIPs) in the field of energy. Chapter 5.7 of NPS EN-1 addresses flood risk and sets out (i) the nature/scope of assessment required by applicants and (ii) the basis for decision-making by the Secretary of State. NPS EN-1 (paragraph 5.7.6) also refers to the requirements of Planning Policy Statement 25 (PPS25) and the associated Practice Guide, or "*successor documents*". PPS25 was replaced by the National Planning Policy Framework (NPPF) in March 2012, a revised version of which was published in July 2018. This FRA has therefore been prepared in accordance with the revised NPPF and the associated Planning Practice Guidance.

1.3.2 This FRA has been prepared in accordance with the relevant national, regional and local planning policy and guidance as set out below:

- Department of Energy and Climate Change, Overarching National Policy Statement for Energy (NPS EN-1) (2011);
- Department of Energy and Climate Change, National Policy Statement for Renewable Energy Infrastructure (NPS EN-3) (2011);
- Department of Energy and Climate Change, National Policy Statement for Electricity Networks Infrastructure (NPS EN-5) (2011);
- National policy regarding development and flood risk as set out within the revised National Planning Policy Framework (NPPF) (2018) and the Planning Practice Guidance (PPG) 'Flood Risk and Coastal Change' (2014);
- DEFRA Non-statutory Technical Standards for Sustainable Drainage Systems (2015);
- The SuDS Manual (C753), CIRIA (2015);
- Sewers for Adoption 7th Edition (2012);
- BS 8582:2013 Code of practice for surface water management for development sites (2013);
- Environment Agency Rainfall run-off management for developments, Report SC030219 (2013);
- Environment Agency Flood risk assessments: climate change allowances (2016);
- Greater London Authority, The London Plan (2016);
- Greater London Authority, Sustainable Design and Construction Supplementary Planning Guidance (2014);
- Environment Agency, Thames Estuary 2100 Plan (2012);
- Greater London Authority, Draft New London Plan showing Minor Suggested Changes (2018);
- Greater London Authority, London Environment Strategy (2018);
- London Borough of Bexley, Bexley Core Strategy (2012);
- Dartford Borough Council, Core Strategy (2011);
- Dartford Borough Council, Dartford Development Policies Plan (2017); and

- Kent County Council, Kent Minerals and Waste Local Plan 2013-2030 (2016).

1.4 Advisories and Exclusions

1.4.1 This FRA has been prepared in accordance with NPS EN-1, NPS EN-3, NPS EN-5, the NPPF and Regional and Local Planning Policy. Where applicable, the proposed flood management (including design level recommendations) and surface water management strategies are based on the relevant British Standards (BS8533), the standing advice provided by the Environment Agency (EA), advice provided by the Lead Local Flood Authority (LLFA) London Borough of Bexley (LBB) or based on common practice.

1.4.2 The findings of this FRA are based upon the data available at the time of the study and relate to the development proposals described in Section 2.

1.5 Statement of Technical Competence

1.5.1 PBA has a designated Water Management team with many years of experience in, amongst other areas, the assessment of flood risk, hydrology and hydraulic modelling, flood management, the Water Framework Directive, surface water drainage and river engineering. PBA's Water Management team includes experienced staff who have relevant academic and professional qualifications. This document has been reviewed and approved by experienced engineers and members of chartered institutions such as the Chartered Institution of Water and Environmental Management (CIWEM) and/or the Institution of Civil Engineers (ICE).

2 Project Description

2.1 Overview

2.1.1 The Proposed Development comprises REP together with an associated Electrical Connection. These are described in turn, together with the anticipated REP operations, below.

2.1.2 As REP will be in excess of 50 MWe capacity it is classified as a Nationally Significant Infrastructure Project (NSIP) under section 14 of the Planning Act 2008 and therefore requires a Development Consent Order (DCO) to authorise its construction and operation.

2.1.3 The Illustrative Site Layout Plan is provided within **Appendix A** which has been used to guide the assessments within this FRA.

2.2 Proposed Development

REP

2.2.1 REP would be on land immediately adjacent to Cory's existing RRRF, within the LBB and would complement the operation of the existing facility. It would comprise an integrated range of technologies including: waste energy recovery, waste anaerobic digestion, solar panels and battery storage. The main elements of REP are as follows:

- Energy Recovery Facility (ERF): to provide thermal treatment of Commercial and Industrial (C&I) residual (non-recyclable) waste with the potential for treatment of (non-recyclable) Municipal Solid Waste (MSW);
- Anaerobic Digestion facility: to process food and green waste. Outputs from the Anaerobic Digestion facility would be transferred off-site for use in the agricultural sector as fertilizer or as an alternative, where appropriate, used as a fuel in the ERF to generate electricity;
- Solar Photovoltaic Installation: to generate electricity. Installed across a wide extent of the roof of the Main REP Building;
- Battery Storage: to store and supply additional power to the local distribution network at times of peak electrical demand. This facility would be integrated into the Main REP building;
- On Site Combined Heat and Power (CHP) Infrastructure: to provide an opportunity for local district heating for nearby residential developments and businesses. REP would be CHP Enabled with necessary on site infrastructure included within the REP site

Electrical Connection

2.2.2 REP would be connected to the electricity distribution network via a new 132 kilovolt (kV) underground electricity cable connection. The route options for the Electrical Connection are shown in the Works Plans (Document Reference 2.4).

2.2.3 In consultation with UK Power Networks ('UKPN'), Cory is considering Electrical Connection route options to connect to the existing National Grid Littlebrook substation located south east of the REP site, in Dartford. The route options are located within the LBB and Dartford Borough, and would run from a new substation proposed to be constructed within the REP site.

REP operations

- Delivery of waste to REP: the majority of waste will be delivered to REP by barge from Waste Transfer Stations (WTS) along the River Thames, utilising the existing jetty which is located immediately to the north of RRRF and the REP site. The remainder would be delivered by road. Whilst CRE are a river-based operator, the application includes flexibility to allow deliveries by road where commercially and environmentally appropriate to do so, e.g. for local waste deliveries from the Bexley area or for food/green waste; and

- Removal of by-products from REP: Incinerator Bottom Ash (IBA) would be transported by river to the existing IBA Facility at the Port of Tilbury for treatment/recycling, and then for onward use as secondary aggregate in the construction sector. Air Pollution Control Residues (APCR) would be taken off-site by road in sealed containers to be treated/recycled for use as a construction material.

3 Site Description

3.1 Site Location

3.1.1 The general location and extent of the Application Site are shown in **Figure 3.1**.

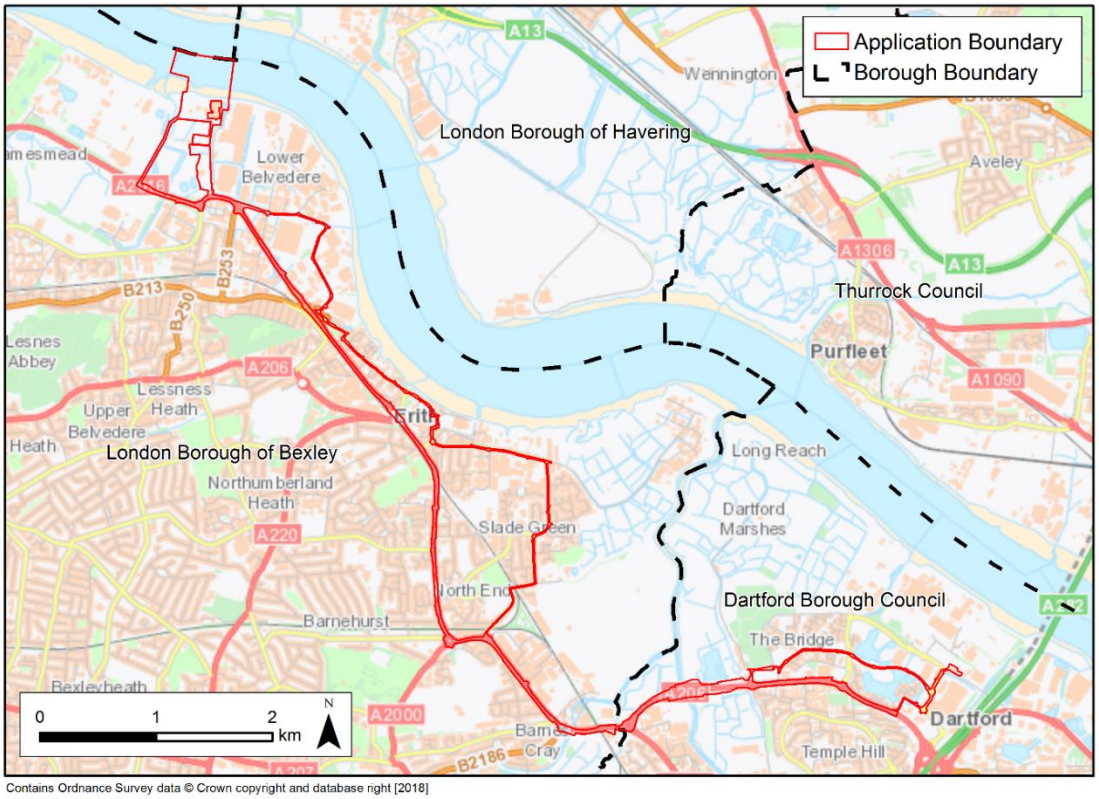
3.1.2 The Application Site is located within the administrative areas of the LBB and Borough of Dartford (Kent). It comprises the REP site (located to the north of Belvedere), the Electrical Connection (extending between the REP site and the Electrical Connection Point at Littlebrook substation in Dartford) and the Main Temporary Construction Compounds (located a short distance to the south of the REP site).

3.1.3 The REP site is located on the south bank of the River Thames and occupies a river frontage position, being set back approximately 20 m from the Thames Path and the tidal flood defences.

3.1.4 Crossness Wastewater Treatment Works is located approximately 200 m to the west of the REP site and the area to the east is characterised by warehousing and distribution. Crossness Nature Reserve, owned and managed by Thames Water, is located adjacent to both the REP site and the Main Temporary Construction Compounds. The reserve extends across approximately 0.25 km^2 and forms part of the Erith Marshes Site of Metropolitan Importance for Nature Conservation.

3.1.5 The Electrical Connection Point at Littlebrook is located approximately 10.5 km to the south-east of the REP site within the Borough of Dartford and the existing substation is set back approximately 500 m from the River Thames.

Figure 3.1: Site Location Plan



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3.2 Site Description

3.2.1 The REP site is currently used predominantly as an ancillary area for RRRF. Current uses include ash container storage, compounds for operational plant maintenance activities, a non-designated Wasteland Habitat Area, circulation roads and car-parking. The REP site therefore comprises both permeable and impermeable surfaces and surface water run-off generally infiltrates into the ground or is routed to the ditches, drains and dykes located to the south and west.

3.2.2 The Main Temporary Construction Compounds would be located on the western side of Norman Road, to the south of the REP site. The land generally comprises previously worked/made ground and includes a building and associated car-parking area (hardstanding). It is bound, in part, by ditches and drains that convey surface water run-off from within and around the area of the proposed compounds and which fall within the catchment of the Great Breach Dyke, located just beyond the western boundary of the Main Temporary Construction Compound.

3.2.3 The Electrical Connection routes, generally pass along principal highway corridors through urban areas, particularly within LBB. The routes are therefore generally characterised by residential development, interspersed with significant industrial and commercial areas.

3.2.4 The Electrical Connection Point at Littlebrook substation is located within an established industrial and commercial area approximately 10.5 km to the south-east of the REP site within the Borough of Dartford.

3.3 Site Topography

3.3.1 According to topographic survey undertaken by Maltby Surveys Limited in February 2018 (**Appendix B**), levels across the REP site generally vary between 1 m AOD along the southern boundary and 3 m AOD along the northern boundary adjacent to the toe of the flood defence embankment.

3.3.2 Topographic survey information is not currently available for the Main Temporary Construction Compounds, and therefore EA Light Detection and Ranging (LiDAR) data of 0.5 m resolution has been used. This data is not as accurate as conventional, ground-based topographic survey, however it provides a helpful indication of existing ground levels. Levels across the Main Temporary Construction Compounds are shown to vary between approximately 2 m AOD and 0.4 m AOD.

3.3.3 LiDAR data was also used to provide existing ground level information for Littlebrook substation. Levels at Littlebrook substation vary between approximately 2.2 m AOD and 3.8 m AOD.

3.4 Watercourses

3.4.1 The principal watercourse in the area is the River Thames. The river is tidally influenced along the reach adjacent to the REP site and the estuary is characterised by an average daily rise and fall of water levels of c.7 m.

3.4.2 The area to the south of the REP site is characterised by a number of ditches and dykes that perform a surface water drainage function. The principal channels in the vicinity of the REP site are The Great Breach Dyke (including Great Breach West) and Horsehead Dyke (which serves a catchment to the south-east of the REP site), as shown on Figure 3.2, **Appendix C**. These channels are, in turn, fed by numerous smaller ditches and dykes that drain the urban area to the south, south-east and south-west of the REP site. The ditch and dyke system serves an area of c.2.95 km^2 and ultimately discharges to the River Thames via two pumping stations, Great Breach Pumping Station located immediately to the south-west of the REP site and Green Level Pumping Station located approximately 1.5 km to the east of the REP site.

3.4.3 To the south-east of the REP site, the Electrical Connection route crosses over the River Cray and the River Darent approximately 3 km and 2 km to the west of the connection point at the Littlebrook substation respectively.

3.5 Water Bodies

3.5.1 A lagoon is located within the north-eastern area of Crossness Wastewater Treatment Works, approximately 0.25 km to the west of the REP site. The largest water body in the vicinity of the REP site is a pond feature located within

the southern area of Crossness Nature Reserve, approximately 0.6 km south of the REP site.

3.5.2 The principal surface water features in the vicinity of the Littlebrook substation are the water bodies forming Littlebrook Nature Park, located approximately 0.3 km to the west of the substation.

3.6 Flood Defences

3.6.1 According to data provided by the EA in June 2018 (**Appendix D**), the REP site falls within an area that benefits from the River Thames tidal flood defences.

3.6.2 The defence consists of an embankment and reinforced concrete wall. The embankment rises to a level of approximately 6 m AOD and the Thames Path and River Thames tidal flood defence wall are located on the crest of the embankment.

3.6.3 According to the topographic survey, the crest level of the defence wall immediately to the north of the REP site is 7.05 m AOD, and EA data states a crest level of 7.10 m AOD in the vicinity of the site. The difference in levels quoted by the topographic survey and EA data may be due to rounding.

3.6.4 Information provided by the EA indicates that the defences currently offer a 1 in 1,000 year (0.1% annual probability) standard of protection. Asset record details indicate that the EA rated the flood defence wall condition as Grade 2 (Good) in 2018, however in subsequent meeting, the EA downgraded some areas to Grade 3 (Fair) and 4 (Poor).

3.6.5 In response to EA requests, a flood defence condition survey was completed in October 2018 for the REP site. A copy of the survey report is presented in **Appendix E**. It concludes that the flood defence is classified at a combination of Grade 3 (Fair) and Grade 2 (Good) condition, with an overall suggested grade of Grade 3 (Fair). The conclusions regarding the current condition of the flood defences are therefore similar or better in comparison to those reported by the EA in 2018.

3.6.6 The October 2018 survey report recommends that remedial works are carried out within 2 years. The works include repairing minor/superficial cracks and expansion joints, replacing missing stones within the stone pitching that characterises foreshore areas, and repairing minor concrete spalling. It is also recommended that the flood defences are inspected by a Chartered Engineer every 2-5 years and that vegetation on the riverward embankment is maintained to an appropriate level to facilitate visual inspection of the defences. The October 2018 survey report concludes that the residual life of the flood defences is expected to be between 70 and 100 years following the completion of remedial works.

3.6.7 As noted above, the Electrical Connection Point at the Littlebrook substation is located approximately 10.5 km to the south-east of the REP site within the

Borough of Dartford. The existing substation is set back approximately 500 m from the tidal flood defences which, according to data provided by the EA in June 2018, comprise an embankment with a crest level of 6.74 m AOD. Information provided by the EA indicates that the defences currently offer a 1 in 1,000 year (0.1% annual probability) standard of protection and, following a visual inspection/condition survey undertaken by the EA in 2017, the defences have been assigned a Grade 2 (Good).

3.7 Existing Drainage Arrangements

3.7.1 As noted above, the REP site comprises both permeable and impermeable surfaces and surface water run-off generally infiltrates into the ground or is routed to the ditches, drains and dykes located to the south and west.

3.7.2 The Main Temporary Construction Compounds are also characterised by both permeable and impermeable surfaces and surface water run-off is routed to the ditches and drains that bound the area.

3.7.3 Surface water run-off along the Electrical Connection Route is captured by highway drainage infrastructure and Littlebrook substation is served by a pipe drainage system.

3.8 Geology and Soils

3.8.1 According to the British Geological Survey 1:50,000 scale maps, the solid geology of the area generally consists of Alluvium overlying River Terrace Gravel and London Clay. Significant and highly varying thicknesses of made ground are also expected to overlie the natural strata across the majority of the Application Site.

3.8.2 The Cranfield University 'Soilscapes' website provides information regarding the drainage characteristics of soils across England and Wales based upon a 1:250,000 scale dataset. This characterises the soils across the REP site and the area to the south through Crossness Nature Reserve as "*loamy and clayey soils of coastal flats with naturally high groundwater*".

3.9 Hydrogeology and Groundwater Vulnerability

3.9.1 Previous ground investigations (detailed within the report titled 'Riverside Energy Park, Belvedere – Phase 1 Ground Condition Assessment (May 2018)' prepared by Peter Brett Associates) noted groundwater strikes at the top of the River Terrace Gravels (10-13 m depth) within the REP site, with the water being sub-artesian as the water level rose to within 3 m of the surface. Similarly, previous investigations within the Norman Road area recorded groundwater strikes at the top of the River Terrace Gravels (7-8 m depth), with the water being semi-artesian as the water rose to 1 m below ground level.

3.9.2 Previous investigations recorded tidal variation in standing water levels and perched water within the made ground.

3.9.3 The report titled 'Riverside Energy Park, Belvedere – Phase 2 Ground Condition Assessment (Contamination) (July 2018)' prepared by Peter Brett Associates presents details of an intrusive geotechnical ground investigation carried out between March and June 2018. The fieldwork included monitoring of groundwater levels and recorded groundwater at generally less than 1 m below ground level across the REP site and also noted a tidal influence.

3.9.4 DEFRA publishes indicative Groundwater Source Protection Zones (SPZs) for 2,000 groundwater sources such as wells, boreholes and springs used for public drinking water supply. The zones define areas where a range of human activities may damage/pollute groundwater. The maps show three main zones (inner, outer and total catchment) and a fourth zone of special interest. Examination of the mapping shows that the REP site is not located within a SPZ. However, the Electrical Connection route passes through zones 1 (inner), 2 (outer) and 3 (total catchment), these zones being associated with groundwater abstractions in Crayford and Dartford.

4 Stakeholder Consultation

4.1.1 Local stakeholders have been consulted to acquire local/site-specific information on flood risk, to confirm design criteria/principles and agree the methodology for the technical assessments/analysis required to inform the FRA. Stakeholders consulted include:

- Environment Agency (EA); and
- London Borough of Bexley (LBB) as Lead Local Flood Authority (LLFA).

4.1.2 Copies of correspondence and meeting notes are included in **Appendix F.**

4.1.3 PBA and Cory met with representatives from the EA in February 2018 to introduce the development proposals, identify the principal issues requiring consideration/assessment from a flood risk/water management perspective and define the broad scope of work to be undertaken in support of the FRA process.

4.1.4 In their subsequent letter dated 11th April 2018, the EA advised that no development should be located over the defences and that all new development including temporary structures should be set back from the defences. The EA also advised that a flood defence condition survey should be undertaken.

4.1.5 Doran Consulting Ltd subsequently submitted details of the following to the EA for review and comment:

- Flood defence condition survey specification;
- Finished floor level strategy (Executive Summary); and
- Drainage design strategy (Executive Summary).

4.1.6 The EA's subsequent letter dated 27th April 2018 noted that the flood defence condition survey should ascertain the remedial works required to ensure the flood defences are commensurate with the lifetime of the development. The EA also highlighted that some elements of the defences had been assigned a condition grade of 3 (fair) and 4 (poor), such that maintenance works were required.

4.1.7 In respect of finished floor levels, the EA confirmed that levels should be set '*well above the current breach model*'. Design levels are discussed in Section 9 of this report.

4.1.8 Regarding the proposed drainage strategy, the EA noted and agreed with the proposal to '*dismiss the use of SuDS for surface water disposal due to the high water table and potential risk of groundwater contamination*'. The EA also agreed that the provision of surface water attenuation using a sealed tank system and pumping to the existing watercourse on the southern site boundary was considered acceptable.

4.1.9 Doran Consulting Ltd submitted full copies of (i) the Drainage Design Strategy Report and (ii) the Floor Level Strategy to the EA for review and comment on 15th May 2018 and the 28th June 2018 respectively.

4.1.10 The EA response dated 21st August 2018 (**Appendix F**) stated their support for the approach set out with regards to the floor levels. It also noted that the Drainage Design Strategy was not reviewed as the issues relating to the EA's remit will be covered under the Environmental Permit.

5 Overview of Flood Risk

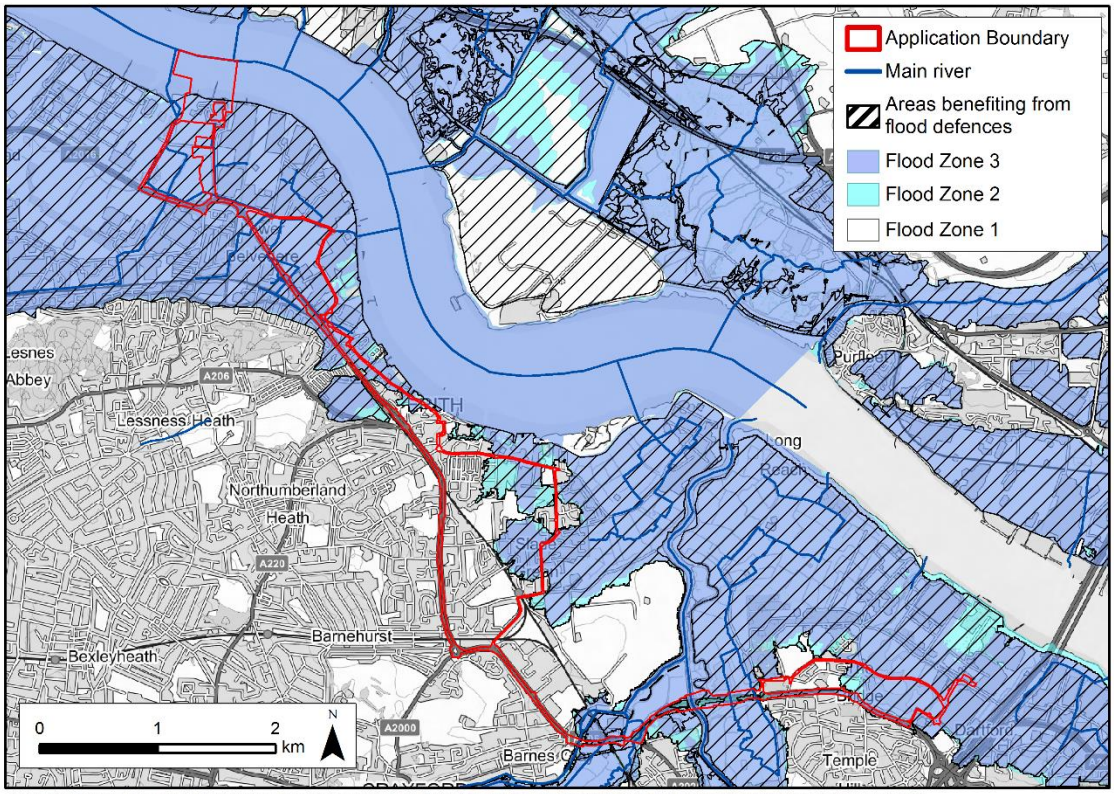
5.1 Environment Agency Flood Maps

Flood Map for Planning (Flood Zone Map)

5.1.1 The EA publishes floodplain maps on the internet (https://flood-map-for-planning.service.gov.uk). These maps show the possible extent of fluvial flooding for a 1 in 100 year flood (that which would have a 1% probability of being exceeded each year) and the possible extent of tidal flooding associated with a 1 in 200 year event, ignoring the presence of flood defences. Also shown is the possible extent of flooding arising from a 1 in 1,000 year event (0.1% probability). An extract from the current (August 2018) EA Flood Map for Planning is shown in Figure 5.1.

5.1.2 The EA Flood Map for Planning provides the basis for planning and for application of the Sequential Test.

Figure 5.1: EA Flood Map for Planning



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5.1.3 The EA Flood Map indicates that both the REP site and Littlebrook substation lie within Flood Zone 3 – High Probability (land having a 1 in 200 or greater annual probability of tidal flooding – shown as dark blue). However, the flood map also indicates that the REP site and Littlebrook substation fall within an area that benefits from flood defences. In this instance, the standard of protection afforded by the defences is 1 in 1,000 years.

5.1.4 The north-western (between the REP site and Erith) and south-eastern (between Barns Cray and Littlebrook substation) parts of the Electrical Connection Route are also shown to lie within Flood Zone 3. The central part of the Electrical Connection Route lies within Flood Zone 1 (Low Probability – land having less than a 1 in 1,000 annual probability of river or sea flooding). The Electrical Connection Route also lies within an area that benefits from flood defences.

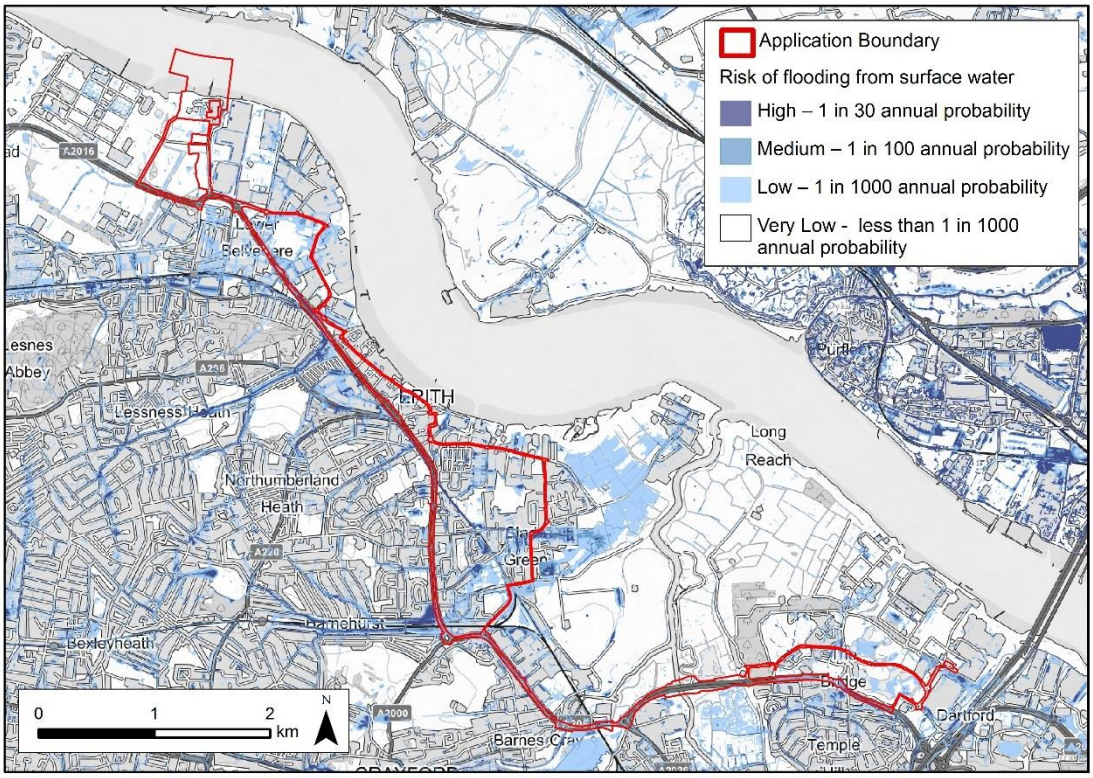
Flood Risk from Surface Water Map

5.1.5 The EA 'Flood Risk from Surface Water Map' (https://flood-warning-information.service.gov.uk/long-term-flood-risk) shows areas that may potentially be susceptible to surface water flooding following an extreme rainfall event (Figure 5.2 below).

5.1.6 It should be noted that this map is generated using a broad methodology applied at the national scale. The model utilises generalised information on infiltration, sewerage infrastructure, rainfall events and catchment topography to route rainfall over a ground surface model. As such, the analysis does not take account of site-scale factors/characteristics that may exert an influence upon surface water flood depths and extents. The map therefore only provides a guide regarding the areas that may be vulnerable to this source of flooding.

5.1.7 The map highlights a number of corridors within the vicinity of the REP site, along the electrical connection route and at Littlebrook Power Station substation at a high, medium and low risk of surface water flooding. The high risk areas generally coincide with watercourses/streams/ditches/drains, highway corridors and topographical 'low' points across the terrain (i.e. areas where surface water would naturally accumulate following rainfall).

Figure 5.2: EA Updated Flood Map for Surface Water



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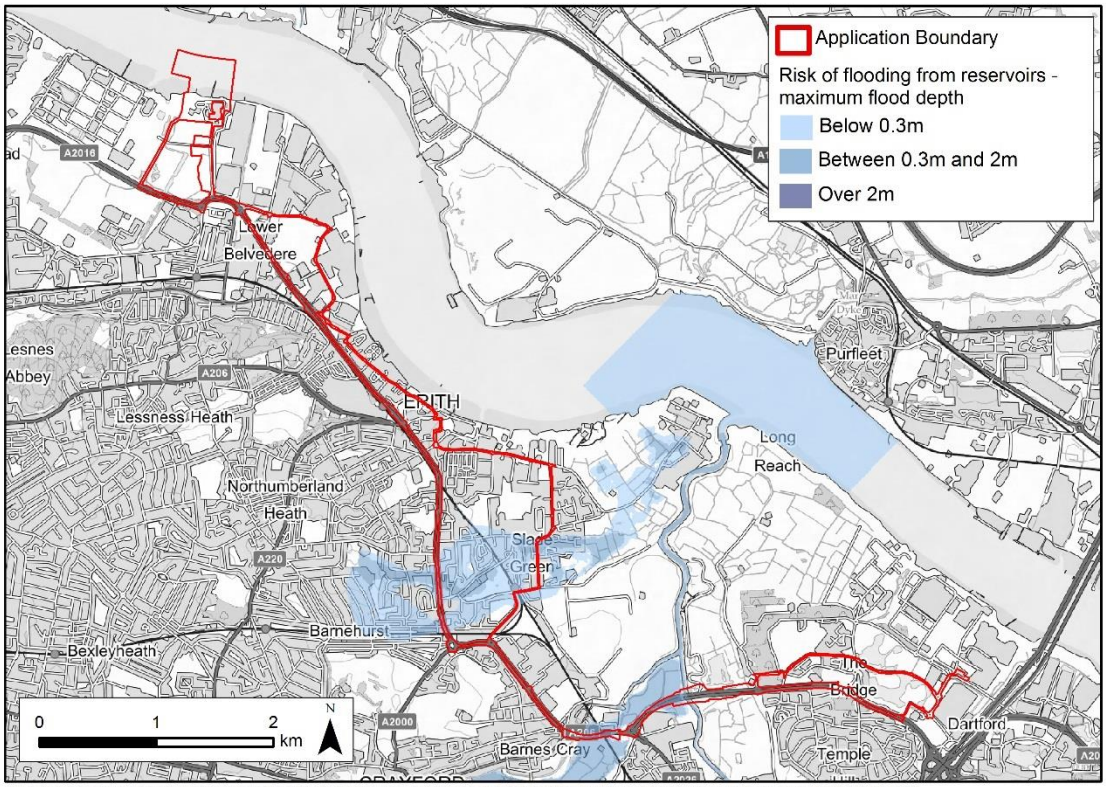
Flood Risk from Reservoirs Map

5.1.8 The EA provides maps (https://flood-warning-information.service.gov.uk/long-term-flood-risk/) showing the area that may be affected by flooding as a result of a breach of a large, raised reservoir (i.e. capable of storing over 25,000 cubic metres of water above the natural level of any part of the surrounding land).

5.1.9 The 'Flood Risk from Reservoirs' map is reproduced in Figure 5.3 below. The largest body of open water in Bexley is Danson Park Reservoir, which is located approximately 6 km to the south-west of the REP site. The EA map identifies an area downstream of the reservoir that may be at risk of flooding following a breach. The flood risk area extends along the River Shuttle and River Cray, extending to the east of the reservoir, such that neither the REP site nor Littlebrook substation would be affected.

5.1.10 In any event, the probability of a reservoir breach occurring is of course very small. The EA is the enforcement authority and therefore responsible for ensuring that the reservoir 'undertaker' (responsible for the safety of the reservoir) observes and complies with the requirements of the Reservoirs Act. In addition, all large, raised reservoirs are inspected and supervised by qualified civil engineers (referred to as Panel Engineers).

Figure 5.3: EA Flood Risk from Reservoirs map



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5.2 London Borough of Bexley Studies

5.2.1 The London Borough of Bexley (LBB) is the LLFA, as defined by the Flood and Water Management Act 2010, with responsibility for the management of flood risk associated with Ordinary Watercourses, surface water and groundwater. In addition, following amendment of the Town and Country Planning (Development Management Procedure) (England) Order in April 2015, the LLFA became a statutory consultee in the planning process in respect of surface water drainage. LBB has commissioned various studies to support both the local plan-making process and its role as LLFA. An overview of the studies of relevance to this FRA is provided below.

London Borough of Bexley Strategic Flood Risk Assessment Level 1 (August 2010)

5.2.2 The assessment was commissioned by LBB to provide an evidence base to support spatial planning decisions at the Borough scale and, specifically, to facilitate application of the Sequential Test and assist in the re-allocation of employment sites.

5.2.3 The Strategic Flood Risk Assessment (SFRA) refers to the EA Flood Zone mapping as published in 2008 for the purposes of defining floodplain extents associated with the River Thames. This mapping has been superseded by that presented in Section 5.1 above.

5.2.4 Mapping presented within the study report shows that the REP site falls within an area benefitting from flood defences and that the standard of protection is 1 in 1,000 years.

5.2.5 Hydraulic modelling of defence failure ('breaching') was undertaken as part of the SFRA. Nine breach locations were assessed for the 1 in 200 year tidal flood event, including an allowance for the projected impacts of climate change up to the year 2107. The nearest breach location is located c.750 m to the east of the REP site and the mapping presented in the SFRA indicates that the maximum water level at the site would be in the range of 4.11-4.40 m AOD. However, this data has since been superseded by the Downriver Breach Inundation Modelling Study 2018 undertaken by the EA (discussed in Section 5.5 below).

5.2.6 The SFRA includes information regarding surface water flooding within the Borough based upon data collected by LBB. No incidents are recorded in the vicinity of the REP site. The study included modelling to map surface water flood risk across the Borough. However, the analysis is based upon a simplified methodology and the mapping has been superseded by that presented in Section 5.1 above.

5.2.7 In terms of historic flooding, the SFRA indicates that the REP site was affected by flooding associated with the 1953 tidal event on the River Thames, before the current defences were constructed c.1984.

5.2.8 Using groundwater level contours provided by the EA and derived from data collected in the late 1990s, the SFRA indicates that the REP site falls within an area where groundwater may be near the surface.

5.2.9 In terms of design principles, the SFRA states that '*The finished floor levels of more vulnerable uses should be above the predicted maximum water level resulting from a breach in the defences during the 1 in 200 year plus climate change tidal event*'. As discussed in Section 9 of this FRA, design levels have been established using data provided by the EA (derived from the Downriver Breach Inundation Modelling Study 2018).

London Borough of Bexley Strategic Flood Risk Assessment Level 2 (October 2014)

5.2.10 As noted above, the Level 1 assessment comprised a Borough-wide study. The Level 2 assessment differs in terms of geographical scope and provides the evidence base for application of the sequential approach to site allocation within six sustainable growth areas. The REP site lies on the fringe of the Belvedere Sustainable Growth Area.

5.2.11 The Level 2 assessment provides information regarding residual tidal flood risk (defence failure), surface water flood risk and groundwater flood risk. The study is based upon the hydraulic modelling analysis of defence failure ('breaching') completed as part of the Level 1 assessment, such that no further modelling work was undertaken as part of the Level 2 study.

5.2.12 The assessment provides mapping that shows the rate of onset of tidal flooding following defence failure. This indicates that the REP site would be affected by flooding approximately 3-6 hours following a defence breach. However, this is based upon analysis of a breach location c.750 m to the east of the REP site.

5.2.13 In respect of surface water flood risk, the assessment refers to the modelling to map surface water flood risk provided as part of the Level 1 assessment (this having been superseded by that presented in Section 5.1, as noted above) and also refers to the Erith Marshes Ditches and Dykes modelling study (Phases 1 and 2), a summary of which is provided in Sections 5.2.21-5.2.23 below.

London Borough of Bexley Preliminary Flood Risk Assessment (June 2011)

5.2.14 The Preliminary Flood Risk Assessment (PFRA) constitutes a high-level screening exercise that collates information on significant local flood risk and identifies Flood Risk Areas, in accordance with Part 2 of the Flood Risk Regulations.

5.2.15 The assessment uses LBB's Level 1 SFRA (discussed above) as the primary source of local flood risk information and refers to national datasets including the Areas Susceptible to Surface Water Flooding map (2008) and the Flood Map for Surface Water (2010), which have been superseded by the data presented in Section 5.1 above.

5.2.16 Mapping presented within the PFRA report indicates that the REP site lies within an area with 'increased potential for elevated groundwater', although the mapping is based upon relatively 'coarse' national datasets.

London Borough of Bexley Local Flood Risk Management Strategy (March 2017)

5.2.17 The Local Flood Risk Management Strategy (LFRMS) sets out how LBB, as LLFA, is responding to flood risk across the Borough associated with surface water, groundwater and Ordinary Watercourses. It sets out, inter alia, LBB's objectives for managing local flood risk and the measures proposed to achieve those objectives and identifies funding and delivery considerations.

5.2.18 The LFRMS refers to LBB's PFRA to provide context regarding the sources of flood risk, flooding mechanisms and the history of flooding across the Borough and notes the breach of the tidal flood defences in 1953 that gave rise to extensive flooding in the Belvedere and Thamesmead areas. It also highlights the 2013-2014 flood event and the associated groundwater flooding during March and April 2014 within the Boroughs of Croydon, Bexley, Bromley, Greenwich and Sutton.

5.2.19 The LFRMS outlines LBB's roles and responsibilities as defined by the Flood Risk Regulations (2009) and the Flood and Water Management Act (2010) and includes a flood risk management Action Plan that provides a framework for achieving objectives set out in the LFRMS.

5.2.20 Although the strategy document includes mapping regarding historic and predicted flood risk, it draws upon the information presented in other reports (as summarised above) and does not therefore include additional modelling/analysis to define the nature/extent of flood risk across the Borough.

Erith Marshes Ditches and Dykes Study – Surface Water Management Final Report (Dec 2009)

5.2.21 The study was commissioned by LBB to develop a fuller understanding of the ditches and dykes system and provide an evidence base to inform the regeneration of the Erith Marshes and Belvedere Employment Areas. The objectives of the study included (i) analysis to simulate how the surface water drainage system behaved during extreme rainfall events and (ii) identification of options to improve operation of the surface water drainage system and reduce flood risk.

5.2.22 The study included development of a hydraulic model of the Thames Water surface water drainage network and the open-channel network of ditches and dykes. This identified a number of locations where capacity constraints were likely to give rise to localised flooding. However, these locations are over 1 km to the south of the REP site, such that it is unaffected by such flooding mechanisms.

Erith Marshes Ditches and Dykes - Hydrology Phase 2 (March 2010)

5.2.23 The Phase 2 study builds upon the preliminary analysis of options (comprising de-silting and structural improvements) to improve operation of the surface water drainage system and reduce flood risk undertaken as part of the 2009 study. The study does not present additional information regarding the 'baseline'/existing flood risk regime in the vicinity of the REP site and the options considered relate to the drainage network serving the area c.1 km to the south of the REP site.

5.3 Dartford Borough Council Studies

Strategic Flood Risk Assessment (SFRA) of Kent Thameside (December 2005)

5.3.1 The study was commissioned by the Kent Thameside Delivery Board (comprising Dartford and Gravesham Borough Councils) to facilitate application of the sequential test and thereby inform strategic planning. It builds upon two previous studies that assembled baseline flood risk data and assessed the effect of flood defence failure through hydraulic modelling of twelve breach locations. The assessment notes that the area in the vicinity of the Littlebrook substation falls within a zone of high residual flood risk. However, the flood risk (defence breach) data that supports the SFRA has since been superseded by data derived from the Downriver Breach Inundation Modelling Study 2018 undertaken on behalf of the EA (discussed in Section 5.5).

Kent Thameside Water Cycle Study Phase 1 (March 2009)

5.3.2 The study considers the potential impact of projected growth in Kent Thameside upon water infrastructure. In addition to water resources and water quality matters, the study addresses flood risk and surface water management. The study report refers to the 2005 Kent Thameside SFRA (discussed above) for information/data in respect of tidal flood risk associated with the River Thames.

5.3.3 The study report includes an update of the Kent Thameside SFRA (2005), which centres upon updating the tidal breach modelling using the latest data (at that time) regarding sea-level rise and an improved modelling methodology. Flood mapping indicates that the area in the vicinity of Littlebrook substation falls within a zone of residual flood risk with a maximum depth of floodwater exceeding 2.5 m. However, the breach modelling has since been superseded by data derived from the Downriver Breach Inundation Modelling Study 2018 undertaken on behalf of the EA (discussed in Section 5.5). The zone of residual flood risk is now defined by the modelling described in Section 5.5.

PPS25 Flood Risk Sequential Test - Dartford's Borough-Wide Assessment (June 2010)

5.3.4 Application of the sequential test is based upon the EA's Flood Maps, the SFRA of Kent Thameside (2005) and the SFRA update incorporated within the Kent Thameside Water Cycle Study Phase 1 (2009).

5.3.5 The assessment is framed around the growth locations set out within Dartford's Strategic Housing Land Availability Assessment (2009) and Dartford's Strategic Employment Land Availability Assessment (2008) and does not extend to include the existing Littlebrook Power Station.

5.4 Kent County Council Studies

5.4.1 Kent County Council (KCC) is the Lead Local Flood Authority (LLFA) for the area which includes the Borough of Dartford, with responsibility for the management of flood risk associated with Ordinary Watercourses, surface water and groundwater. In addition, following amendment of the Town and Country Planning (Development Management Procedure) (England) Order, in April 2015 the LLFA became a statutory consultee in the planning process in respect of surface water drainage.

Preliminary Flood Risk Assessment (September 2011)

5.4.2 The PFRA is a high-level screening exercise to locate areas of significant risk (where 30,000 people or more are estimated to be at risk of surface water flooding). Detailed modelling or similar, to define the nature/extent of flood risk, was not undertaken as part of the PFRA, such that the assessment was based upon national datasets, including the Areas Susceptible to Surface Water Flooding map (2008) and the Flood Map for Surface Water (2010), which have been superseded by the data presented in Section 5.1 above.

5.4.3 The PFRA report does not include detailed, site-specific flood risk data for the Dartford area (the location of Littlebrook substation) and notes that the flood risk data that supports the assessment is generally 'indicative' only.

Local Flood Risk Management Strategy (LFRMS) 2017-2023

5.4.4 The LFRMS sets out how KCC, as LLFA, is responding to flood risk across the County associated with surface water, groundwater and ordinary watercourses. It sets out, inter alia, KCC's objectives for managing local flood risk and the measures proposed to achieve those objectives and identifies funding and delivery considerations.

5.4.5 The Strategy refers to KCC's PFRA and the suite of Surface Water Management Plans prepared for the various Boroughs/Districts to identify the locations where flood risk is an issue.

5.4.6 The strategy document does not include flood risk mapping or modelling/analysis to define the nature/extent of flood risk within the Dartford area.

Thameside Stage 1 Surface Water Management Plan (May 2013)

5.4.7 The Stage 1 Surface Water Management Plan (SuWMP) identifies flood prone areas and sets out an action plan for managing the risks identified across the Dartford and Gravesham Boroughs.

5.4.8 The SuWMP provides details of historic flooding and mapping, which identifies that the area around Littlebrook substation has been affected by tidal flooding arising from the River Thames. For surface water, mapping presented in the SuWMP is based upon the Flood Map for Surface Water, which has been superseded by the data presented in Section 5.1 above. The Plan does not include any site-scale modelling/analysis to define the nature/extent of flood risk in the vicinity of the Littlebrook substation.

Dartford Surface Water Management Plan Stage 2 (November 2016)

5.4.9 The Stage 2 Plan builds upon the Thameside Stage 1 study discussed above. It provides a detailed understanding of the causes and consequences of surface water flooding and explores the costs and benefits of mitigation measures.

5.4.10 The Plan is based upon the Updated Flood Map for Surface Water (as presented in Section 5.1 above) and data derived through hydraulic modelling. In terms of the areas that may be affected by surface water flooding following extreme rainfall in the vicinity of Littlebrook substation, the flood risk mapping presented in the SuWMP report generally correlates with that presented in Section 5.1 above.

5.5 Environment Agency Product 4 Data

REP Site

5.5.1 EA Product 4 data is presented in **Appendix D**. The EA data (4th June 2018) shows that the site lies within Flood Zone 3 - High Probability (land having a 1 in 200 or greater annual probability of tidal flooding), ignoring the presence of flood defences.

5.5.2 Modelled 'in-channel' flood levels are provided as part of the Product 4 package. This data is taken from the Thames Estuary 2100 study that was completed in 2008 and provides the overarching flood management strategy for the Thames Estuary. The nearest model node to the site is Node 3.9 (located immediately upstream of the REP site). Table 5.1 below shows the modelled in-channel flood levels at model node 3.9 for (i) 2008 and (ii) 2100 including climate change.

Table 5-1: EA Modelled 'in-channel' Flood Levels and Flood Defence Heights

Extreme Water Level* (mAOD) 2008 Levels	Left Defence (mAOD)	Right Defence (mAOD)
6.00	7.20	7.10
Extreme Water Level* (mAOD) 2100 Climate Change Levels	**Left Defence (mAOD)**	**Right Defence (mAOD)**
6.72	8.20	8.20

*1 in 1,000 year (0.1% Annual Exceedance Probability)

5.5.3 The data presented above indicates that the 1 in 1,000 year flood levels do not exceed the defence crest level. On this basis, it is concluded that the site is defended from tidal flooding up to the 1 in 1,000 (0.1%) Annual Exceedance Probability event, such that the actual risk of tidal flooding is low.

5.5.4 The Product 4 package also includes data taken from the Thames Tidal Downriver Breach Inundation Modelling Study 2018. Using the 2008 TE2100 'in-channel' levels, the 0.5% (1 in 200 year) and 0.1% (1 in 1,000 year) events were modelled for both the 2014 and 2115 scenarios, including climate change.

5.5.5 The data shows that the REP site would be inundated by floodwater during a defence breach. For the 2115 scenario (including climate change) modelled levels vary between 2.49 m AODN and 5.08 m AODN for the 1 in 200 year event and 2.63 m AODN and 5.14 m AODN for the 1 in 1,000 year event, with the highest levels recorded at nodes in close proximity to the flood defence. This data has been used for the purposes of establishing design levels for the proposed energy generating infrastructure within the REP site (discussed in Section 9 of this FRA).

Littlebrook Substation

5.5.6 EA Product 4 data is presented in **Appendix D**. The EA data (4th June 2018) shows that the substation lies within Flood Zone 3 - High Probability (land having a 1 in 200 or greater annual probability of tidal flooding), ignoring the presence of flood defences.

5.5.7 Modelled 'in-channel' flood levels are provided as part of the Product 4 package. This data is taken from the Thames Estuary 2100 study that was completed in 2008 and provides the overarching flood management strategy for the Thames Estuary. The nearest model node to the site is node 3.18 (located immediately downstream of the substation site). Table 5.2 below shows the modelled in-channel flood levels at model node 3.18 for (i) 2008 and (ii) 2100 including climate change.

Table 5-2: EA Modelled 'in-channel' Flood Levels and Flood Defence Heights

Extreme Water Level* (mAOD) 2008 Levels	Left Defence (mAOD)	Right Defence (mAOD)
5.94	6.9	6.35
Extreme Water Level* (mAOD) 2100 Climate Change Levels	**Left Defence (mAOD)**	**Right Defence (mAOD)**
6.60	8.00	8.00

*1 in 1,000 year (0.1% Annual Exceedance Probability)

5.5.8 The data presented above indicates that the 1 in 1,000 year flood levels do not exceed the defence crest level. On this basis, it is concluded that the substation is defended from tidal flooding up to the 1 in 1,000 (0.1%) Annual Exceedance Probability event, such that the actual risk of tidal flooding is low.

5.5.9 The Product 4 package also includes data taken from the Thames Tidal Downriver Breach Inundation Modelling Study 2018. Using the 2008 TE2100 'in-channel' levels, the 0.5% (1 in 200 year) and 0.1% (1 in 1,000 year) events were modelled for both the 2014 and 2115 scenarios, including climate change.

5.5.10 The data shows that the substation site would be inundated by floodwater during a defence breach. For the 2115 scenario (including climate change) modelled levels vary between 4.69 m AODN and 4.84 m AODN for the 1 in 200 year event and 4.88 m AODN and 5.08 m AODN for the 1 in 1,000 year event.

5.6 Historic Flooding

5.6.1 EA Product 4 data (**Appendix D**) includes a historic flood map. This shows that both the REP site and the site of Littlebrook substation were affected by tidal flooding associated with a storm surge in 1953.

5.6.2 The London Borough of Bexley Local Flood Risk Management Strategy (March 2017) notes that the most significant fluvial event occurred in 1977. However, the areas affected (Crayford and Old Bexley) are located several kilometres from both the REP site and the site of Littlebrook substation.

6 Proposed Development and Sequential Test

6.1.1 The NPPF requires that the sequential risk-based approach is applied by the Local Planning Authority in determining the suitability of land for development in flood risk areas. The aim of this approach is to steer development to areas at the lowest probability of flooding.

6.1.2 The REP site lies within the Belvedere region of the LBB, an area designated for employment growth within the Bexley Core Strategy (Policy CS12), the plan-making process having been informed by a SFRA, as required by the NPPF.

6.1.3 In addition, the Belvedere region lies within (i) the Thames Gateway (designated for growth within the Thames Gateway Delivery Plan (2007)) and (ii) a designated London Plan Opportunity Area (comprising brownfield land and offering significant capacity for growth).

6.1.4 On this basis, in accordance with Paragraph 162 of the revised NPPF (July 2018), as the REP site is located within an area allocated in development plans through the sequential test, it is not necessary to apply the sequential test again.

6.1.5 The Proposed Development is categorised as 'Essential Infrastructure' within the context of Table 2 (Reference ID: 7-066-20140306) of the PPG. According to Table 3 of the PPG (Reference ID: 7-067-20140306), the Exception Test must be applied where Essential Infrastructure is proposed in Flood Zone 3. The revised NPPF (July 2018) Paragraph 160 requires that, for the Exception Test to be passed, it should be demonstrated that:

- The development would provide wider sustainability benefits to the community that outweigh the flood risk; and
- The development will be safe for its lifetime taking account of the vulnerability of its users, without increasing flood risk elsewhere and, where possible, will reduce flood risk overall.

6.1.6 In terms of the first part of the Exception Test, the principal sustainability benefits associated with REP include:

- diverting waste from landfill and moving it up the waste hierarchy;
- supporting the drive for waste self-sufficiency within London;
- renewable and low carbon electricity;
- CHP Enabled with scope to support heat demand associated with regeneration within the Thameside area; and
- sustainable transport (delivered through predominately using existing river freight infrastructure).

6.1.7 This FRA addresses the second part of the Exception Test and demonstrates that the Proposed Development will be safe for its lifetime.

7 Surface Water Management Strategy

7.1.1 Development of the REP site will give rise to an increase in the impermeable area within the catchment of the Great Breach Dyke which, in the absence of mitigation, will result in increased surface water run-off to the watercourses/drains/dykes in the vicinity of the REP site. A scheme for controlling surface water outflows is therefore required, to regulate flows to the watercourse network and demonstrate that flood risk downstream is not increased as a result of the development proposals.

7.1.2 Full details regarding the proposed surface water drainage strategy for the REP site are set out in the document titled 'Drainage Design Strategy (February 2018)' prepared by Doran Consulting Limited, a copy of which is presented in **Appendix G**. The strategy has been prepared in consultation with the EA and LBB (as Lead Local Flood Authority) and correspondence is included within **Appendix G**. The strategy is based on an Illustrative Site Layout. The final surface water drainage strategy will be secured for the REP Site via a Requirement to submit details for approval to the relevant LLFA.

7.1.3 As set out in the report enclosed in **Appendix G**, approximately 60% of the site is characterised by impermeable surfacing and surface water run-off currently outfalls to the watercourse network immediately to the south of the REP site.

7.1.4 The report enclosed in **Appendix G** notes that the feasibility of employing infiltration drainage solutions is constrained by (i) the high water table and (ii) the nature of the industrial processes within the REP site and associated risk of groundwater contamination.

7.1.5 The surface water management strategy has therefore been designed such that the rate of surface water run-off leaving the site and entering the adjacent watercourse network is limited to the 1 in 100 year greenfield rate of 35.3 l/s. Surface water storage will be provided by a below ground tanked system with capacity to cater for a 1 in 100 year plus climate change (+40% increase in rainfall intensity) event.

7.1.6 In accordance with planning policy requirements, surface water run-off from the REP site will therefore be managed in a sustainable manner and, as set out in the report enclosed in **Appendix G**, the strategy will deliver 'betterment' when reviewed within the context of the existing (pre-development) surface water run-off regime.

7.1.7 Following consultation with UKPN, it is currently anticipated that works at Littlebrook substation will be limited to the installation and connection of 132 kV cables (below ground) to existing substation infrastructure. No building or surfacing works are required such that the proposed works will not impact upon the surface water run-off regime.

8 Impact of Climate Change

8.1.1 In February 2016 the EA published guidance in respect of the climate change allowances (https://www.gov.uk/guidance/flood-risk-assessments-climate-change-allowances) that should be used as the basis for preparing FRAs. The guidance sets out the climate change allowances for peak river flow, peak rainfall intensity, sea level rise, off-shore wind speeds and extreme wave height.

8.1.2 The EA Product 4 data discussed in Section 5.5 includes 'in-channel' flood level data for the River Thames (taken from the Thames Estuary 2100 study (2008)) and breach flood level data (taken from the Thames Downriver Breach Inundation Modelling Study (2018)). The flood level data includes allowances for climate change, in accordance with EA requirements, and this data has been taken forward for the purposes of defining design levels (as set out in the report enclosed in **Appendix H**).

8.1.3 In respect of allowances for peak rainfall intensity (used to inform design of surface water management infrastructure, as set out in the report enclosed in **Appendix G**), scheme design has been based upon a +40% uplift in rainfall intensity, as required by LBB as the LLFA.

9 Design Recommendations

9.1 Finished Floor Levels

9.1.1 The EA has advised (letter dated 21st December 2017 enclosed in **Appendix F**) that '*…any new development at this location to have finished floor levels set no lower than the breach flood event at this site*'.

9.1.2 Full details regarding design levels for the proposed Energy Recovery Facility and associated infrastructure are set out in the document titled '*Floor Level Strategy Report (January 2018)*' prepared by Doran Consulting Limited, a copy of which is presented in **Appendix H**. The strategy has been prepared in consultation with the EA and correspondence is included within **Appendix F**.

9.1.3 As set out in the report enclosed in **Appendix H**, a finished floor level (FFL) of 2.97 m AOD is proposed. This is based upon 0.5% (1 in 200 year) AEP flood level data, including an allowance for climate change, associated with a breach of the flood defences, taken from the Thames Tidal Downriver Breach Inundation Modelling Study (2018) undertaken on behalf of the EA. In accordance with EA requirements, the FFL includes a freeboard above the breach flood level.

9.1.4 The report enclosed in **Appendix H** notes that breach flood levels in the north-western area of the REP site may exceed 2.97 m AOD, such that there is the potential for floodwater to enter the building. The report therefore recommends that flood sensitive equipment is set a minimum of 400 mm above the recommended FFL in these areas.

9.1.5 As noted in Section 7 above, following consultation with UKPN, it is anticipated that works at Littlebrook substation will be limited to the installation and connection of 132 kV cables (below ground) to existing substation infrastructure. No new infrastructure is proposed externally and works will be undertaken in accordance with UKPN Engineering Design Standard EDS 07-0106 (Substation Flood Protection).

9.2 Flood Defences

9.2.1 As set out in Section 3 above, information provided by the EA confirms that the REP site benefits from flood defences and that the defences currently offer a 1 in 1,000 year (0.1% annual probability) standard of protection.

9.2.2 The design life of REP is c.40 years and it is anticipated that the facility will be operational from 2024. According to the EA Product 4 data (**Appendix D**), the 1 in 1,000 year flood level, including climate change, will be 6.40 m AOD in 2070. The current defence crest level is 7.10 m AOD. It is not therefore necessary to raise the flood defences to maintain the current standard of flood protection for the lifetime of the Proposed Development.

9.2.3 According to EA Product 4 data, the tidal flood defences will ultimately be raised to 8.2 m AOD, in accordance with the policy set out in the Thames Estuary 2100 Plan. Maintenance of the tidal flood defences is the responsibility of the riparian owner (Cory, the Applicant).

9.3 Safe Access

9.3.1 Consideration should be given to the incorporation of safe access and egress arrangements to ensure that operational staff/visitors are safe during periods of flooding.

9.3.2 As noted in Section 3 above, the REP site lies within an area that benefits from flood defences. Providing the defences operate as intended, access and exit arrangements will not be adversely affected during a 0.1% (1 in 1,000 year) AEP tidal event on the River Thames. Should the area in the vicinity of the REP site be inundated following a breach of the tidal flood defences, such that safe exit is not possible, safe refuge may be provided for operational staff/visitors within the administration block and other areas of the building which will be located above the 0.5% (1 in 200 year) AEP breach flood level.

9.4 Flood Incident Management

9.4.1 A flood incident preparedness, response and recovery plan should be prepared for the REP site. Amongst other matters, this should set out the actions to be taken following notification of a potential tidal surge event and during and following flood conditions. The plan should identify operational 'trigger' levels and the roles and responsibilities of REP operational staff/managers.

9.4.2 The plan would need to extend to include the jetty and associated infrastructure/mechanical equipment.

9.4.3 The plan should be prepared in consultation with stakeholders prior to the facility becoming operational.

10 Residual Risk

10.1.1 It is difficult to completely guard against flooding since extreme events greater than the design standard event are always possible. However, risk may be minimised through the application of 'best practice' design, construction and management techniques, such as incorporation of a suitable freeboard.

10.1.2 In addition to more extreme conditions, the nature of flood risk within and in the vicinity of the REP site may vary as a result of changes in landform and changes to the surface water drainage infrastructure. However, changes to landform are considered unlikely once the REP site has been developed. Similarly, changes to the surface water drainage system are unlikely to adversely affect flood risk on account of such infrastructure being appropriately managed and maintained.

10.1.3 The blockage of watercourse crossings/culverts in the vicinity of the REP site has the potential to increase flood levels. However, it is highly unlikely that the REP site would be affected as it will be elevated well above the network of ditches and dykes. In any event, the likelihood of blockage can be minimised through periodic inspection and maintenance/clearance of watercourse corridors.

10.1.4 The principal residual flood risk issues in this instance relate to (i) failure/breaching of the tidal flood defences and (ii) the operation/performance of the surface water drainage system serving the REP site.

10.1.5 As set out in Section 9, the finished floor levels of infrastructure within the REP site will be set above the 0.5% (1 in 200 year) AEP flood level, including an allowance for climate change, associated with a breach of the flood defences. In accordance with EA requirements, the FFL includes a freeboard above the breach flood level. In addition, in the north-western part of the site, where breach flood levels may exceed the finished floor level, flood sensitive equipment is to be located a minimum of 400 mm above the finished floor level to provide additional resilience.

10.1.6 Rainfall events in excess of the design capacity of the surface water drainage network may result in temporary above ground flooding, potentially giving rise to overland flows. However, residual flood risk may be mitigated/minimised through the application of 'best practice' design principles, including careful consideration of the design of external ground levels to facilitate the routing of overland flows away from buildings and towards the surface water storage infrastructure. 'Best practice' design principles include requirements to ensure all proposals account for the potential effects of climate change and therefore much of the potential residual risk can be considered to be accounted for within the design.

10.1.7 As noted in Section 9 above, a flood incident management plan should be prepared so that visitors/operational staff are aware of the action to be taken in the event of tidal floodwater/surface water affecting the REP site and associated highway access.

11 Summary and Concluding Remarks

11.1 Summary

11.1.1 This Flood Risk Assessment (FRA) has been prepared to support an application for a Development Consent Order relating to construction and operation of Riverside Energy Park. The Proposed Development comprises energy generating equipment with an electrical output of up to 96 megawatts (MWe), together with an associated Electrical Connection to export power to the electricity network.

11.1.2 The assessment considers both the REP site and the Electrical Connection Point at Littlebrook substation and may be summarised as follows:

- Prior to progressing the assessment, stakeholders including the EA and the relevant LLFA were consulted to acquire site-specific information on flood risk and to agree design principles and the methodology for preparation of the FRA;
- The REP site is located on the south bank of the River Thames within the LBB and occupies a river frontage position. Littlebrook substation is located approximately 10.5 km to the south-east of the REP site within the neighbouring Borough of Dartford and is set back approximately 500 m from the River Thames.
- According to the EA's Flood Map for Planning and EA Product 4 data, both the REP site and Littlebrook substation lie within Flood Zone 3 - High Probability (land having a 1 in 200 or greater annual probability of tidal flooding). However, the flood map also indicates that the REP site and Littlebrook substation fall within an area that benefits from flood defences. In this instance, the standard of protection afforded by the defences is 1 in 1,000 years.
- The REP site lies within designated growth areas allocated in development plans through the sequential test such that, in accordance with Paragraph 162 of the revised NPPF (July 2018), it is not necessary to apply the Sequential Test again. The Exception Test has been applied and it is concluded that the proposals accord with the requirements of the NPPF.
- Although the REP site benefits from flood defences, such that the actual risk of tidal flooding is low, there is a residual risk of flooding associated with the failure/breaching of the tidal flood defences. Data taken from the Thames Tidal Downriver Breach Inundation Modelling Study 2018 (undertaken on behalf of the EA) for the 2115 scenario (including an allowance for climate change) indicates that flood levels associated with a defence breach vary between 2.49 m AODN and 5.08 m AODN for the 0.5% (1 in 200 year) Annual Exceedance Probability event.

- Similarly, the Littlebrook Power Station substation is potentially at risk of flooding following a defence breach. Data taken from the Thames Tidal Downriver Breach Inundation Modelling Study 2018 for the 2115 scenario (including an allowance for climate change) indicates that flood levels associated with a defence breach vary between 4.69 m AODN and 4.84 m AODN for the 0.5% (1 in 200 year) Annual Exceedance Probability event.

- Finished floor levels of infrastructure within the REP site will be set above the 0.5% (1 in 200 year) AEP flood level, including an allowance for climate change, associated with a breach of the flood defences. In accordance with EA requirements, the FFL includes a freeboard above the breach flood level. In addition, in the north-western part of the site, where breach flood levels may exceed the finished floor level, flood sensitive equipment is to be located a minimum of 400 mm above the finished floor level.

- Works at Littlebrook substation will be limited to the installation and connection of 132 kV cables (below ground) to existing substation infrastructure. No new infrastructure is proposed to be installed other than the below ground cable and works within the existing substation building, and works will be undertaken in accordance with UKPN Engineering Design Standard EDS 07-0106 (Substation Flood Protection).

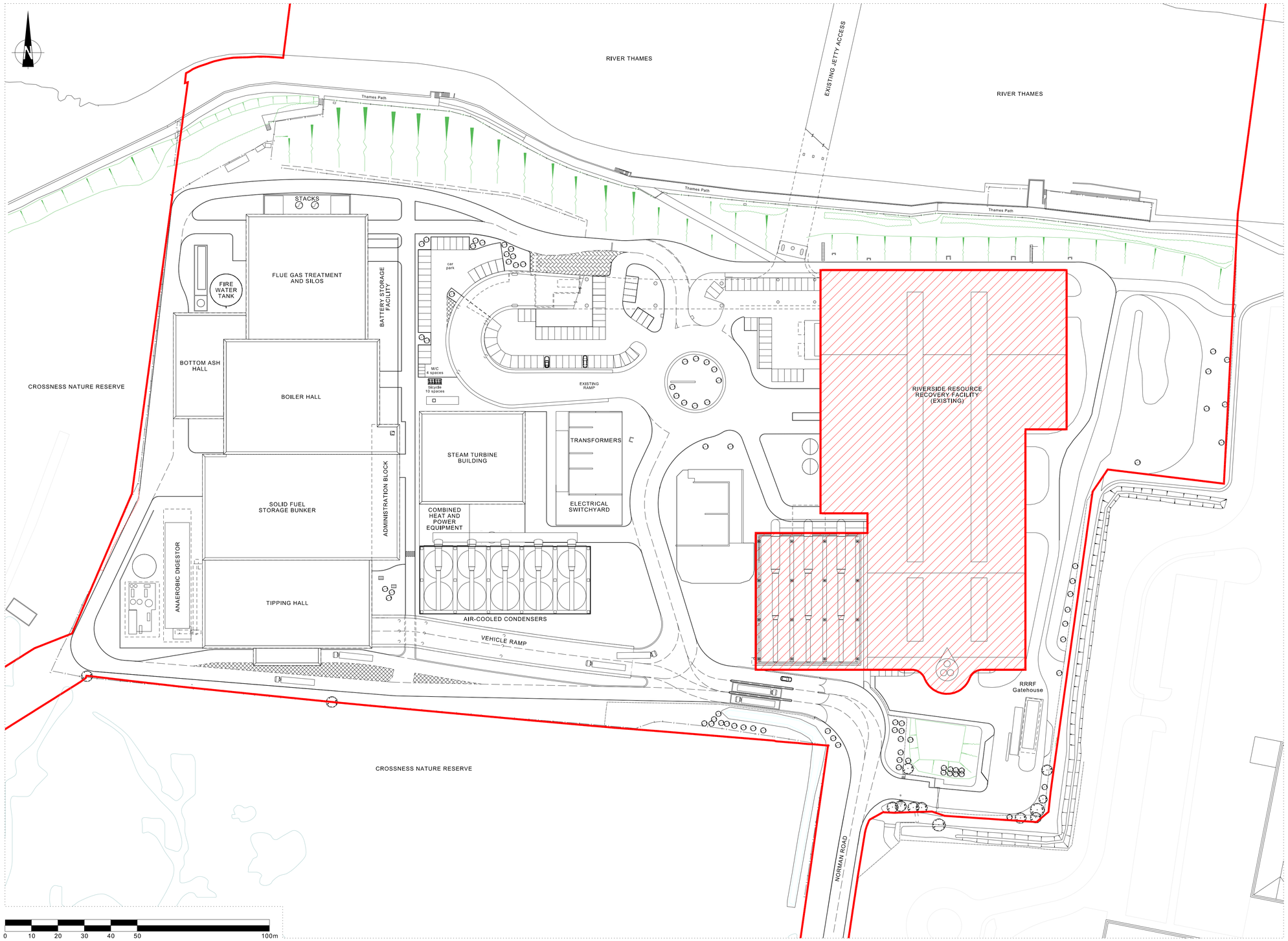
- The proposals include a surface water management strategy, designed in accordance with the requirements of the LLFA, to limit surface water outflows from the REP site to the greenfield rate. No building or surfacing works are required at Littlebrook substation, such that the surface water run-off regime will be unaffected by the proposals. Flood risk downstream will not therefore be increased as a result of the development proposals.

- The development proposals and associated mitigation measures are designed to take into account the predicted impacts of climate change, such that adaptability and resilience are ‘built-in’ to the proposals.

- Residual risk matters may be mitigated/minimised through the application of ‘best practice’ design, construction and management techniques and will be addressed as part of the detailed design process.

11.1.3 The development will be safe for its lifetime without increasing flood risk elsewhere, thus meeting the requirements of National Policy Statements EN-1, EN-3 and EN-5 and the revised National Planning Policy Framework (NPPF). On this basis, it is concluded that flood risk considerations have been adequately addressed as part of the application for a Development Consent Order (DCO) for REP.

Appendix A Indicative Site Layout Plan



KEY:

ORDER LIMITS

AREA NOT INCLUDED IN DEVELOPMENT CONSENT ORDER

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CORY RIVERSIDE ENERGY

RIVERSIDE ENERGY PARK

NORMAN ROAD BELVEDERE LONDON

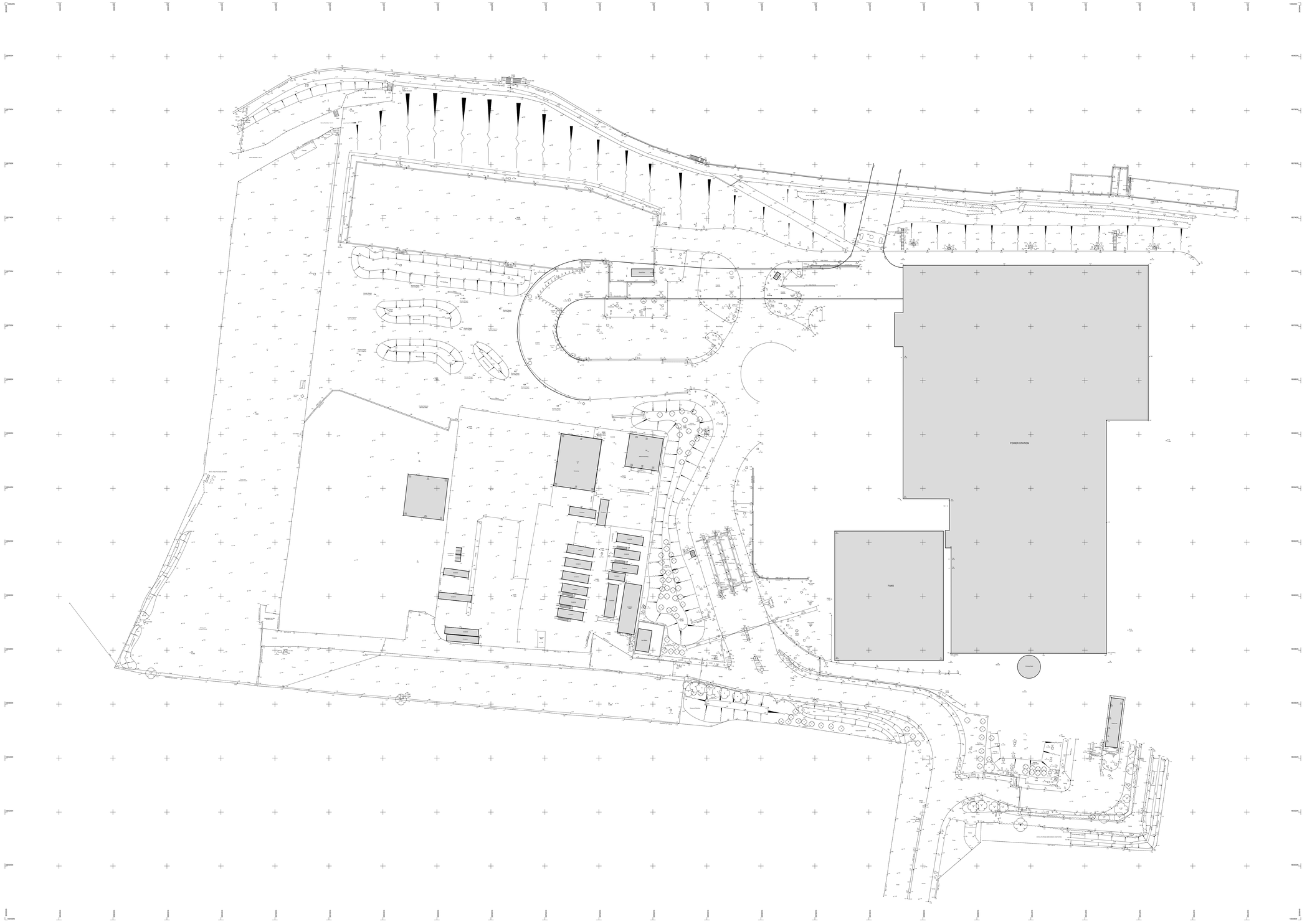
DOC REF 2.4 ILLUSTRATIVE SITE LAYOUT PLAN

THE RIVERSIDE ENERGY PARK SITE LONDON

REGULATION 5(2)(o)

Date	31.10.18
A1 Scale	1:750
Drawn by	AG
Checked by	PC
Drawing Number	DOC REF 2.4

Appendix B Topographic Survey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FANS
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Norman Road North
Norman Road South
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Gate No.2
Gate No.3
Gate No.4
Gate No.5
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Gate No.7
Gate No.8
Gate No.9
Gate No.10
Gate No.11
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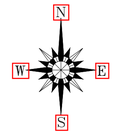
Gate No.19
Gate No.20
Gate

Grid



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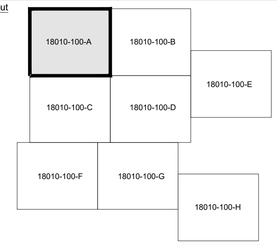

LEGEND

BANKING — Top / Bottom

BUSHES & HEDGES

TREES — MT / 3T / 0.2 / 6 (Multiple Trunks: No of Trunks; Dia of Bole; Height of Tree)

NOTE:- SPREADS AND HEIGHTS ARE INDICATIVE ONLY

GATES — Single / Double

WALL — Width drawn to scale 0.23m

BUILDING

OPEN SIDED BUILDING

GLASS ROOFED

CONTOURS 25.50

ABBREVIATIONS (WHERE APPLICABLE)

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ARCH HEAD LEVEL	AHL	MONITORING WELL	MW
ARCH SPRINGER HEIGHT	ASH	NOTICE BOARD	NB
ARCH SPRINGER LEVEL	ASL	NAME PLATE	NP
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BUS STOP	BS	RAIN WATER PIPE	RWP
CABLE TV	CATV	SLUICE VALVE	SV
COVER LEVEL	CL	STOP COCK	SC
CABLE MARKER	CM	SOFFIT LEVEL	SOF
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CONCRETE POST	CP	TREE STUMP	ST
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INTERWOVEN FENCE	IWF	STEEL PALISADE SECURITY FENCE	SPSF
IRON RAILING FENCE	IRF	TUBULAR STEEL RAIL FENCE	TSRF

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DRAWN	LCD	Hitachi Zosen Inova AG
CHECKED	SJM	SCALE
RICS		1/200 (A1 Sheet)

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TOPOGRAPHICAL SURVEY

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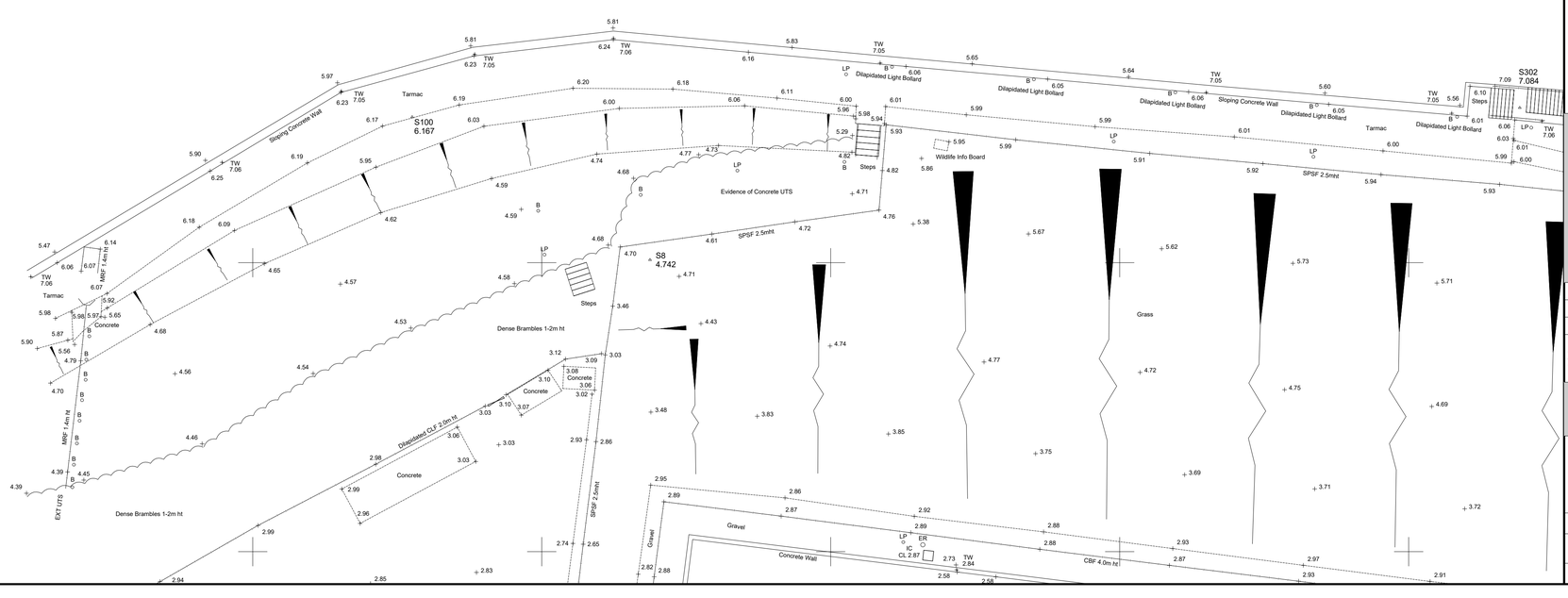
Date : Feb 2017



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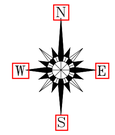

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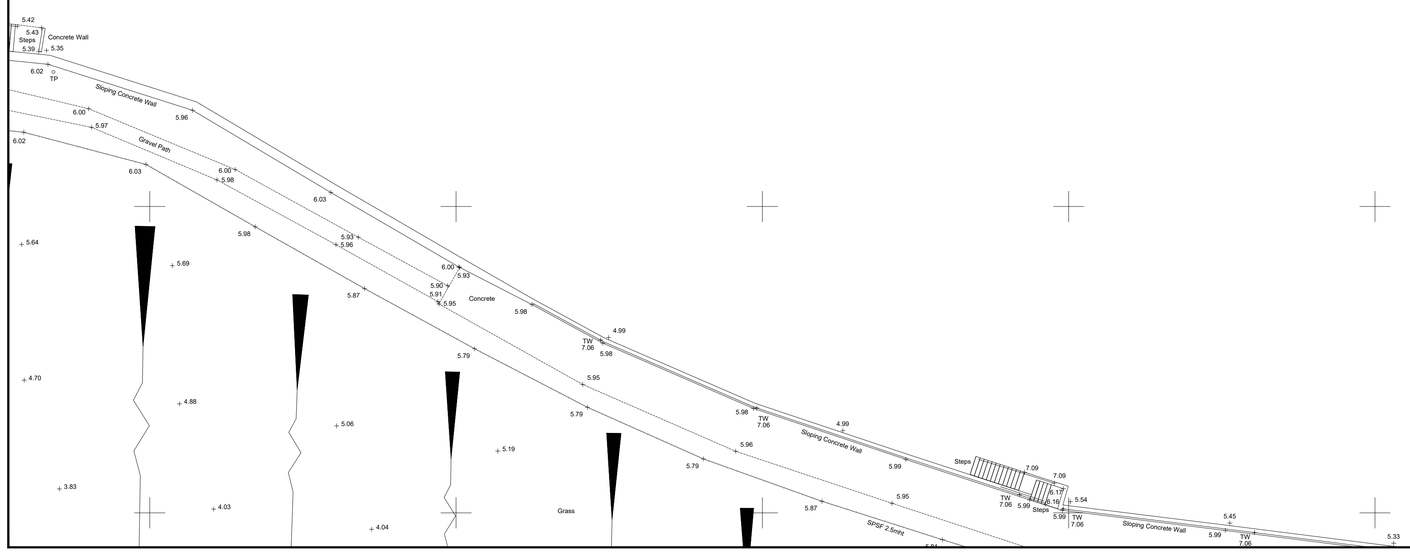

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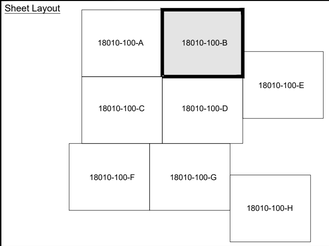

LEGEND

BANKING — Top / Bottom

WALL — Width drawn to scale 0.23w

BUSHES & HEDGES

BUILDING

TREES — MT / 3T / 0.2 / 6 (Multiple Trunks / No of Trunks / Dia of Bole / Height of Tree)

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GLASS ROOFED

GATES — Single / Double

CONTOURS — 25.50

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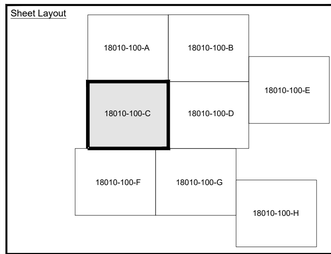

LEGEND

BANKING — Top / Bottom

WALL — Width drawn to scale 0.23w

BUSHES & HEDGES

BUILDING

TREES — MT / 3T / 0.2 / 6 (Multiple Trunks, No of Trunks, Dia of Bole, Height of Tree)

OPEN SIDED BUILDING

NOTE:- SPREADS AND HEIGHTS ARE INDICATIVE ONLY

GLASS ROOFED

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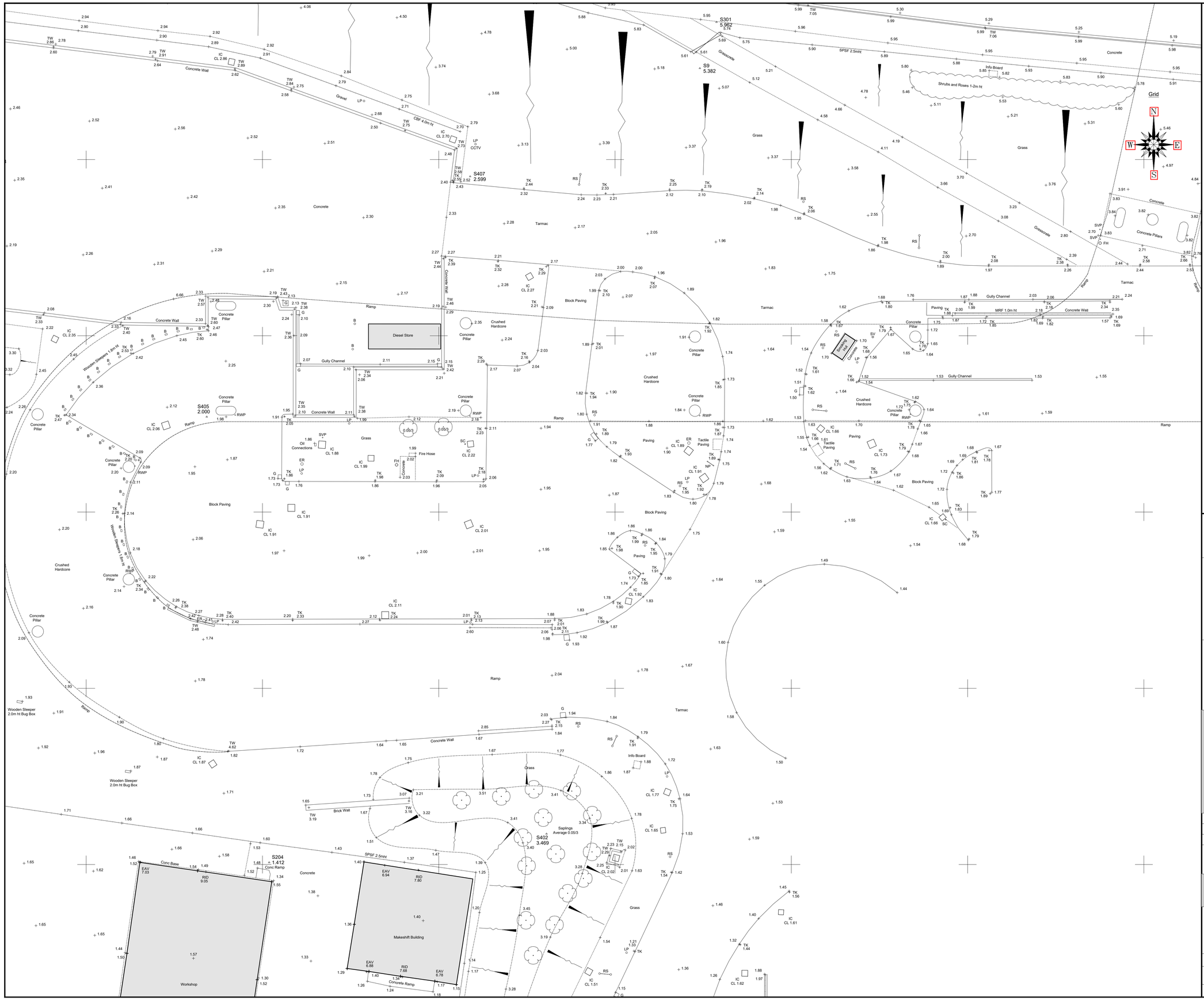

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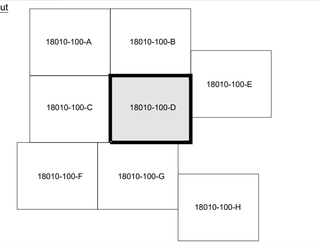

LEGEND

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Job No	Rev	Drawing Number
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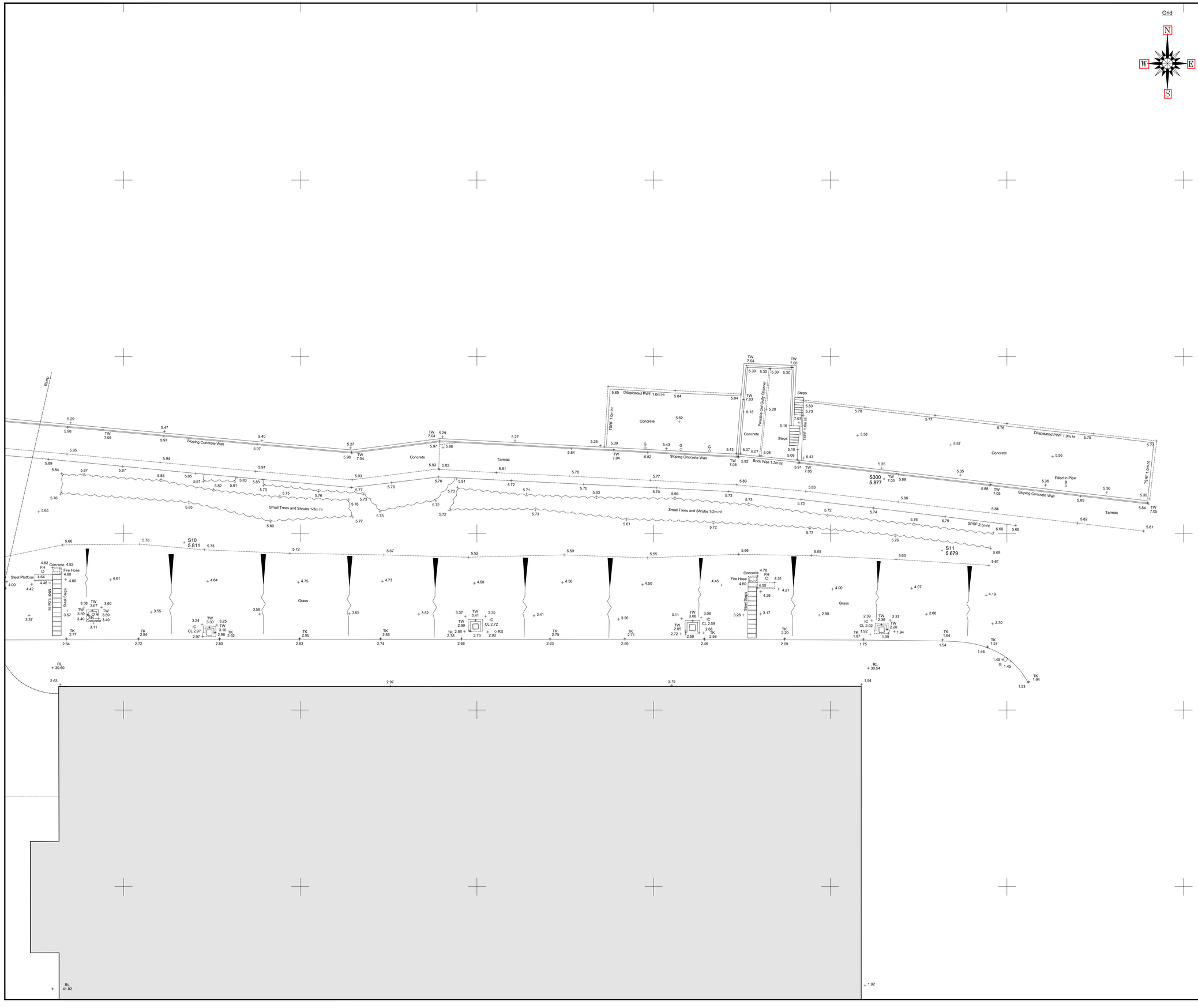
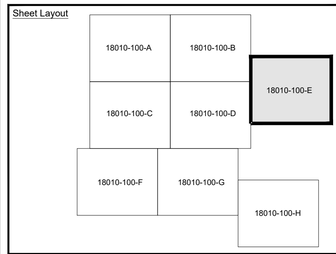
Date : Feb 2017		



Sheet Layout



LEGEND

BANKING — Top / Bottom

WALL — Width drawn to scale 0.23w

BUSHES & HEDGES

BUILDING

TREES — MT / 3T / 0.2 / 6 (Multiple Trunks / No of Trunks / Dia of Bole / Height of Tree)

OPEN SIDED BUILDING

NOTE:- SPREADS AND HEIGHTS ARE INDICATIVE ONLY

GLASS ROOFED

GATES — Single / Double

CONTOURS — 25.50

ABBREVIATIONS (WHERE APPLICABLE)

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ARCH HEAD LEVEL	AHL	MONITORING WELL	MW
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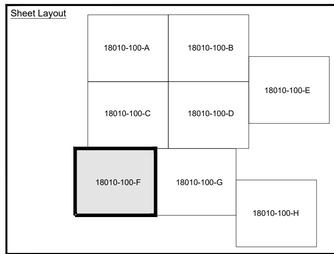

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OPEN SIDED BUILDING

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S202 1.354
S201 1.315
S206 1.331
S200 1.257
S401 3.391
S207 1.211
S4 1.345
S3 1.261
Grid
N
W
E
S
Gravel
Concrete
Tarmac
Grass
Grasscrete
Container
Container Office
Sub Station
Tarmac Gate House
Weighbridge
Saplings Average 0.05/3
Saplings Average 0.1/5
Saplings Average 0.1/3
Grass and Brambles
Ditch
Sapling 0.05/3
Dilapidated Conc Gully Channel
Conc Ramp
Conc Base
Concrete Base
Concrete Steps
Concrete Plinth
Concrete Wall
Brick Wall
Swing Barrier
Intercom
Stay Wire
Fire Hose
Tactile Paving
Block Paving
Gravel Gate Run
Con Box
Meter
Removed
Dilapidated
Ummade Ground
SPSF 2.5mht
SPSF 2.3m ht
SPSF 3.0m ht
SPSF 2.5m ht
SPSF 2.5mht
SPSF 2.5mht
SPSF 2.5m ht
SPSF 2.5mht
SPSF 2.5m ht
TSRF 1.2m ht
TSRF 0.9m ht
SPSF 2.5mht
SPSF 2.5mht
SPSF 2.5mht
SPSF 2.5m ht
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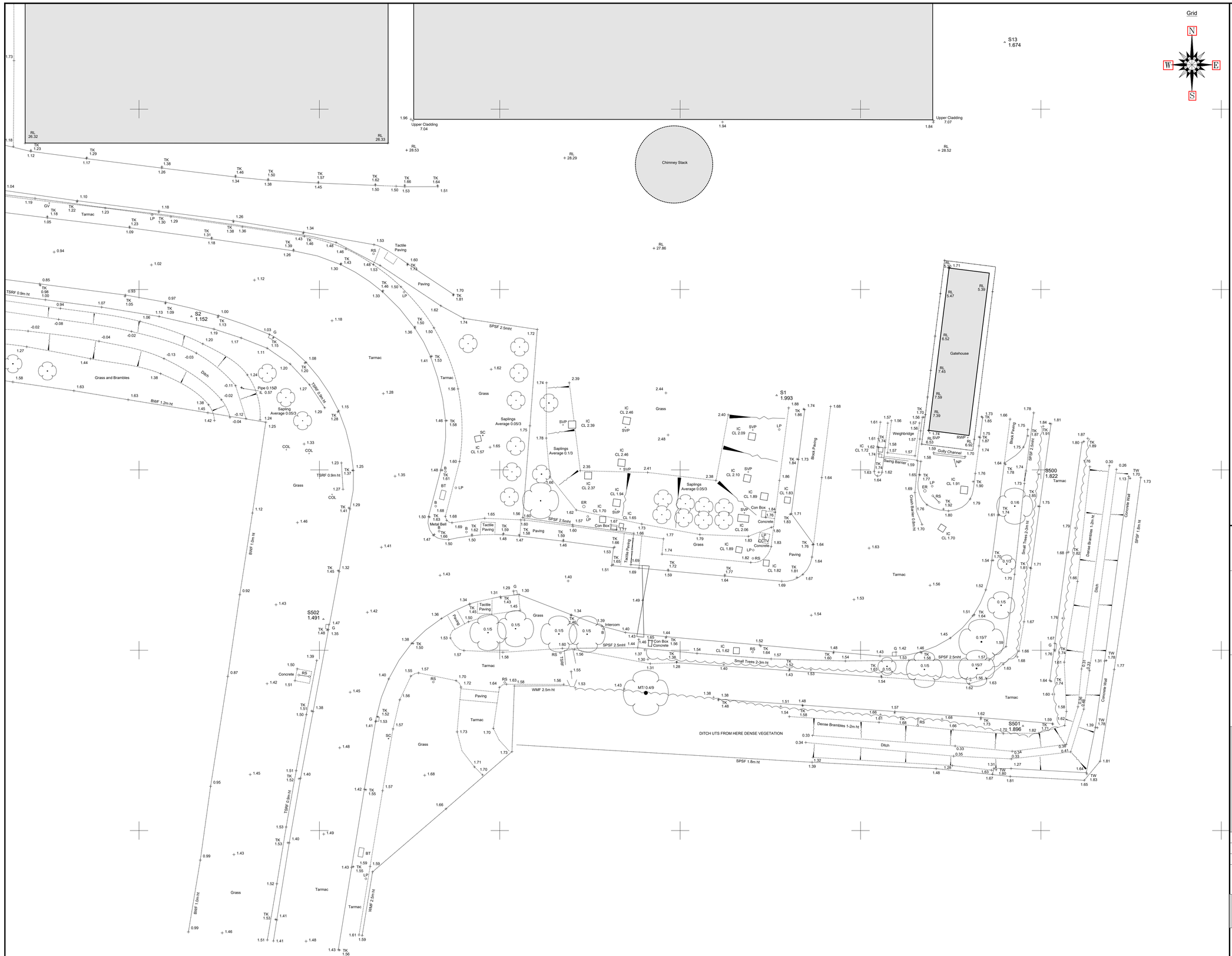

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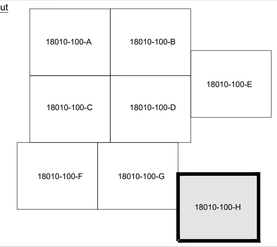

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Norman Road North, Belvedere, DA17 6JY

TOPOGRAPHICAL SURVEY

Job No	Rev	Drawing Number
18/010		18/010/100-H
Date : Feb 2017		

Appendix C Surface Water Features Plan

Indicative Application Boundary
Local Nature Reserve (LNR)

See Inset

Crossness Wastewater Treatment Works

Crossness Nature Reserve

Green Level Pumping Station

River Thames

Lesnes Abbey Woods

A2016 Bronze Age Way

River Darent

River Cray

Littlebrook Power Station

Littlebrook Nature Park

A206

Surface Water Drain/Ditch

Great Breach Pumping Station

Great Breach West

Great Breach Dyke

Horsehead Dyke

Norman Road

Inset

Barking Reach
Halfway Reach
Creekmouth
Thamesmead
Lower Belvedere
Belvedere
Abbey Wood
Lesnes Abbey
Bostall Heath
Erith Reach
Erith
Erith Rands
Purfleet
Long Reach
Wennington
Crayford
Barnehurst
Slade Green
Dartford Marshes
DARTFORD
Temple Hill
Crossways
Old Bexley
Northumberland Heath
Lessness Heath

0 1 2 km

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RIVERSIDE ENERGY PARK

pba peterbrett

Client: CORY RIVERSIDE ENERGY

1:30,000 @ A3
31/08/18
Drawn: HC/HG
Checked: SH

Surface Water Features

Figure 3.2 | Rev B

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Appendix D EA Product 4 Data

Product 4 (Detailed Flood Risk) for: Littlebrook Power Station, Dartford, DA1 5PZ
Requested by: Stuart Harwood, Peter Brett Associates LLP
Reference: KSL 87575 AB (previous request KSL 74537 UE)
Date: 4 June 2018

Contents

- Flood Map for Planning (Rivers and Sea)
- Flood Map Extract
- Thames Estuary 2100 (TE2100)
- Thames Tidal Downriver Breach Inundation Modelling 2018
- Thames Tidal Downriver Breach Inundation Modelling Map
- Site Node Locations Map
- Defence Details
- Recorded Flood Events Data
- Recorded Flood Events Outlines Map
- Additional Information

The information provided is based on the best data available as of the date of this letter.

You may feel it is appropriate to contact our office at regular intervals, to check whether any amendments/ improvements to the data for this location have been made. Should you re-contact us after a period of time, please quote the above reference in order to help us deal with your query.

Please refer to the Open Government Licence which explains the permitted use of this information.

Orchard House, Endeavour Park, London Road, Addington, West Malling, Kent, ME19 5SH.
Customer services line: 020 8474 6848
Email: kslenquiries@environment-agency.gov.uk
Website: https://www.gov.uk/government/organisations/environment-agency

Flood Map for Planning (Rivers and Sea)

The Flood Map:

Our Flood Map shows the natural floodplain for areas at risk from river and tidal flooding. The floodplain is specifically mapped ignoring the presence and effect of defences. Although flood defences reduce the risk of flooding they cannot completely remove that risk as they may be over topped or breached during a flood event.

The Flood Map indicates areas with a 1% (0.5% in tidal areas), Annual Exceedance Probability (AEP) - the probability of a flood of a particular magnitude, or greater, occurring in any given year, and a 0.1% AEP of flooding from rivers and/or the sea in any given year. In addition, the map also shows the location of some flood defences and the areas that benefit from them.

The Flood Map is intended to act as a guide to indicate the potential risk of flooding. When producing it we use the best data available to us at the time and also take into account historic flooding and local knowledge. The Flood Map is updated on a quarterly basis to account for any amendments required. These amendments are then displayed on the internet at https://www.gov.uk/check-flood-risk

At this Site:

The Flood Map shows that this site lies within the outline of Flood Zone 3. This zone comprises land assessed as having a 0.5% (1 in 200) or greater annual probability of tidal flooding.

is not within the current 'Extreme Flood Outline'. According to the Flood Map, which provides a general estimate of the likelihood of flooding across England & Wales, this site is shown to have less than 0.1% (1 in 1000) chance of flooding in any year from rivers and/or the sea.

Enclosed is an extract of our Flood Map which shows this information for your area.

Method of production

The Flood Map at this location has been derived using detailed modelling of the tidal River Thames through the North Kent Coastal Modelling study completed in 2013 by JBA Consulting.

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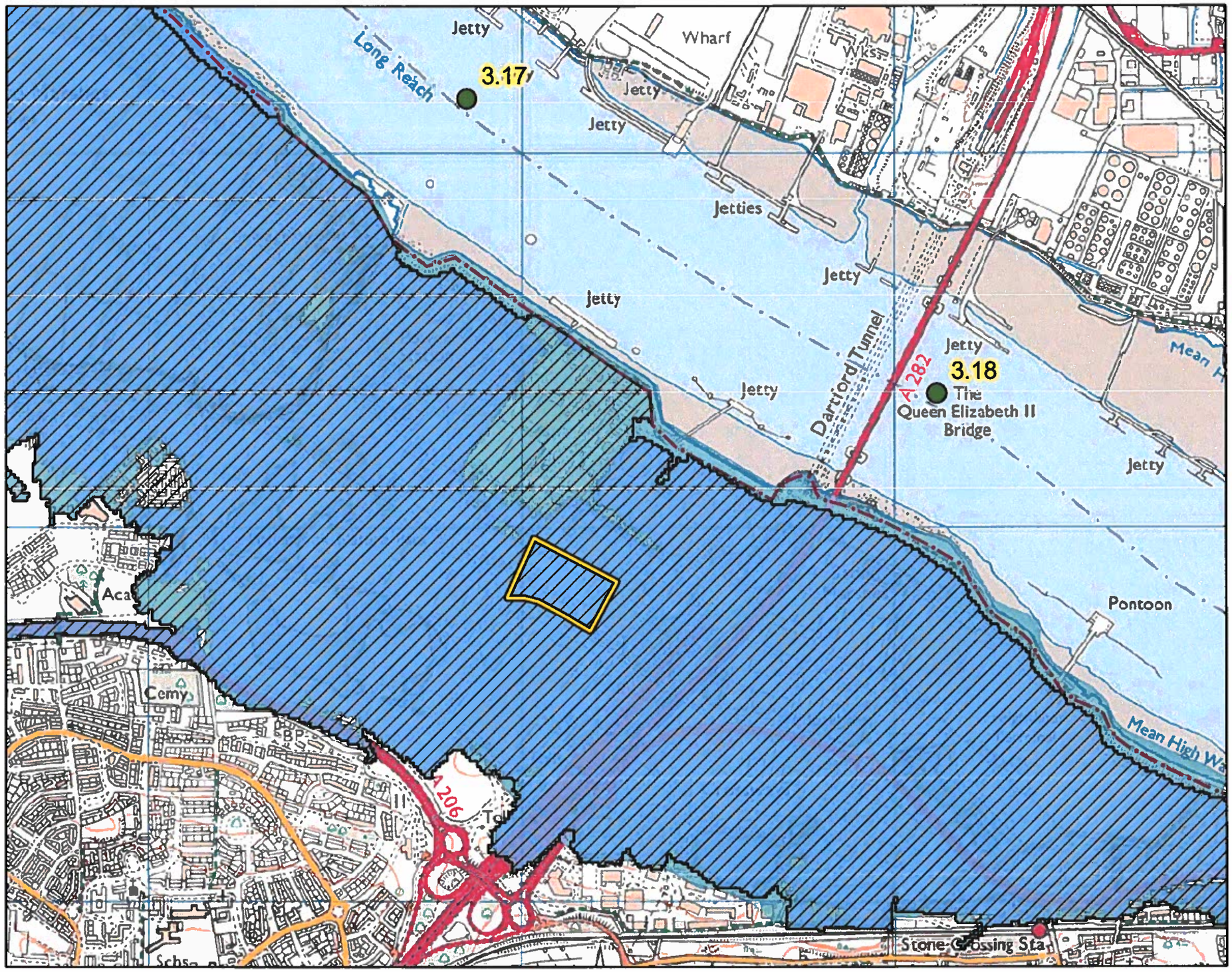
Detailed FRA/FCA Map centred on DA1 5PZ created 4 June 2018 [Ref: KSL 87575 AB]



Environment Agency

Scale 1: 15,000

N W E S

Legend

- Site Location
- TE2100 Model Nodes
- Flood Map - Defences
- Flood Map - Flood Storage Areas
- Areas Benefiting from Flood Defences
- Flood Map - Flood Zone 3
- Flood Map - Flood Zone 2

Flood Map for Planning (assuming no defences)

Flood Zone 3 shows the area that could be affected by flooding:
- from the sea with a 0.5% or greater chance of occurring each year
- or from a river with a 1% or greater chance of occurring each year.

Flood Zone 2 shows the extent of an extreme flood from rivers or the sea with up to a 0.1% chance of occurring each year.

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Thames Estuary 2100 (TE2100)

You have requested in-channel flood levels for the tidal river Thames. These have been taken from the Thames Estuary 2100 study completed by HR Wallingford in 2008. The modelled node closest to your site is **3.18**; the locations of nearby nodes are also shown on the enclosed map.

Details about the TE2100 plan

The TE2100 plan is now live and within it are a set of levels on which the flood risk management strategy is based. The plan is the overarching flood management strategy for the Thames Estuary and therefore any development planning should be based on the same underlying data.

Details about the TE2100 in-channel levels

The TE2100 in-channel levels take into account operation of the Thames Barrier when considering future levels. The Thames Barrier requires regular maintenance and with additional closures the opportunity for maintenance will be reduced. When this happens, river levels – for which the Barrier would normally shut for the 2008 epoch – will have to be allowed through to ensure that the barrier is not shut too often. For this reason, levels upriver of the barrier will increase and the tidal walls will need to be heightened to match.

For further information about the Thames Barrier please visit our website at:

https://www.gov.uk/the-thames-barrier

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TE2100 2008 levels:

Levels downriver of the Thames Barrier are 0.1% AEP (1 in 1000) and levels upriver are the highest levels permitted by the Thames Barrier, described as the Maximum Likely Water Levels (MLWLs). The defence levels (left defence, right defence) are the minimum levels to which the defences should be built.

Location	Node	Easting	Northing	Extreme water level (m)	Left defence (m)	Right defence (m)	Allow for future defence raising to a level of...	
							Left Bank (m)	Right Bank (m)
	3.16	555005	177890	5.95	7.15	6.70	8.10	8.10
	3.17	555856	177145	5.94	6.85	6.74	8.00	8.00
QEII bridge	3.18	557116	176358	5.94	6.90	6.35	8.00	8.00
	3.19	558233	175677	5.92	6.85	6.75	8.00	8.00
	3.2	559232	175943	5.90	6.85	6.28	8.00	8.00

TE2100 climate change levels:

Location	Node	Easting	Northing	1000-year design water levels					
				2000	2040	2070	2100	2120	2170
	3.16	555005	177890	5.95	6.16	6.31	6.63	6.82	7.31
	3.17	555856	177145	5.94	6.15	6.30	6.62	6.81	7.28
QEII bridge	3.18	557116	176358	5.94	6.15	6.29	6.60	6.79	7.25
	3.19	558233	175677	5.92	6.13	6.28	6.60	6.78	7.23
	3.2	559232	175943	5.90	6.11	6.27	6.58	6.76	7.22

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Thames Tidal Downriver Breach Inundation Modelling - 2018

The table below displays site-specific modelled flood levels at your site. These have been taken from the Downrvier Breach Inundation Modelling Study 2018 completed by Atkins Ltd. in May 2018.

We have developed a modelling approach where all downriver breach locations along the Thames are equitably modelled, to ensure a consistent approach across London. This modelling simulates continuous tidal breaches along the entire extent of the Thames between the Thames Barrier and east of Gravesend on the south bank and east of Tilbury on the north bank. For hard and composite defences breaches are set at 20 m wide; for soft defences, breaches are 50 m wide. In both cases, the defence breach scour distance was assumed to extend into the floodplain by the same distance as the breach width.

Based on the 2008 TE2100 in-channel levels, the 0.5% (1 in 200 year) and 0.1% (1 in 1000 year) annual probability of exceedance tidal events were modelled for all breach locations downriver of the Thames Barrier. These were modelled for the 2014 year epoch (current year), as well as 2100 epoch which include allowances for climate change.

This model has been designed for catchment wide flood risk mapping. It should be noted that it was not created to produce flood levels for specific development sites within London.

	National Grid Reference		Modelled levels in mAODN for 0.5% AEP		Modelled levels in mAODN for 0.1% AEP	
Node	Easting	Northing	2014	2115	2014	2115
1	556039	175965	Nil return	4.81	Nil return	5.05
2	556115	175928	4.18	4.80	4.27	5.03
3	556179	175894	4.19	4.79	4.27	5.02
4	556239	175862	4.21	4.75	4.30	4.98
5	556014	175911	4.15	4.83	4.23	5.06
6	556064	175886	Nil return	4.81	Nil return	5.03
7	556133	175890	4.18	4.80	4.27	5.03
8	555996	175865	4.14	4.84	4.23	5.08
9	556071	175838	4.16	4.80	4.25	5.03
10	556120	175842	Nil return	4.80	Nil return	5.03
11	556137	175806	4.18	4.79	4.26	5.02
12	556171	175837	4.18	4.80	4.26	5.03

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	National Grid Reference		Modelled levels in mAODN for 0.5% AEP		Modelled levels in mAODN for 0.1% AEP	
Node	Easting	Northing	2014	2115	2014	2115
13	556224	175809	4.22	4.70	4.31	4.92
14	555967	175814	4.14	4.84	4.23	5.08
15	556041	175796	4.18	4.81	4.26	5.04
16	556120	175752	4.20	4.72	4.28	4.93
17	556181	175717	4.24	4.69	4.33	4.88
18	556195	175761	4.25	4.69	4.34	4.89

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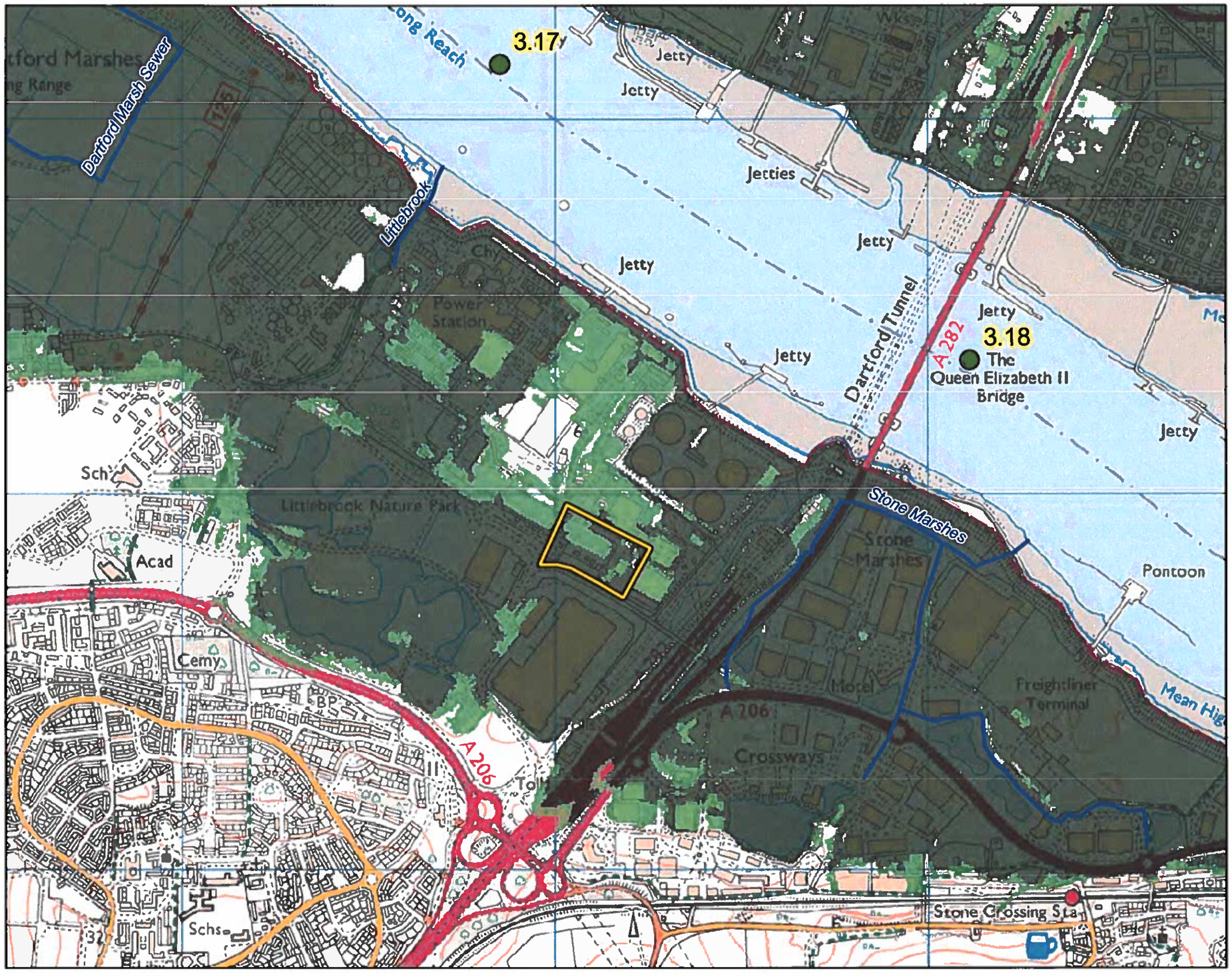
Downriver Breach Modelling Map centred on DA1 5PZ created 4 June 2018 [Ref: KSL 87575 AB]



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Scale 1: 15,000

N W E S

Legend

- Site Location
- TE2100 Model Nodes
- Main Rivers
- Flood Map - Defences

Downriver 0.5% AEP Outlines

Epoch

- 2014 (Current year)
- 2115

Thames Tidal Downriver Breach Inundation Modelling 2018

A modelled representation of all tidal breach locations along the Thames from the Thames Barrier to Gravesend, based on low floodplain topography. For hard and composite defences breaches are set at 20 m wide; for soft defences, breaches are 50 m wide. In both cases, the defence breach scour distance was assumed to extend into the floodplain by the same distance as the breach width.
The modelling is based on the 2008 TE2100 in-channel levels, with an allowance for climate change for epoch 2115.

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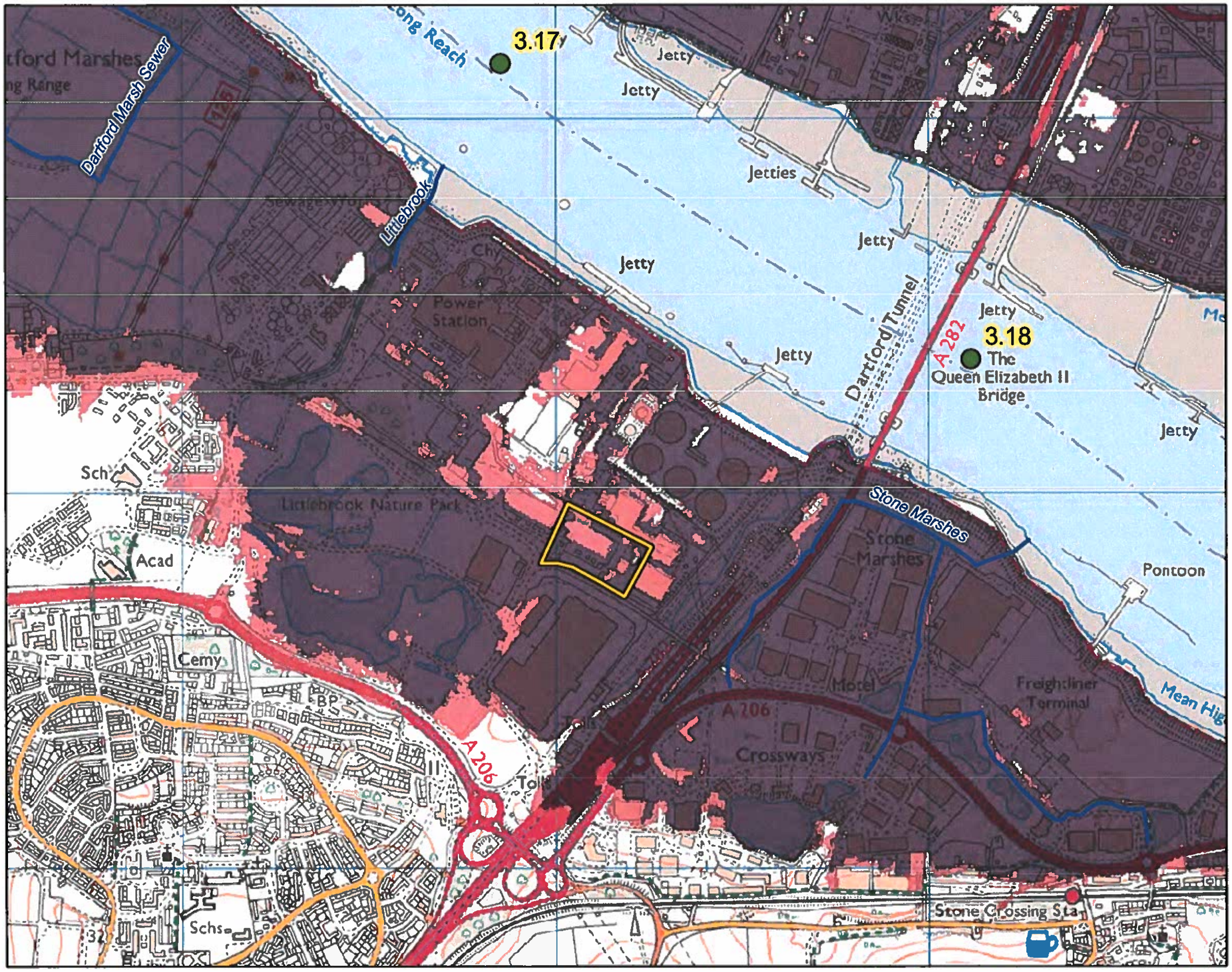
Downriver Breach Modelling Map centred on DA1 5PZ created 4 June 2018 [Ref: KSL 87575 AB]



Environment Agency

Scale 1: 15,000

N W E S

Legend

- Site Location
- TE2100 Model Nodes
- Main Rivers
- Flood Map - Defences

Downriver 0.1% AEP Outlines

Epoch

- 2014 (Current year)
- 2115

Thames Tidal Downriver Breach Inundation Modelling 2018

A modelled representation of all tidal breach locations along the Thames from the Thames Barrier to Gravesend, based on low floodplain topography. For hard and composite defences breaches are set at 20 m wide; for soft defences, breaches are 50 m wide. In both cases, the defence breach scour distance was assumed to extend into the floodplain by the same distance as the breach width.
The modelling is based on the 2008 TE2100 in-channel levels, with an allowance for climate change for epoch 2115.

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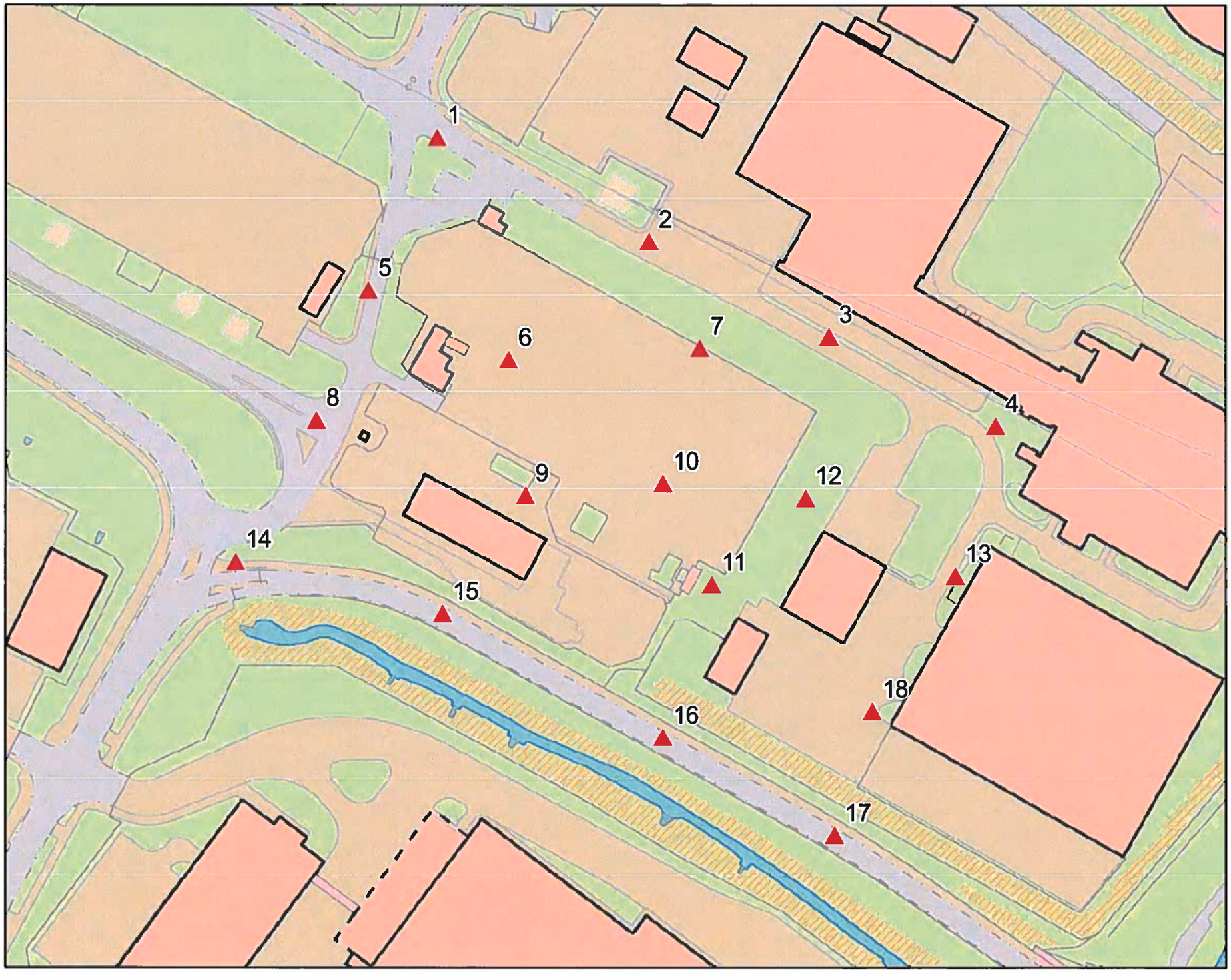
Node Location Map centred on DA1 5PZ created 4 June 2018 [Ref: KSL 87575 AB]



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Scale 1: 2,000

N
W
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Legend

▲ Node Point Locations

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Defence Details

The design standard of protection of the flood defences in this area of the Thames is 0.1% AEP; they are designed to defend London up to a 1 in 1000 year **tidal** flood event. The defences are all raised, man-made and privately owned. It is the riparian owners' responsibility to ensure that they are maintained to a crest level of **6.35m AODN** (the Statutory Flood Defence Level in this reach of the Thames). We inspect them twice a year to ensure that they remain fit for purpose. The current condition grade for defences in the area is 2 (good), on a scale of 1 (very good) to 5 (very poor). For more information on your rights and responsibilities as a riparian owner, please see our document 'Living on the edge' found on our website at:

https://www.gov.uk/government/publications/riverside-ownership-rights-and-responsibilities

There are no planned improvements in this area. Please see the 'Thames Estuary 2100' document on our website for the short, medium and long term Flood Risk Management strategy for London:

https://www.gov.uk/government/publications/thames-estuary-2100-te2100

Areas Benefiting from Flood Defences

This site is within an area benefiting from flood defences, as shown on the enclosed extract of our Flood Map. Areas benefiting from flood defences are defined as those areas which benefit from formal flood defences specifically in the event of flooding from rivers with a 1% (1 in 100) chance in any given year, or flooding from the sea with a 0.5% (1 in 200) chance in any given year.

If the defences were not there, these areas would be flooded. An area of land may benefit from the presence of a flood defence even if the defence has overtopped, if the presence of the defence means that the flood water does not extend as far as it would if the defence were not there.

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Recorded Flood Events Data

We hold records of historic flood events from rivers and the sea. Information on the floods that may have affected the area local to your site is provided below and in the enclosed map (if relevant).

Flood Event Data

1953 – The site was subject to tidal flooding, due to a storm surge in the North Sea, on the night of the 31st January into the morning of 1st February. An approximate level in the Thames at the time was 5.06m AODN.

Due to the fact that our records are not comprehensive, we would advise that you make further enquiries locally with specific reference to flooding at this location. You should consider contacting the relevant Local Planning Authority and/or water/sewerage undertaker for the area.

We map flooding to land, not individual properties. Our historic flood event record outlines are an indication of the geographical extent of an observed flood event. Our historic flood event outlines do not give any indication of flood levels for individual properties. They also do not imply that any property within the outline has flooded internally.

Please be aware that flooding can come from different sources. Examples of these are:

- from rivers or the sea;
- surface water (i.e. rainwater flowing over or accumulating on the ground before it is able to enter rivers or the drainage system);
- overflowing or backing up of sewer or drainage systems which have been overwhelmed,
- groundwater rising up from underground aquifers

Currently the Environment Agency can only supply flood risk data relating to the chance of flooding from rivers or the sea. However you should be aware that in recent years, there has been an increase in flood damage caused by surface water flooding and drainage systems that have been overwhelmed.

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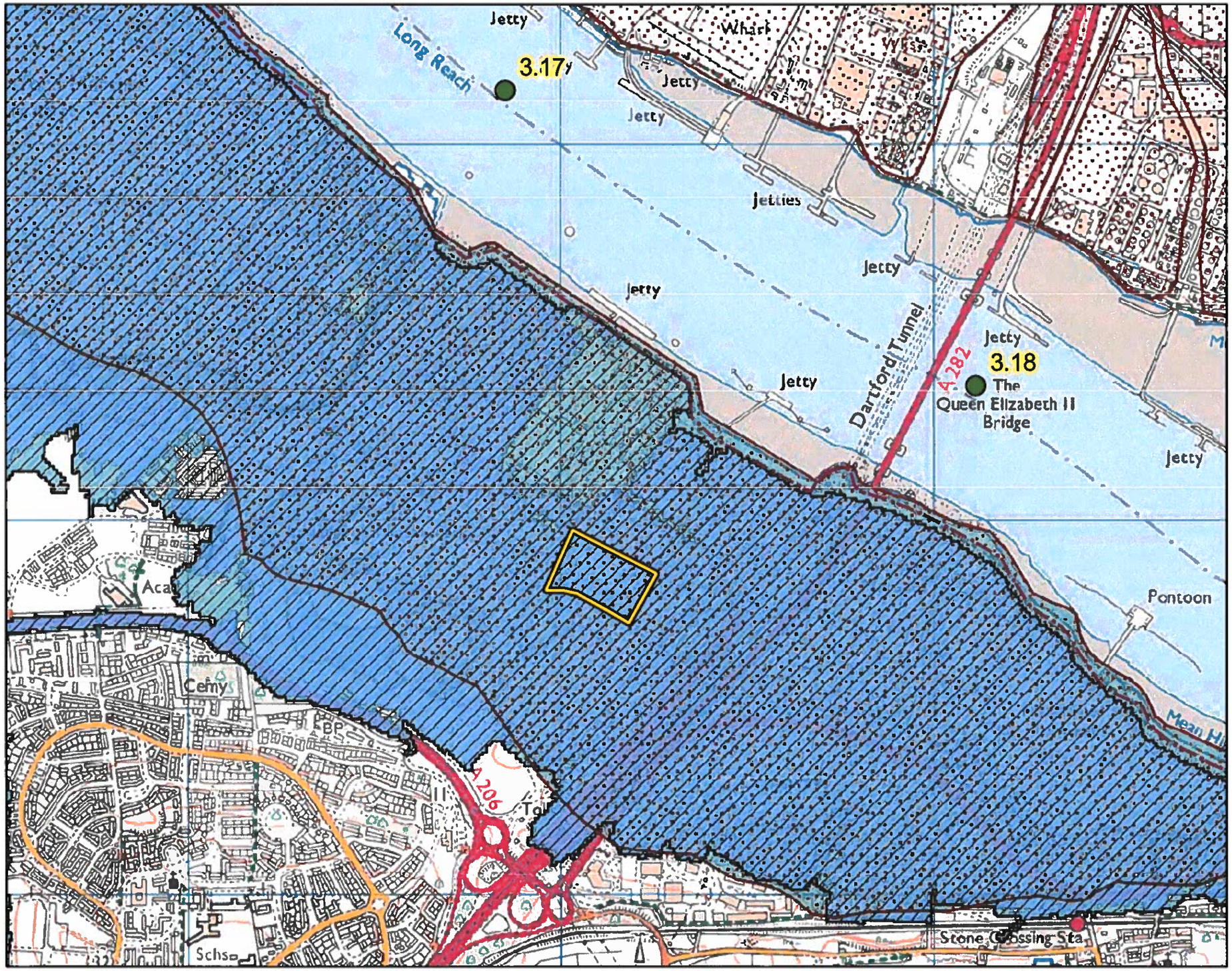
Historic Flood Map centred on DA1 5PZ created 4 June 2018 [Ref: KSL 87575 AB]



Environment Agency

Scale 1: 15,000

N W E S

Legend

- Site Location
- TE2100 Model Nodes
- Flood Map - Defences
- Jan 1953 Flood Outline
- Flood Map - Flood Storage Areas
- Areas Benefiting from Flood Defences
- Flood Map - Flood Zone 3
- Flood Map - Flood Zone 2

Flood Map for Planning
(assuming no defences)

Flood Zone 3 shows the area that could be affected by flooding:
- from the sea with a 0.5% or greater chance of occurring each year
- or from a river with a 1% or greater chance of occurring each year.

Flood Zone 2 shows the extent of an extreme flood from rivers or the sea with up to a 0.1% chance of occurring each year.

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Additional Information

Information Warning - OS background mapping

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Planning advice and guidance

The Environment Agency are keen to work with partners to enable development which is resilient to flooding for its lifetime and provides wider benefits to communities. If you have requested this information to help inform a development proposal, then we recommend engaging with us as early as possible by using the pre-application form available from our website:
https://www.gov.uk/government/publications/pre-planning-application-enquiry-form-preliminary-opinion

Complete the form in the link and email back to kslplanning@environment-agency.gov.uk

We recognise the value of early engagement in development planning decisions. This allows complex issues to be discussed, innovative solutions to be developed that both enables new development and protects existing communities. Such engagement can often avoid delays in the planning process following planning application submission, by reaching agreements up-front. We offer a charged pre-application advice service for applicants who wish to discuss a development proposal.
We can also provide a preliminary opinion for free which will identify environmental constraints related to our responsibilities including flooding, waste, land contamination, water quality, biodiversity, navigation, pollution, water resources, foul drainage or Environmental Impact Assessment.

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Flood Risk Assessments guidance

Flood risk standing advice for applicants

In preparing your planning application submission, you should refer to the Environment Agency's Flood Risk Standing Advice and the Planning Practice Guidance for information about what flood risk assessment is needed for new development in the different Flood Zones. This information can be accessed via:

https://www.gov.uk/flood-risk-assessment-standing-advice

http://planningguidance.planningportal.gov.uk/

https://www.gov.uk/guidance/flood-risk-assessment-for-planning-applications

https://www.gov.uk/guidance/flood-risk-and-coastal-change

You should also consult the Strategic Flood Risk Assessment and flood risk local plan policies produced by your local planning authority.

You should note that:

1. Information supplied by the Environment Agency may be used to assist in producing a Flood Risk Assessment where one is required, but does not constitute such an assessment on its own.
2. This information covers flood risk from main rivers and the sea, and you will need to consider other potential sources of flooding, such as groundwater or overland runoff. You should discuss surface water management with your Lead Local Flood Authority.
3. Where a planning application requires a FRA and this is not submitted or deficient, the Environment Agency may well raise an objection due to insufficient information

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Surface Water

We have provided two national Surface Water maps, under our Strategic Overview for flooding, to your Lead Local Flood Authority who are responsible for local flood risk (i.e. surface runoff, ground water and ordinary watercourse), which alongside their existing local information will help them in determining what best represents surface water flood risk in your area.

Your Lead Local Flood Authority have reviewed these and determined what it believes best represents surface water flood risk. You should therefore contact this authority so they can provide you with the most up to date information about surface water flood risk in your area.

You may also wish to consider contacting the appropriate relevant Local Planning Authority and/or water/sewerage undertaker for the area. They may be able to provide some knowledge on the risk of flooding from other sources. We are working with these organisations to improve knowledge and understanding of surface water flooding.

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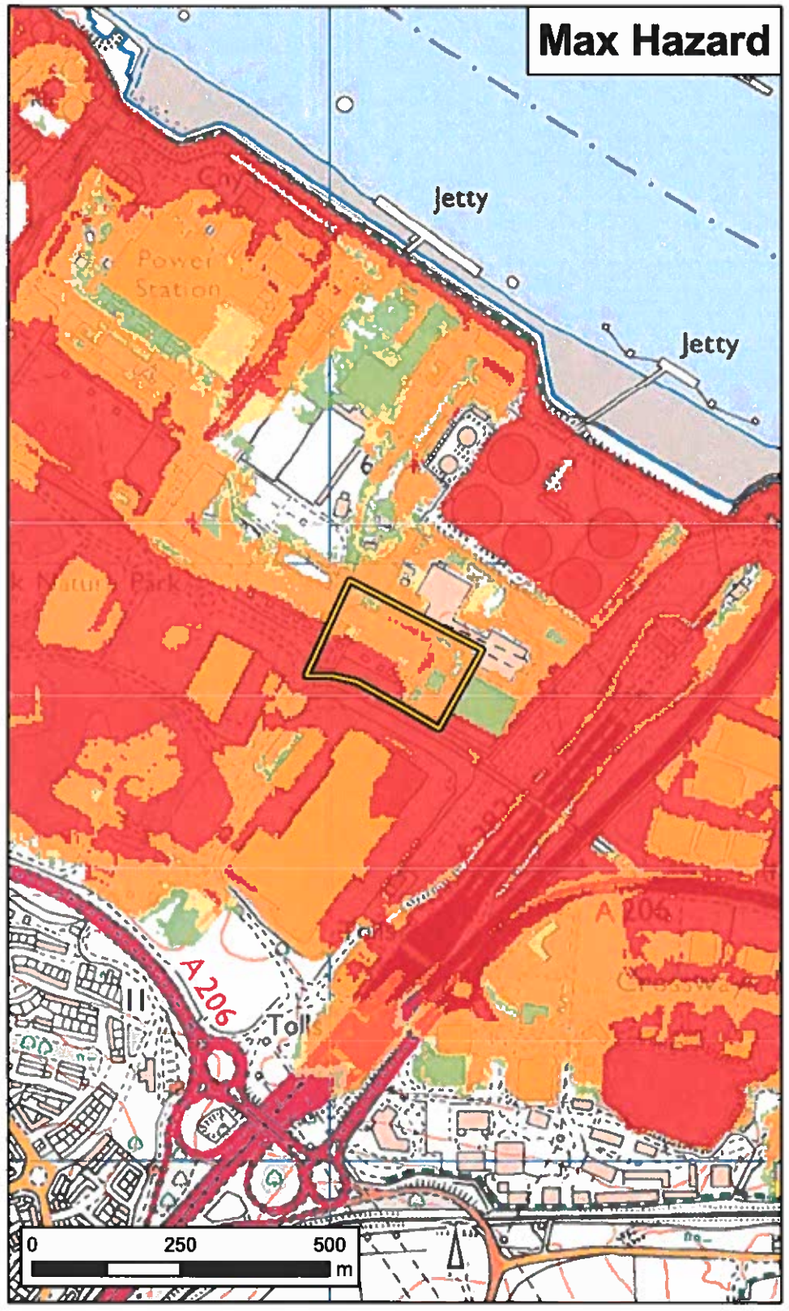

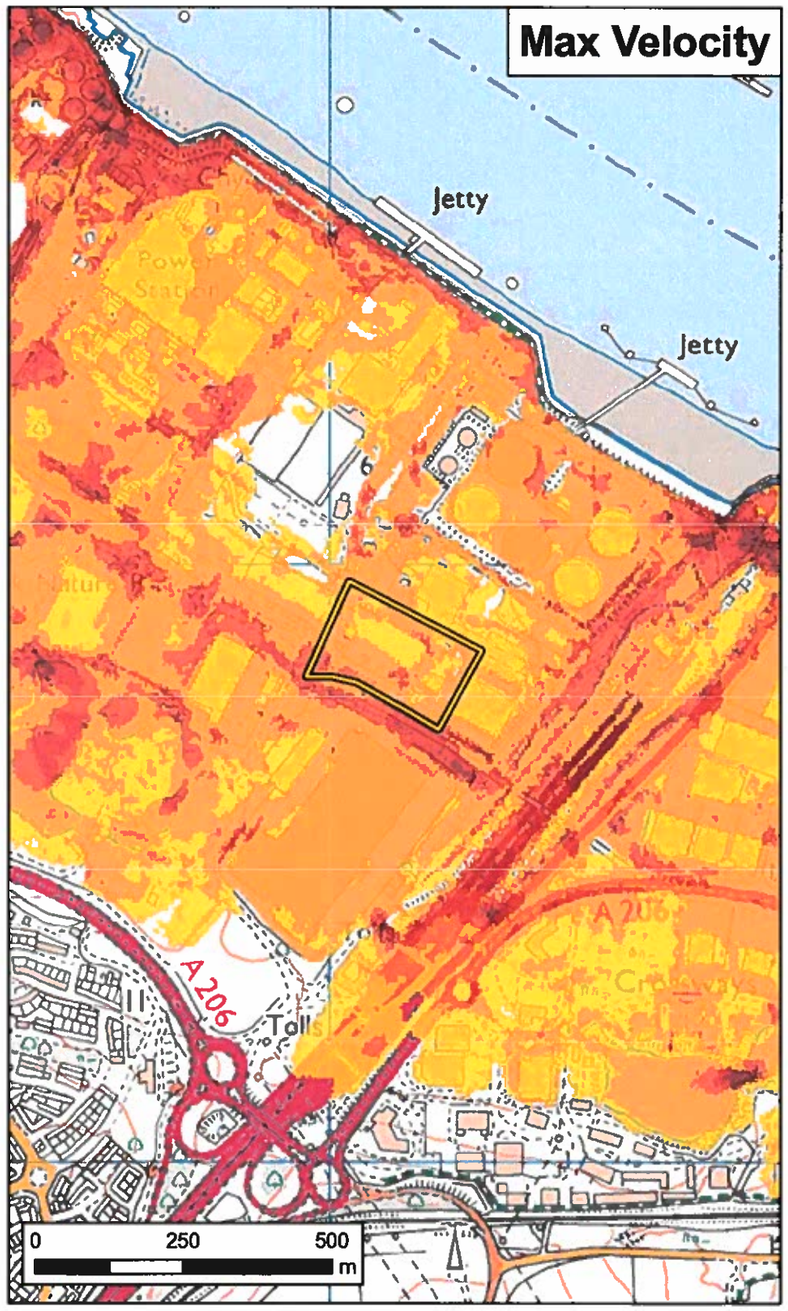

Max Hazard

- Less than 0.75 (Low Hazard)
- Between 0.75 and 1.25 (Danger for Some)
- Between 1.25 and 2.00 (Danger for Most)
- Greater than 2.00 (Danger for All)

Max Depth (m)

- 0 - 0.25
- 0.25 - 1.00
- 1.00 - 1.50
- 1.50 - 2.00
- > 2.00

Max Velocity (m/s)

- 0 - 0.3
- 0.3 - 1.0
- 1.0 - 1.5
- 1.5 - 2.5
- > 2.5

Date Printed	04/06/2018	Scenario year	2115	Scenario Annual Chance	0.5% (1 in 200)

This map shows the combined flood hazard to people (called a hazard rating) if our flood defences are breached at any given single location, for a range of scenarios. The hazard rating depends on the depth and velocity of floodwater, and maximum values of these are also mapped.

The map is based on computer modelling of simulated breaches covering the entire extent between the Thames Barrier and Gravesend. Each breach has been modelled individually and the results combined to create this map. Multiple breaches, other combinations of breaches, different sized tidal surges or flood flows may all give different results.

The map only considers the consequences of a breach, it does not make any assumption about the likelihood of a breach occurring. The likelihood of a breach occurring will depend on a number of different factors, including the construction and condition of the defences in the area. A breach is less likely where defences are of a good standard, but a risk of breaching remains.

Please contact the Environment Agency for further information on emergency planning associated with flood risk in this area.

General Enquiries No: 03708 506 506. Weekday Daytime calls cost 5p plus up to 6p per minute from BT Weekend Unlimited. Mobile and other providers' charges may vary

Environment Agency

Thames Tidal Downriver Breach Hazard Mapping

Map Centred on DA1 5PZ
KSL 87575 AB

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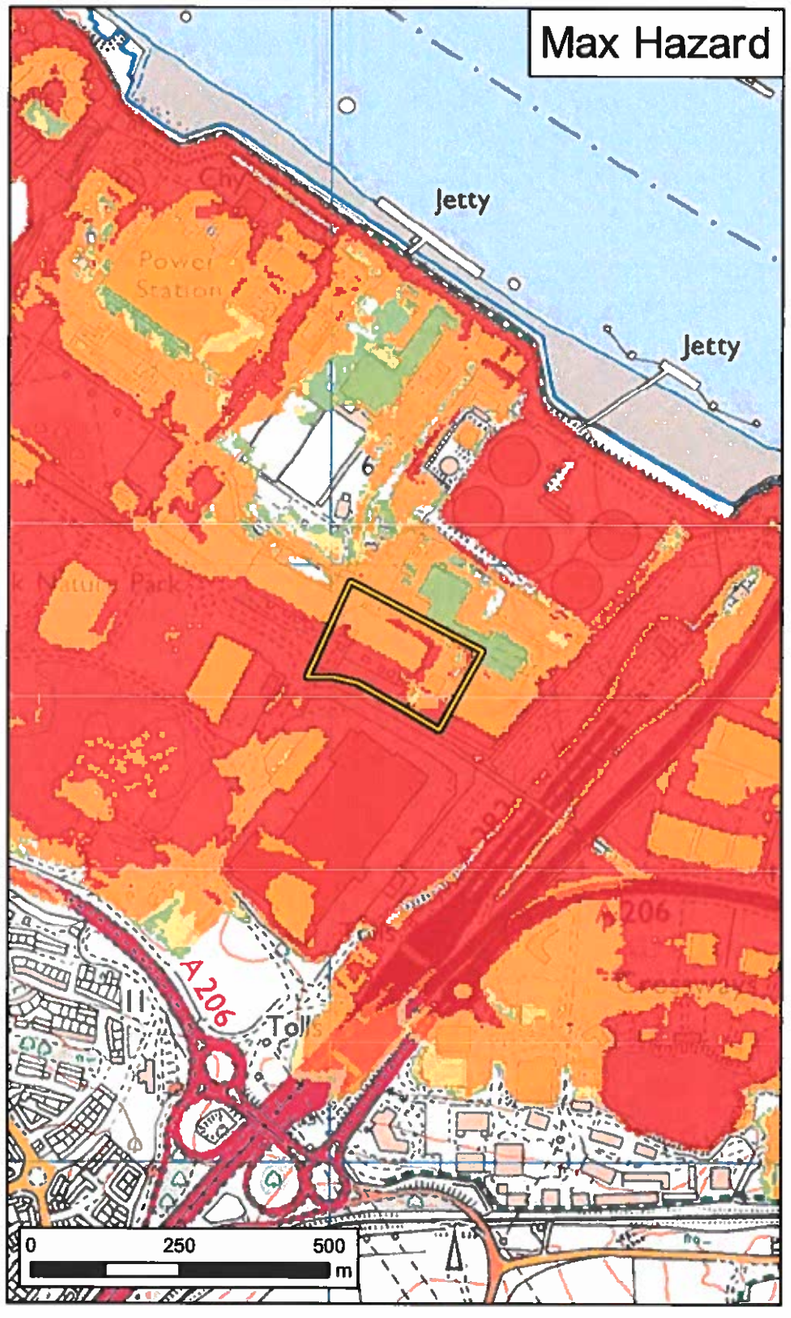

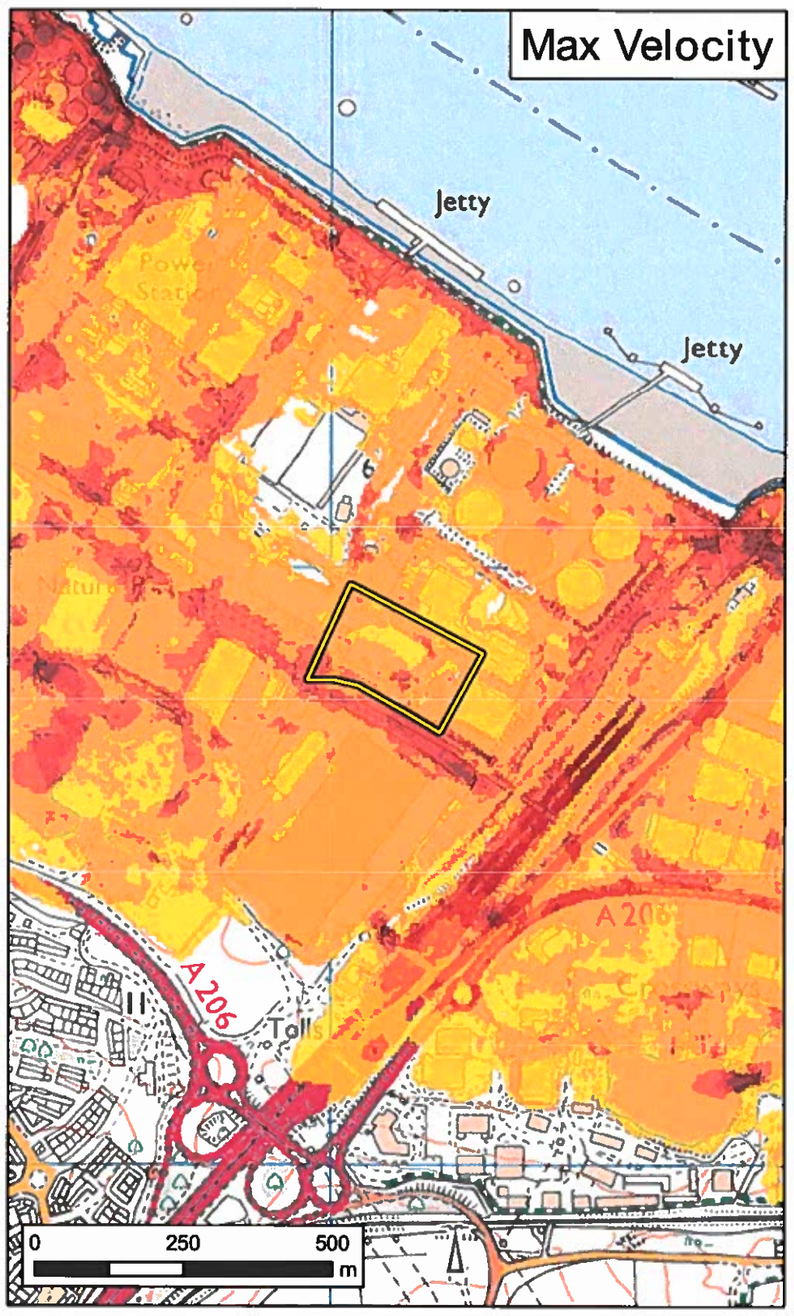

Max Hazard

- Less than 0.75 (Low Hazard)
- Between 0.75 and 1.25 (Danger for Some)
- Between 1.25 and 2.00 (Danger for Most)
- Greater than 2.00 (Danger for All)

Max Depth (m)

- 0 - 0.25
- 0.25 - 1.00
- 1.00 - 1.50
- 1.50 - 2.00
- > 2.00

Max Velocity (m/s)

- 0 - 0.3
- 0.3 - 1.0
- 1.0 - 1.5
- 1.5 - 2.5
- > 2.5

Date Printed	04/06/2018	Scenario year	2115	Scenario Annual Chance	0.1% (1 in 1000)

This map shows the combined flood hazard to people (called a hazard rating) if our flood defences are breached at any given single location, for a range of scenarios. The hazard rating depends on the depth and velocity of floodwater, and maximum values of these are also mapped.

The map is based on computer modelling of simulated breaches covering the entire extent between the Thames Barrier and Gravesend. Each breach has been modelled individually and the results combined to create this map. Multiple breaches, other combinations of breaches, different sized tidal surges or flood flows may all give different results.

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Thames Tidal Downriver Breach Hazard Mapping

Map Centred on DA1 5PZ
KSL 87575 AB

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Product 4 (Detailed Flood Risk) for: Land adjacent to Riverside Resource Recovery Ltd [TQ4946780680]
Requested by: Stuart Harwood, Peter Brett Associates LLP
Reference: KSL 87642 AB (previous request KSL 74869 UE)
Date: 4 June 2018

Contents

- Flood Map for Planning (Rivers and Sea)
- Flood Map Extract
- Thames Estuary 2100 (TE2100)
- Thames Tidal Downriver Breach Inundation Modelling 2018
- Thames Tidal Downriver Breach Inundation Modelling Map
- Site Node Locations Map
- Defence Details
- Recorded Flood Events Data
- Recorded Flood Events Outlines Map
- Additional Information

The information provided is based on the best data available as of the date of this letter.

You may feel it is appropriate to contact our office at regular intervals, to check whether any amendments/ improvements to the data for this location have been made. Should you re-contact us after a period of time, please quote the above reference in order to help us deal with your query.

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Flood Map for Planning (Rivers and Sea)

The Flood Map:

Our Flood Map shows the natural floodplain for areas at risk from river and tidal flooding. The floodplain is specifically mapped ignoring the presence and effect of defences. Although flood defences reduce the risk of flooding they cannot completely remove that risk as they may be over topped or breached during a flood event.

The Flood Map indicates areas with a 1% (0.5% in tidal areas), Annual Exceedance Probability (AEP) - the probability of a flood of a particular magnitude, or greater, occurring in any given year, and a 0.1% AEP of flooding from rivers and/or the sea in any given year. In addition, the map also shows the location of some flood defences and the areas that benefit from them.

The Flood Map is intended to act as a guide to indicate the potential risk of flooding. When producing it we use the best data available to us at the time and also take into account historic flooding and local knowledge. The Flood Map is updated on a quarterly basis to account for any amendments required. These amendments are then displayed on the internet at https://www.gov.uk/check-flood-risk

At this Site:

The Flood Map shows that this site lies within the outline of Flood Zone 3. This zone comprises land assessed as having a 0.5% (1 in 200) or greater annual probability of tidal flooding.

Enclosed is an extract of our Flood Map which shows this information for your area.

Method of production

The Flood Map at this location has been derived using detailed modelling of the tidal River Thames through the North Kent Coastal Modelling study completed in 2013 by JBA Consulting.

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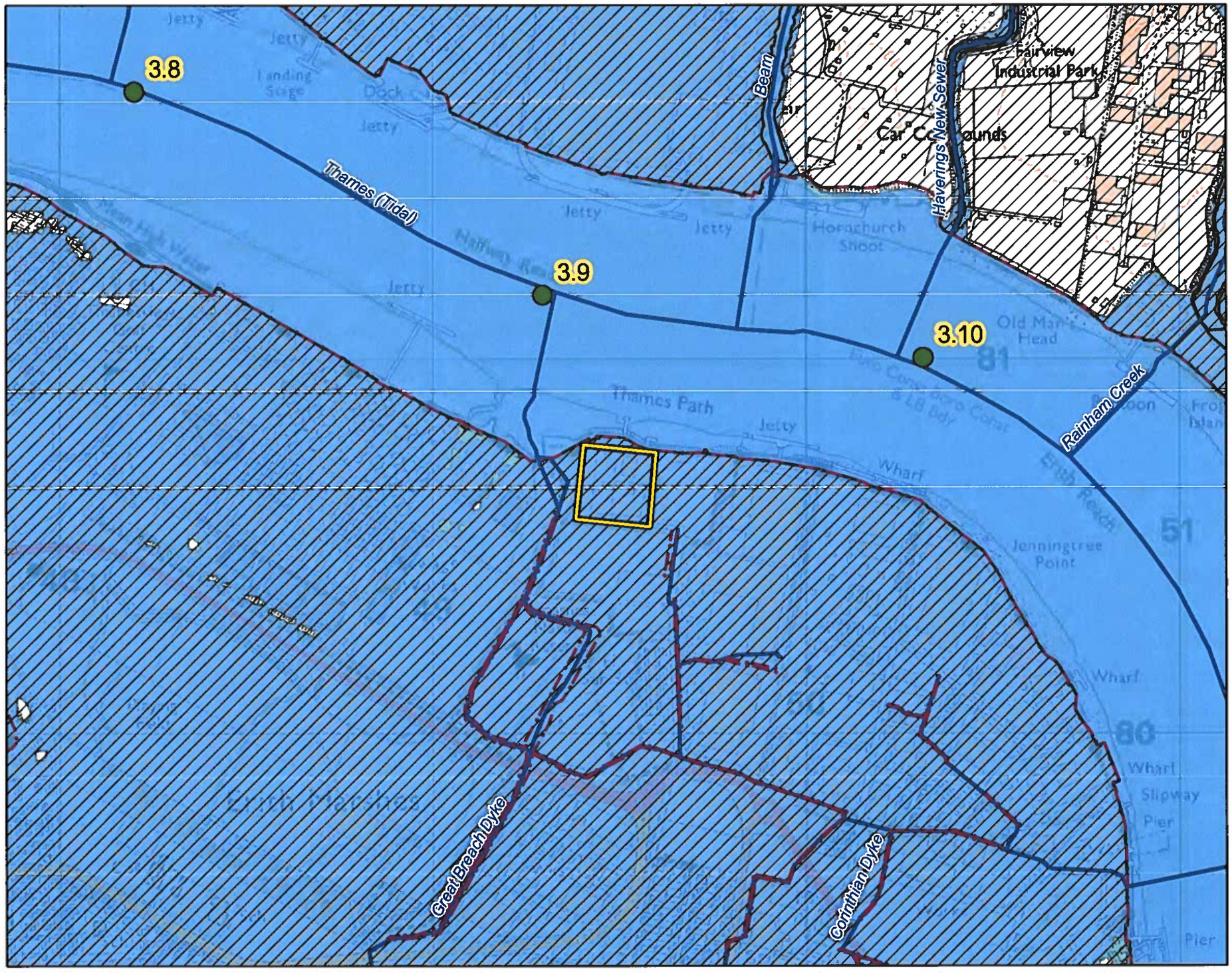
Detailed FRA/FCA Map centred on TQ4946780680 created 4 June 2018 [Ref: KSL 87642 AB]



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Scale 1: 15,000

N W E S

Legend

- Site Location
- TE2100 Model Nodes
- Flood Map - Defences
- Main Rivers
- Flood Map - Flood Storage Areas
- Areas Benefiting from Flood Defences
- Flood Map - Flood Zone 3
- Flood Map - Flood Zone 2

Flood Map for Planning (assuming no defences)

Flood Zone 3 shows the area that could be affected by flooding:
- from the sea with a 0.5% or greater chance of occurring each year
- or from a river with a 1% or greater chance of occurring each year.

Flood Zone 2 shows the extent of an extreme flood from rivers or the sea with up to a 0.1% chance of occurring each year.

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Thames Estuary 2100 (TE2100)

You have requested in-channel flood levels for the tidal river Thames. These have been taken from the Thames Estuary 2100 study completed by HR Wallingford in 2008. The modelled node closest to your site is **3.9**; the locations of nearby nodes are also shown on the enclosed map.

Details about the TE2100 plan

The TE2100 plan is now live and within it are a set of levels on which the flood risk management strategy is based. The plan is the overarching flood management strategy for the Thames Estuary and therefore any development planning should be based on the same underlying data.

Details about the TE2100 in-channel levels

The TE2100 in-channel levels take into account operation of the Thames Barrier when considering future levels. The Thames Barrier requires regular maintenance and with additional closures the opportunity for maintenance will be reduced. When this happens, river levels – for which the Barrier would normally shut for the 2008 epoch – will have to be allowed through to ensure that the barrier is not shut too often. For this reason, levels upriver of the barrier will increase and the tidal walls will need to be heightened to match.

For further information about the Thames Barrier please visit our website at:

https://www.gov.uk/the-thames-barrier

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TE2100 2008 levels:

Levels downriver of the Thames Barrier are 0.1% AEP (1 in 1000) and levels upriver are the highest levels permitted by the Thames Barrier, described as the Maximum Likely Water Levels (MLWLs). The defence levels (left defence, right defence) are the minimum levels to which the defences should be built.

Location	Node	Easting	Northing	Extreme water level (m)	Left defence (m)	Right defence (m)	Allow for future defence raising to a level of...	
							Left Bank (m)	Right Bank (m)
	3.7	547183	181618	6.01	7.30	7.10	8.20	8.20
	3.8	548204	181714	6.01	7.30	7.10	8.20	8.20
Beam River	3.9	549299	181171	6.00	7.20	7.10	8.20	8.20
	3.10	550318	181003	5.98	7.10	7.10	8.10	8.10
	3.11	551166	180048	5.97	7.05	7.10	8.10	8.10

TE2100 climate change levels:

Location	Node	Easting	Northing	1000-year design water levels					
				2000	2040	2070	2100	2120	2170
	3.7	547183	181618	6.01	6.22	6.42	6.75	6.95	7.46
	3.8	548204	181714	6.01	6.22	6.41	6.74	6.94	7.44
Beam River	3.9	549299	181171	6.00	6.21	6.40	6.72	6.92	7.42
	3.10	550318	181003	5.98	6.19	6.37	6.70	6.90	7.40
	3.11	551166	180048	5.97	6.18	6.37	6.70	6.90	7.39

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Thames Tidal Downriver Breach Inundation Modelling - 2018

The table below displays site-specific modelled flood levels at your site. These have been taken from the Downrvier Breach Inundation Modelling Study 2018 completed by Atkins Ltd. in May 2018.

We have developed a modelling approach where all downriver breach locations along the Thames are equitably modelled, to ensure a consistent approach across London. This modelling simulates continuous tidal breaches along the entire extent of the Thames between the Thames Barrier and east of Gravesend on the south bank and east of Tilbury on the north bank. For hard and composite defences breaches are set at 20 m wide; for soft defences, breaches are 50 m wide. In both cases, the defence breach scour distance was assumed to extend into the floodplain by the same distance as the breach width.

Based on the 2008 TE2100 in-channel levels, the 0.5% (1 in 200 year) and 0.1% (1 in 1000 year) annual probability of exceedance tidal events were modelled for all breach locations downriver of the Thames Barrier. These were modelled for the 2014 year epoch (current year), as well as 2100 epoch which include allowances for climate change.

This model has been designed for catchment wide flood risk mapping. It should be noted that it was not created to produce flood levels for specific development sites within London.

	National Grid Reference		Modelled levels in mAODN for 0.5% AEP		Modelled levels in mAODN for 0.1% AEP	
Node	Easting	Northing	2014	2115	2014	2115
1	549411	180767	4.82	5.08	4.93	5.14
2	549458	180761	3.58	3.72	3.64	3.77
3	549511	180755	2.30	2.49	2.34	2.63
4	549593	180744	4.30	4.56	4.40	4.63
5	549407	180725	2.92	3.01	2.96	3.04
6	549485	180713	2.28	2.49	2.32	2.63
7	549568	180710	2.51	2.58	2.55	2.63
8	549401	180679	2.37	2.49	2.41	2.63
9	549464	180667	2.03	2.49	2.08	2.63
10	549529	180669	2.45	2.62	2.52	2.67
11	549590	180672	2.37	2.53	2.43	2.63

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	National Grid Reference		Modelled levels in mAODN for 0.5% AEP		Modelled levels in mAODN for 0.1% AEP	
Node	Easting	Northing	2014	2115	2014	2115
12	549396	180631	1.92	2.49	1.97	2.63
13	549457	180626	1.97	2.49	2.02	2.63
14	549535	180608	1.97	2.49	2.01	2.63
15	549584	180612	1.99	2.49	2.02	2.63
16	549390	180580	1.87	2.49	1.97	2.63
17	549449	180573	1.87	2.49	1.97	2.63
18	549508	180565	1.87	2.49	1.97	2.63
19	549579	180556	1.87	2.49	1.97	2.63

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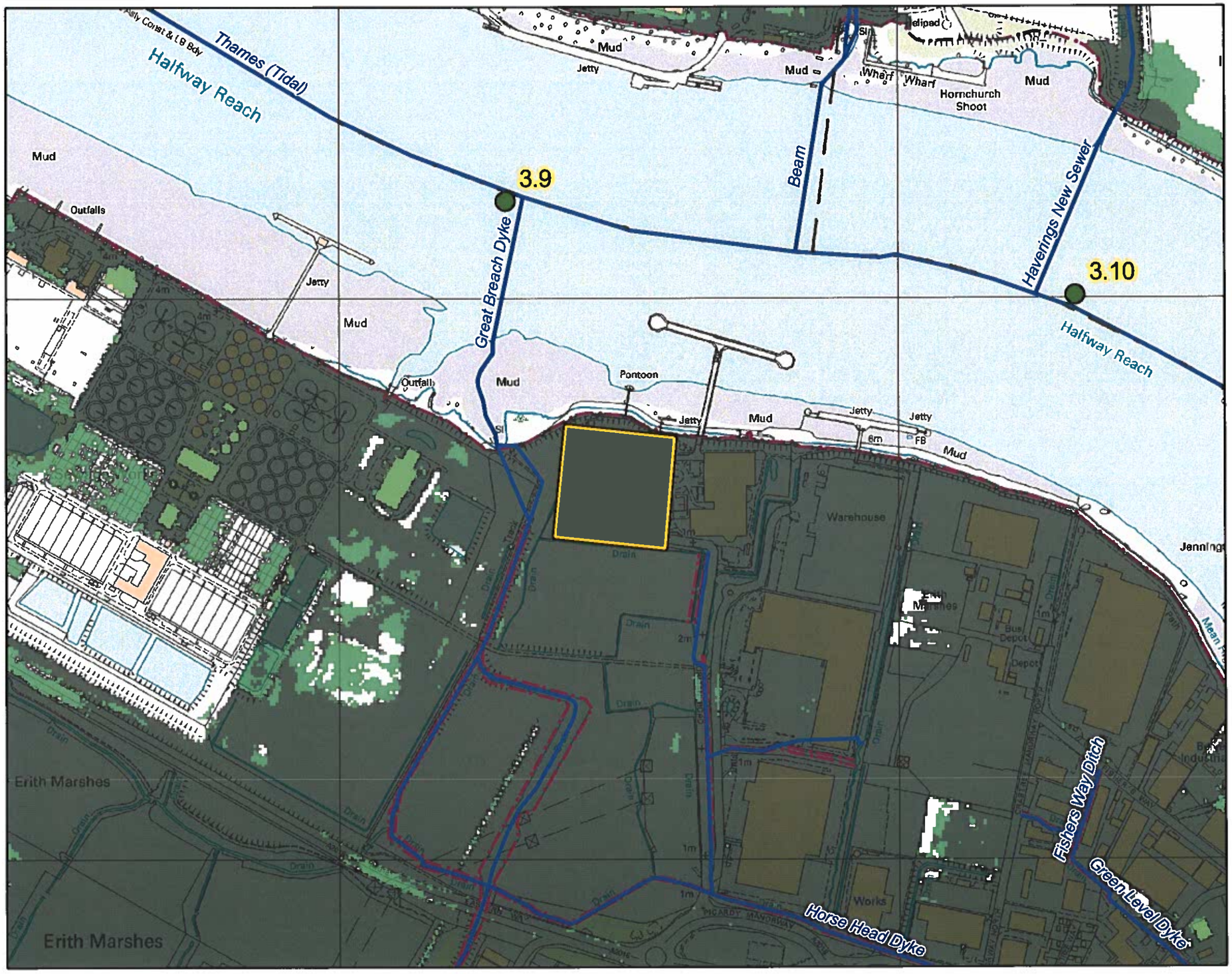
Downriver Breach Modelling Map centred on TQ4946780680 created 4 June 2018 [Ref: KSL 87642 AB]



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Scale 1: 10,000

N W E S

Legend

- Site Location
- TE2100 Model Nodes
- Main Rivers
- Flood Map - Defences

Downriver 0.5% AEP Outlines

Epoch

- 2014 (Current year)
- 2115

Thames Tidal Downriver Breach Inundation Modelling 2018

A modelled representation of all tidal breach locations along the Thames from the Thames Barrier to Gravesend, based on low floodplain topography. For hard and composite defences breaches are set at 20 m wide; for soft defences, breaches are 50 m wide. In both cases, the defence breach scour distance was assumed to extend into the floodplain by the same distance as the breach width.
The modelling is based on the 2008 TE2100 in-channel levels, with an allowance for climate change for epoch 2115.

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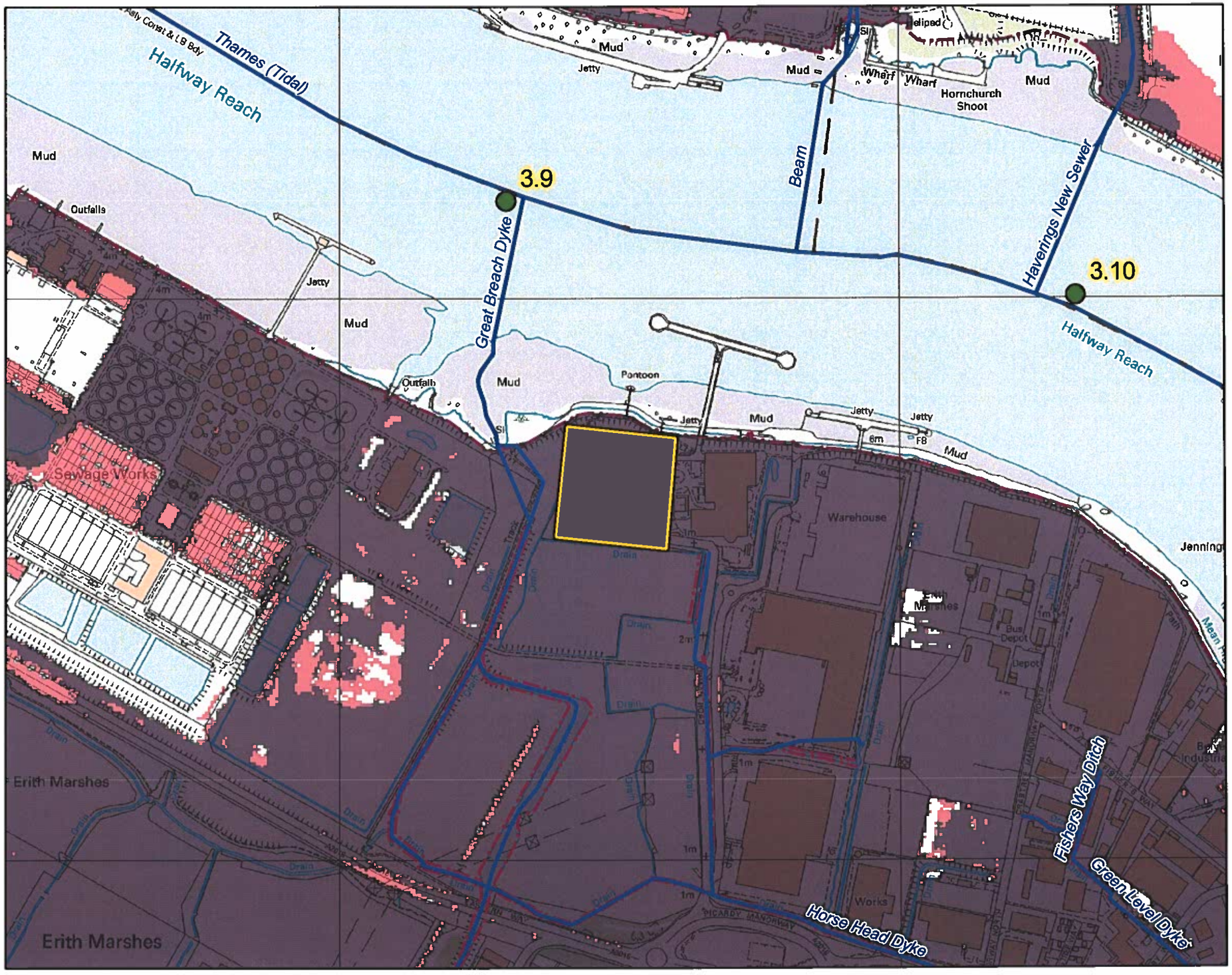

Environment Agency

Scale 1: 10,000

N W E S

Legend

- Site Location
- TE2100 Model Nodes
- Main Rivers
- Flood Map - Defences

Downriver 0.1% AEP Outlines

Epoch

- 2014 (Current year)
- 2115

Thames Tidal Downriver Breach Inundation Modelling 2018

A modelled representation of all tidal breach locations along the Thames from the Thames Barrier to Gravesend, based on low floodplain topography. For hard and composite defences breaches are set at 20 m wide; for soft defences, breaches are 50 m wide. In both cases, the defence breach scour distance was assumed to extend into the floodplain by the same distance as the breach width.
The modelling is based on the 2008 TE2100 in-channel levels, with an allowance for climate change for epoch 2115.

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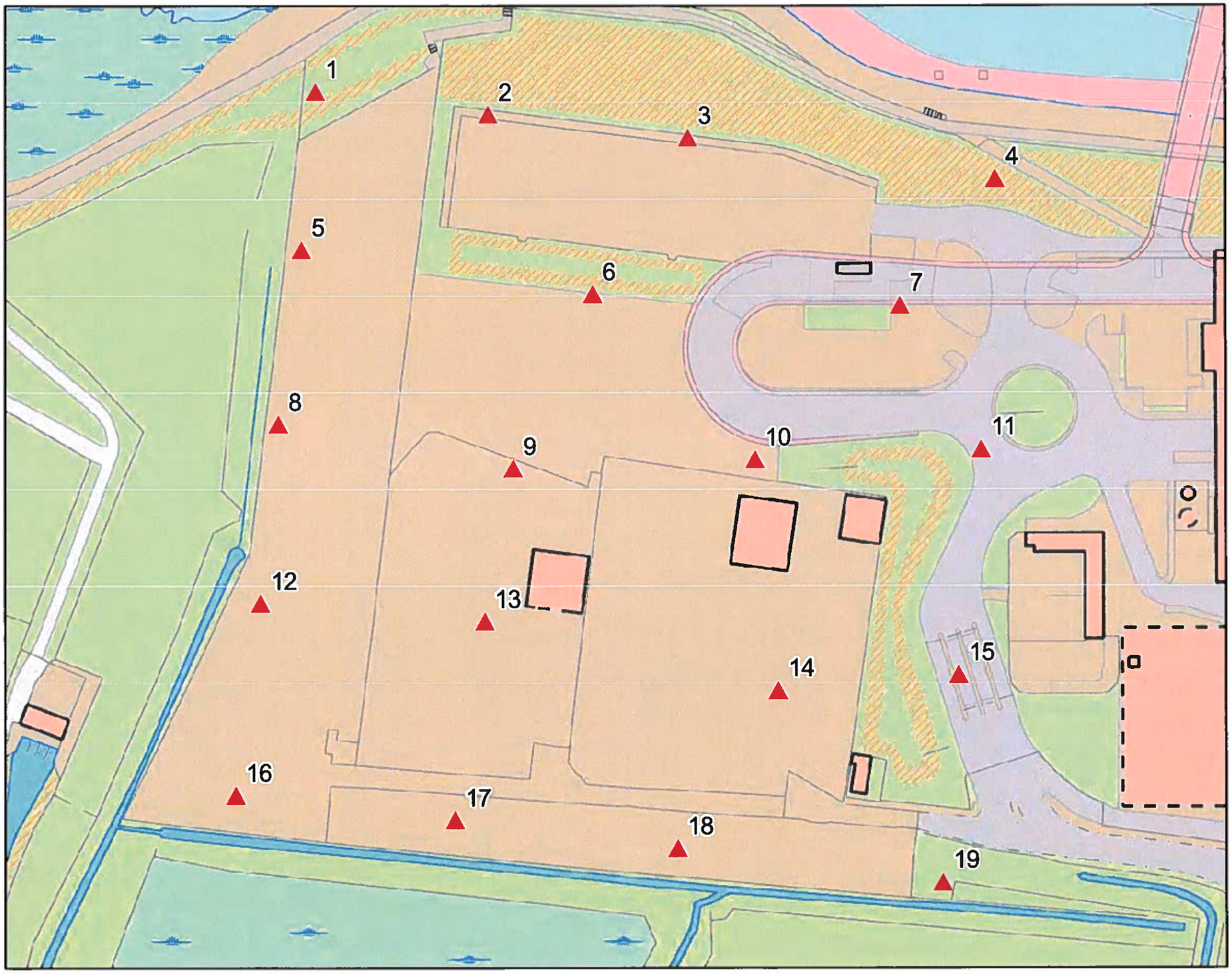

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Scale 1: 1,500

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Legend

▲ Node Point Locations

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Defence Details

The design standard of protection of the flood defences in this area of the Thames is 0.1% AEP; they are designed to defend London up to a 1 in 1000 year **tidal** flood event. The defences are all raised, man-made and privately owned. It is the riparian owners' responsibility to ensure that they are maintained to a crest level of **7.10m AODN** (the Statutory Flood Defence Level in this reach of the Thames). We inspect them twice a year to ensure that they remain fit for purpose. The current condition grade for defences in the area is 2 (good), on a scale of 1 (very good) to 5 (very poor). For more information on your rights and responsibilities as a riparian owner, please see our document 'Living on the edge' found on our website at:

https://www.gov.uk/government/publications/riverside-ownership-rights-and-responsibilities

There are no planned improvements in this area. Please see the 'Thames Estuary 2100' document on our website for the short, medium and long term Flood Risk Management strategy for London:

https://www.gov.uk/government/publications/thames-estuary-2100-te2100

Areas Benefiting from Flood Defences

This site is within an area benefiting from flood defences, as shown on the enclosed extract of our Flood Map. Areas benefiting from flood defences are defined as those areas which benefit from formal flood defences specifically in the event of flooding from rivers with a 1% (1 in 100) chance in any given year, or flooding from the sea with a 0.5% (1 in 200) chance in any given year.

If the defences were not there, these areas would be flooded. An area of land may benefit from the presence of a flood defence even if the defence has overtopped, if the presence of the defence means that the flood water does not extend as far as it would if the defence were not there.

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Recorded Flood Events Data

We hold records of historic flood events from rivers and the sea. Information on the floods that may have affected the area local to your site is provided below and in the enclosed map (if relevant).

Flood Event Data

1953 – The site was subject to tidal flooding, due to a storm surge in the North Sea, on the night of the 31st January into the morning of 1st February. An approximate level in the Thames at the time was 5.10m AODN.

Due to the fact that our records are not comprehensive, we would advise that you make further enquiries locally with specific reference to flooding at this location. You should consider contacting the relevant Local Planning Authority and/or water/sewerage undertaker for the area.

We map flooding to land, not individual properties. Our historic flood event record outlines are an indication of the geographical extent of an observed flood event. Our historic flood event outlines do not give any indication of flood levels for individual properties. They also do not imply that any property within the outline has flooded internally.

Please be aware that flooding can come from different sources. Examples of these are:

- from rivers or the sea;
- surface water (i.e. rainwater flowing over or accumulating on the ground before it is able to enter rivers or the drainage system);
- overflowing or backing up of sewer or drainage systems which have been overwhelmed,
- groundwater rising up from underground aquifers

Currently the Environment Agency can only supply flood risk data relating to the chance of flooding from rivers or the sea. However you should be aware that in recent years, there has been an increase in flood damage caused by surface water flooding and drainage systems that have been overwhelmed.

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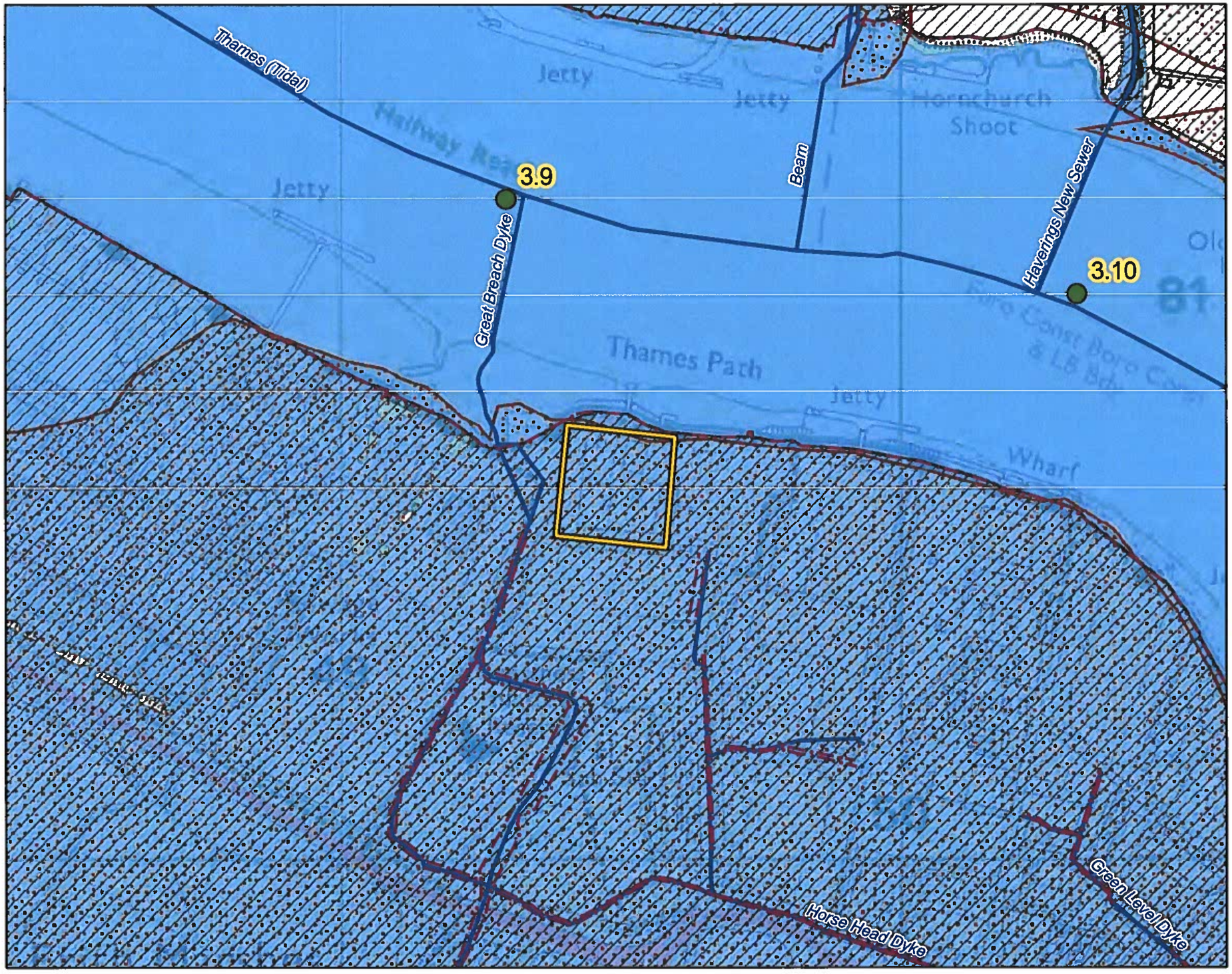
Historic Flood Map centred on TQ4946780680 created 4 June 2018 [Ref: KSL 87642 AB]



Environment Agency

Scale 1: 10,000

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Legend

- Site Location
- TE2100 Model Nodes
- Flood Map - Defences
- Main Rivers
- Jan 1953 Flood Outline
- Flood Map - Flood Storage Areas
- Areas Benefiting from Flood Defences
- Flood Map - Flood Zone 3
- Flood Map - Flood Zone 2

Flood Map for Planning
(assuming no defences)

Flood Zone 3 shows the area that could be affected by flooding:
- from the sea with a 0.5% or greater chance of occurring each year
- or from a river with a 1% or greater chance of occurring each year.

Flood Zone 2 shows the extent of an extreme flood from rivers or the sea with up to a 0.1% chance of occurring each year.

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Additional Information

Information Warning - OS background mapping

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Planning advice and guidance

The Environment Agency are keen to work with partners to enable development which is resilient to flooding for its lifetime and provides wider benefits to communities. If you have requested this information to help inform a development proposal, then we recommend engaging with us as early as possible by using the pre-application form available from our website:
https://www.gov.uk/government/publications/pre-planning-application-enquiry-form-preliminary-opinion

Complete the form in the link and email back to kslplanning@environment-agency.gov.uk

We recognise the value of early engagement in development planning decisions. This allows complex issues to be discussed, innovative solutions to be developed that both enables new development and protects existing communities. Such engagement can often avoid delays in the planning process following planning application submission, by reaching agreements up-front. We offer a charged pre-application advice service for applicants who wish to discuss a development proposal.
We can also provide a preliminary opinion for free which will identify environmental constraints related to our responsibilities including flooding, waste, land contamination, water quality, biodiversity, navigation, pollution, water resources, foul drainage or Environmental Impact Assessment.

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Flood Risk Assessments guidance

Flood risk standing advice for applicants

In preparing your planning application submission, you should refer to the Environment Agency's Flood Risk Standing Advice and the Planning Practice Guidance for information about what flood risk assessment is needed for new development in the different Flood Zones. This information can be accessed via:

https://www.gov.uk/flood-risk-assessment-standing-advice

http://planningguidance.planningportal.gov.uk/

https://www.gov.uk/guidance/flood-risk-assessment-for-planning-applications

https://www.gov.uk/guidance/flood-risk-and-coastal-change

You should also consult the Strategic Flood Risk Assessment and flood risk local plan policies produced by your local planning authority.

You should note that:

1. Information supplied by the Environment Agency may be used to assist in producing a Flood Risk Assessment where one is required, but does not constitute such an assessment on its own.
2. This information covers flood risk from main rivers and the sea, and you will need to consider other potential sources of flooding, such as groundwater or overland runoff. You should discuss surface water management with your Lead Local Flood Authority.
3. Where a planning application requires a FRA and this is not submitted or deficient, the Environment Agency may well raise an objection due to insufficient information

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Surface Water

We have provided two national Surface Water maps, under our Strategic Overview for flooding, to your Lead Local Flood Authority who are responsible for local flood risk (i.e. surface runoff, ground water and ordinary watercourse), which alongside their existing local information will help them in determining what best represents surface water flood risk in your area.

Your Lead Local Flood Authority have reviewed these and determined what it believes best represents surface water flood risk. You should therefore contact this authority so they can provide you with the most up to date information about surface water flood risk in your area.

You may also wish to consider contacting the appropriate relevant Local Planning Authority and/or water/sewerage undertaker for the area. They may be able to provide some knowledge on the risk of flooding from other sources. We are working with these organisations to improve knowledge and understanding of surface water flooding.

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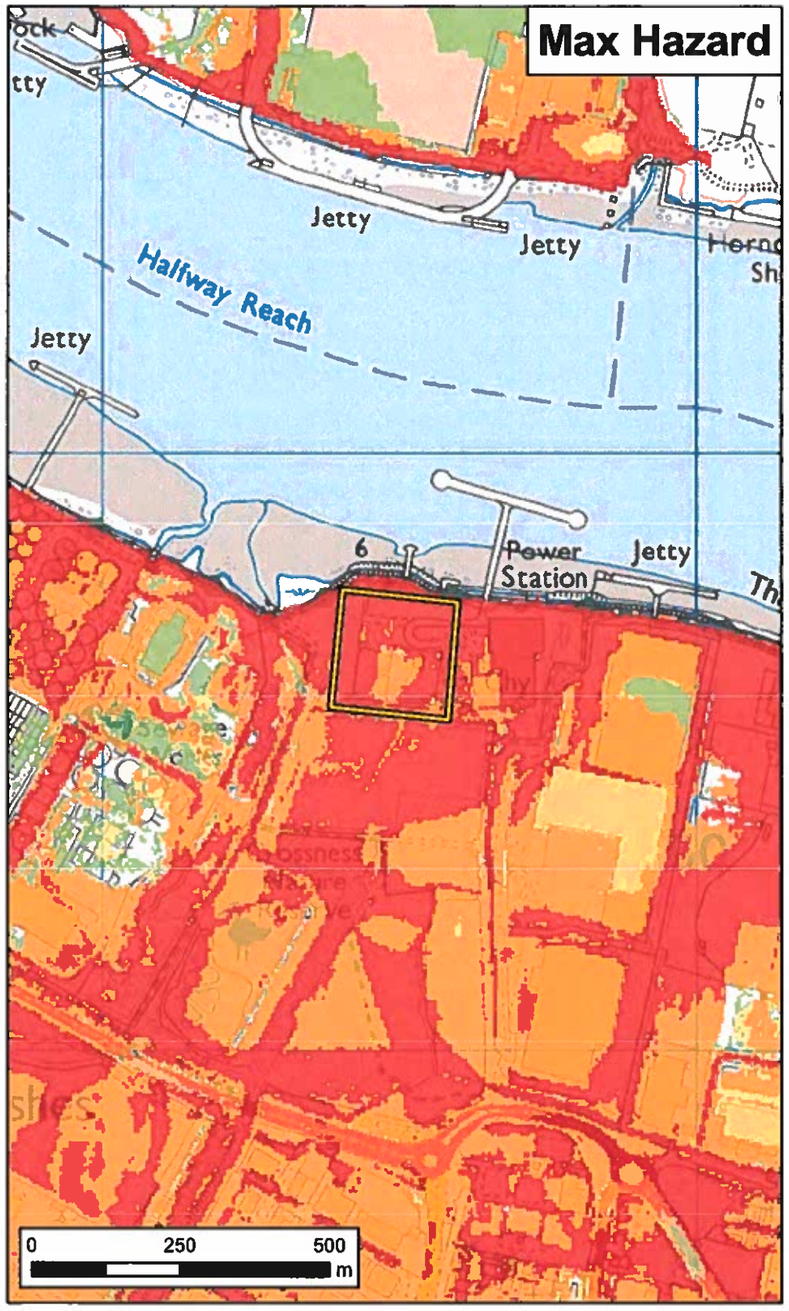

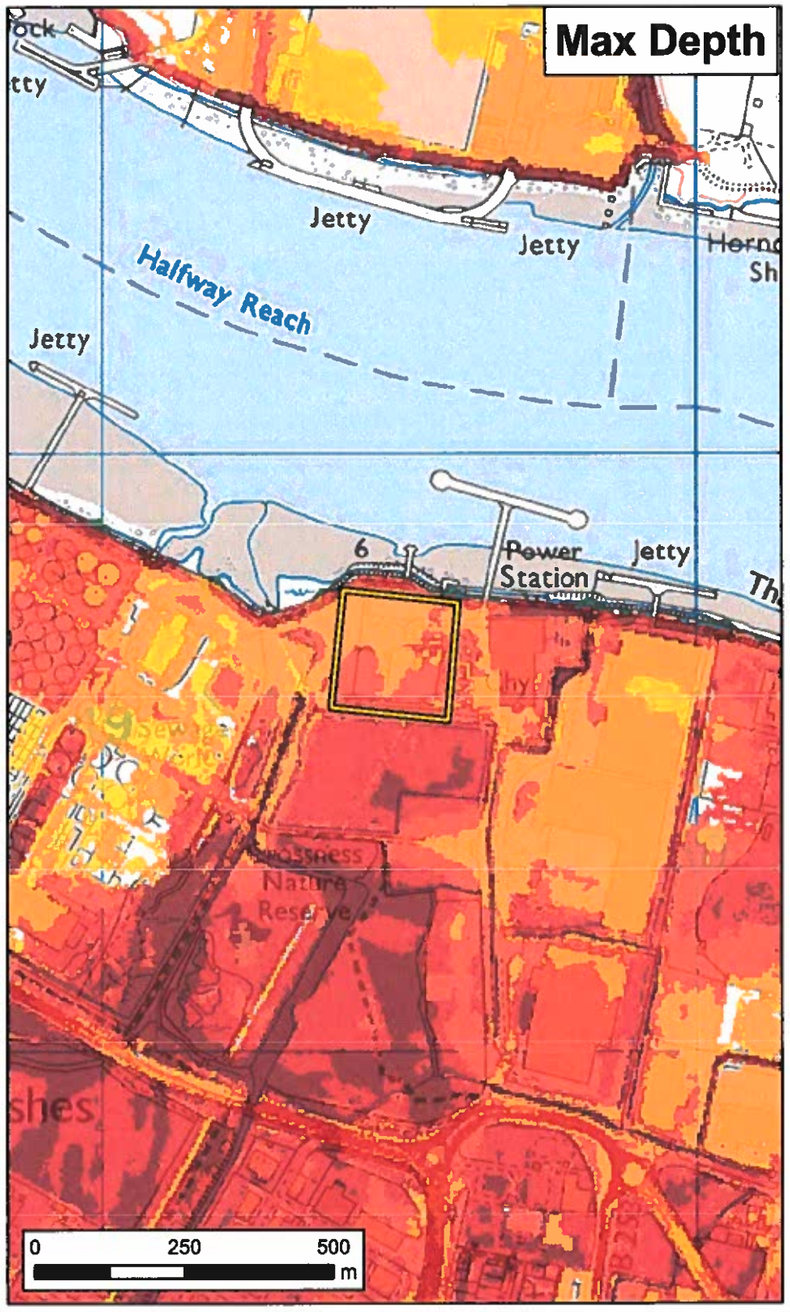

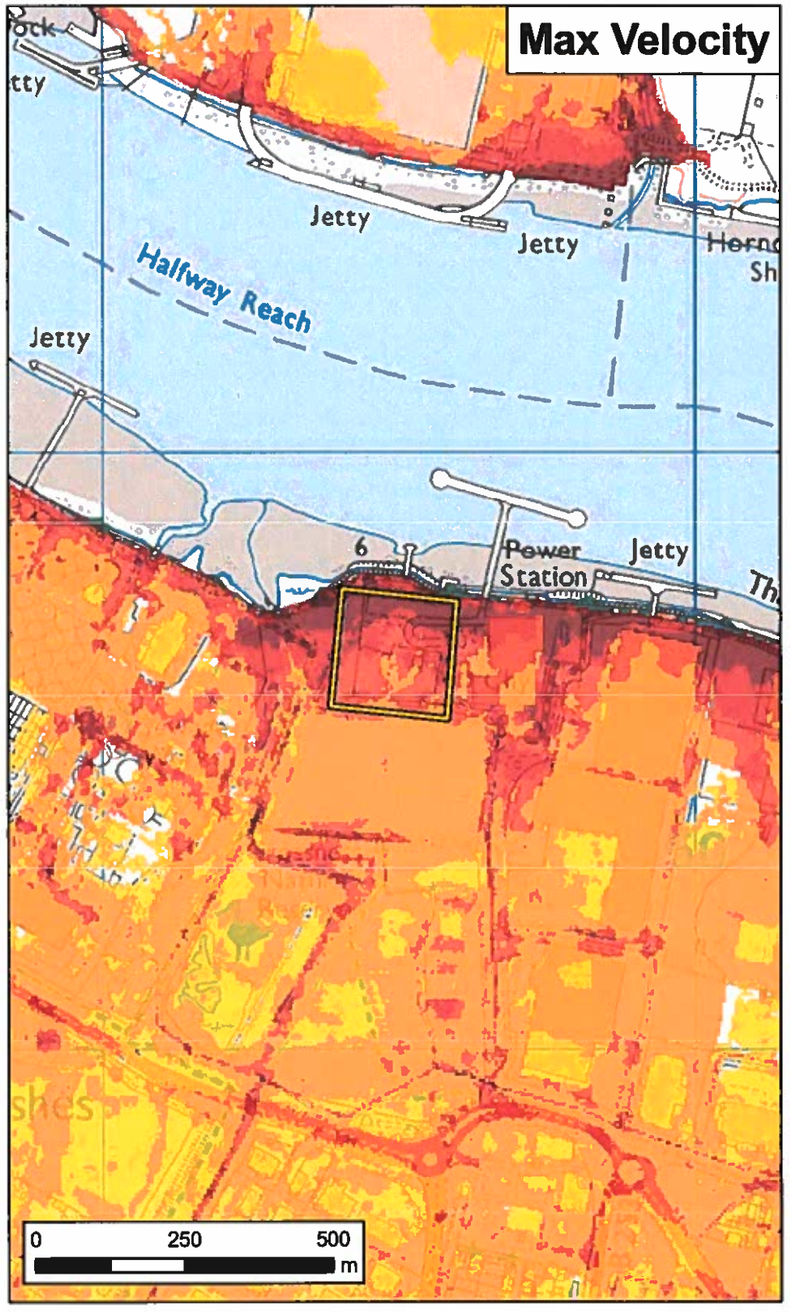

Max Hazard

- Less than 0.75 (Low Hazard)
- Between 0.75 and 1.25 (Danger for Some)
- Between 1.25 and 2.00 (Danger for Most)
- Greater than 2.00 (Danger for All)

Max Depth (m)

- 0 - 0.25
- 0.25 - 1.00
- 1.00 - 1.50
- 1.50 - 2.00
- > 2.00

Max Velocity (m/s)

- 0 - 0.3
- 0.3 - 1.0
- 1.0 - 1.5
- 1.5 - 2.5
- > 2.5

Date Printed	04/06/2018	**Scenario year**	2115	**Scenario Annual Chance**	0.5% (1 in 200)

This map shows the combined flood hazard to people (called a hazard rating) if our flood defences are breached at any given single location, for a range of scenarios. The hazard rating depends on the depth and velocity of floodwater, and maximum values of these are also mapped.

The map is based on computer modelling of simulated breaches covering the entire extent between the Thames Barrier and Gravesend. Each breach has been modelled individually and the results combined to create this map. Multiple breaches, other combinations of breaches, different sized tidal surges or flood flows may all give different results.

The map only considers the consequences of a breach, it does not make any assumption about the likelihood of a breach occurring. The likelihood of a breach occurring will depend on a number of different factors, including the construction and condition of the defences in the area. A breach is less likely where defences are of a good standard, but a risk of breaching remains.

Please contact the Environment Agency for further information on emergency planning associated with flood risk in this area.

General Enquiries No: 03708 506 506. Weekday Daytime calls cost 5p plus up to 6p per minute from BT Weekend Unlimited. Mobile and other providers' charges may vary

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Thames Tidal Downriver Breach Hazard Mapping

Map Centred on TQ4946780680
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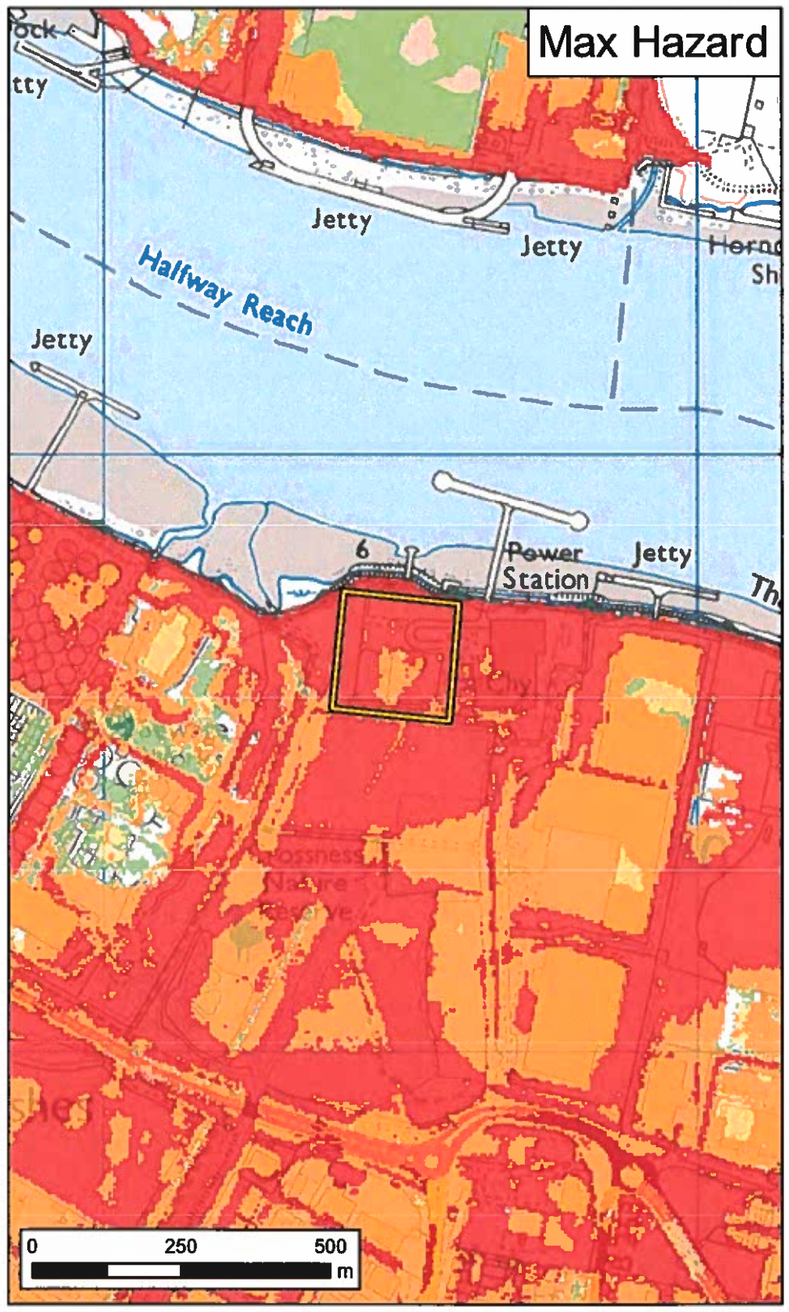

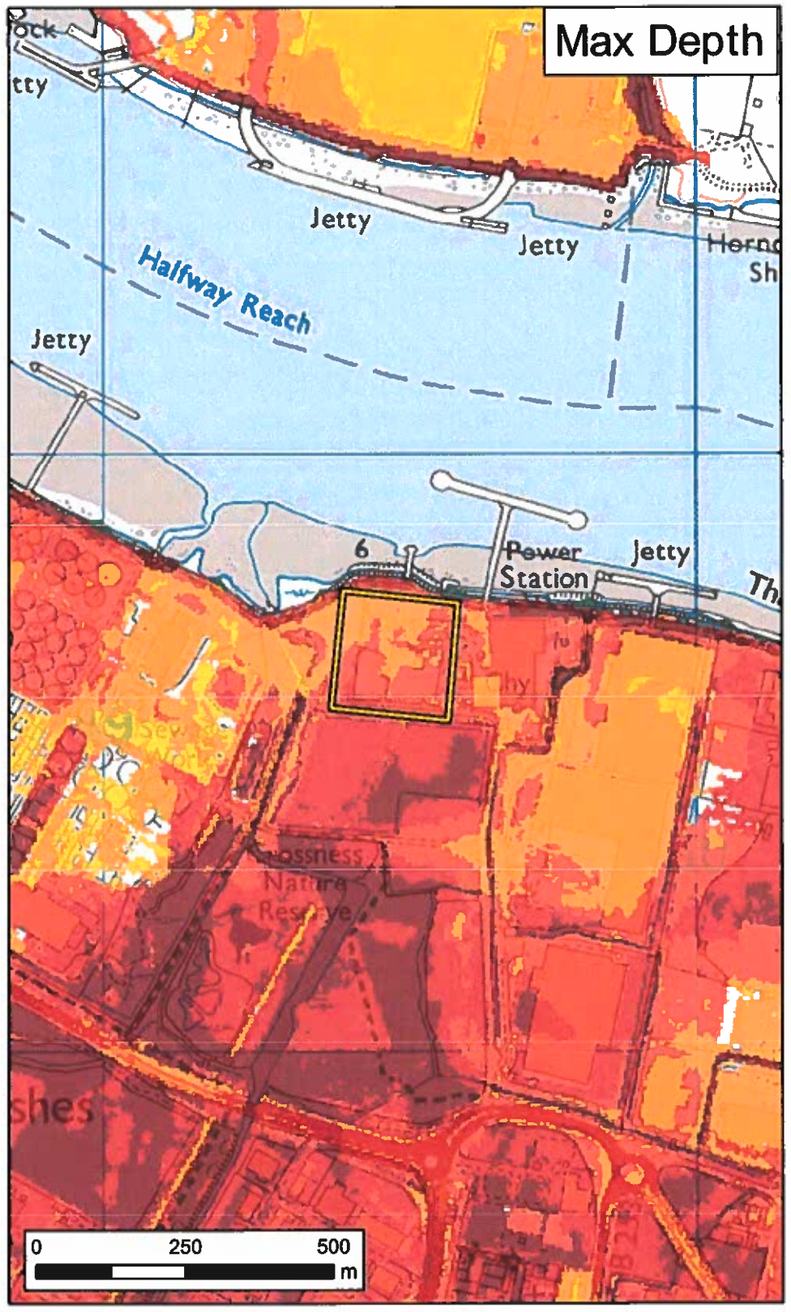

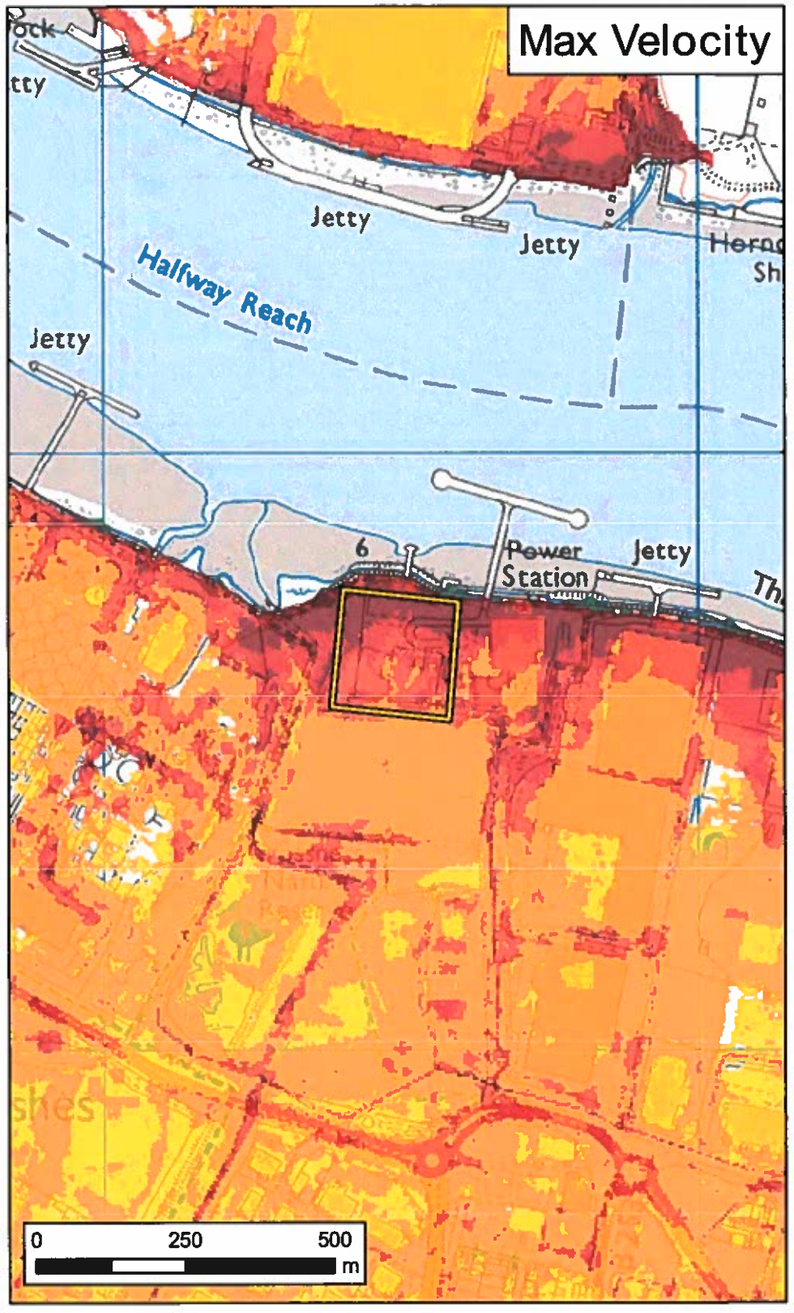

Max Hazard

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- Between 0.75 and 1.25 (Danger for Some)
- Between 1.25 and 2.00 (Danger for Most)
- Greater than 2.00 (Danger for All)

Max Depth (m)

- 0 - 0.25
- 0.25 - 1.00
- 1.00 - 1.50
- 1.50 - 2.00
- > 2.00

Max Velocity (m/s)

- 0 - 0.3
- 0.3 - 1.0
- 1.0 - 1.5
- 1.5 - 2.5
- > 2.5

Date Printed	04/06/2018	Scenario year	2115	Scenario Annual Chance	0.1% (1 in 1000)

This map shows the combined flood hazard to people (called a hazard rating) if our flood defences are breached at any given single location, for a range of scenarios. The hazard rating depends on the depth and velocity of floodwater, and maximum values of these are also mapped.

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Thames Tidal Downriver Breach Hazard Mapping

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Appendix E Flood Defence Condition Survey

Riverside Energy Park

EXISTING FLOOD DEFENCE STRUCTURE

River Wall Condition Survey

On behalf of

Hitachi Zosen Inova AG

Document No:	A118035-TG-GEN-XX-RP-C-0001
Revision:	P04
Issue Date:	16/10/2018

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Document Issue Record

Project:	Riverside Energy Park, Belvedere, London
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Document No:	A118035-TG-GEN-XX-RP-C-0001
Revision:	P04
Filename:	A118035-TG-GEN-XX-RP-C-0001 P04.Docx

Rev	Date	Description and Purpose of Issue	Prepared	Reviewed	Approved
P01	10/08/2018	For Approval	NPA	MJB	OAA
P02	28/09/2018	For Approval	NPA	MJB	OAA
P03	09/10/2018	For Approval	NPA	MJB	APM
P04	16/10/2018	Additional survey area	NPA	MJB	OAA

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1. EXECUTIVE SUMMARY

This report describes the findings of the visual inspection of the existing flood defence structures at the site of the proposed Riverside Energy Park (REP), Belvedere. Tony Gee (TG) has undertaken the visual inspection on behalf of Hitachi Zosen Inova AG. The inspection was carried out on 2nd August 2018. A second inspection was carried out on 12th October 2018.

The scope of the visual inspection included the investigation of the following sections of the flood defence structure:

- Section 1- A tied sheet pile wall
- Section 2- Structural (reinforced concrete) wall with and without gabions at toe
- Section 3- A reinforced concrete apron on CFA piles
- Landward embankment

During the visual inspection, each aspect of the structure was given a grade. The grades were based upon the Condition Assessment Manual (Environment Agency, 2006). Grading of the structure was found to be between 2 (good) and 3 (fair).

From these grades and depending on the type and environment of the component of the structure, a residual life was calculated using the Guidance on Determining Asset Deterioration and the Use of Condition Grade Deterioration Curves (Environment Agency, 2009).

The main points gained from the inspection and the subsequent investigation were as follows:

- The riverward embankment in Section 1 and 2 was in fair condition with some remedial work suggested. The remedial work includes repairing cracks and missing stonework.
- The riverward embankment in Section 3 was in fair condition with monitoring of the void in the lower concrete foreshore at the toe of the riverward embankment at blocks 27 and 28 being recommended.
- The concrete wall was in fair condition in Section 1. Its condition has been worsened due to the vegetation growth in the expansion joints.
- The concrete wall was in good condition in Section 2.
- The concrete wall was in fair condition in Section 3 with recommended work to be done to improve the condition of the expansion joints.
- The landward embankment was in good condition.
- The joints between adjacent sections and the concrete wall to the tarmac footpath in Section 3 were in poor condition, it has been recommended that these are repaired.
- It has been suggested that the structure is monitored at regular intervals and that vegetation levels are kept such that monitoring and maintenance can easily be carried out.

The residual design life of the wall (subject to ongoing maintenance and inspections to monitor the rate of deterioration) is expected to be between 70 and 100 years (between the years 2088 to 2118) following the implementation of remedial works proposed within the report.

2. INTRODUCTION

2.1 Brief

Hitachi Zosen Inova AG commissioned Tony Gee (TG) to undertake a condition survey of the existing flood defence structures at the Riverside Resource Recovery Facility (RRRF), Belvedere.

The purpose of the inspection was to assess the condition of approximately 420m of existing flood defence assets on the south bank of the River Thames, which lie within land owned by the end client, Cory Riverside Energy (Cory). Figure 1 shows the extent of the visual inspection.

Figure 1. Flood Defence Structure at the Riverside Energy Park site

The visual survey allowed TG to:

- Obtain information on the defence type, structure, standard of protection, crest level, and condition.
- Ascertain the required remedial works to ensure the flood defences are commensurate with the lifetime of the development
- Recommend what maintenance is required to the flood defence structure and to adjacent lands to ensure the flood defences are commensurate with the lifetime of the development and to allow access for future inspections of the structures.

The outcome of the inspection will inform recommendations on the condition of the structure, feeding into planning approvals for the proposed Riverside Energy Park (REP) which is proposed to be constructed alongside the existing RRRF.

2.2 Background

The initial inspection of the flood defence was undertaken on 2nd August between the hours of 0800 and 1600. The weather on the day of the visit was dry and sunny with highs of 30°C. Prior to the inspection, the weather in the area had been dry, with high temperatures and minimal rainfall for approximately six weeks.

A secondary inspection of the flood defence was undertaken on 12th October 2018 between the hours of 0900 and 1200. The weather on the day was dry and sunny with highs of 22°C.

The closet tide level data to the site was data from North Woolwich, the data for the 2nd August was as follows:

Time (GMT/BST)	Level (m)
0434 / 0534	6.7
1047 / 1147	1.1
1647 / 1747	6.6
2306 / 0006	0.8

The closet tide level data to the site was data from North Woolwich, the data for the 12th October was as follows:

Time (GMT/BST)	Level (m)
0310 / 0410	7.4
0951 / 1051	0.7
1526 / 1626	7.5
2159 / 2259	0.6

This data was based on information provided within the Port of London Handbook. These levels are to chart datum (C.D.) which are 3.35m higher than ordnance datum (O.D.). (http://www.pla.co.uk/assets/platidetablesmaster2018v46.pdf)

The detailed methodology of the visual inspection can be found in the separate method statement document, ref. A118035-TG-GEN-XX-MS-C-0001.

2.3 Scope of Inspection

The inspection was carried out by experienced civil engineers to incorporate a thorough, close visual examination of all visible and accessible parts of the structure and its various elements.

The inspection covered a number of structural types. Working along the site in a downstream direction, the structures included:-

- Section1- A tied sheet pile wall
- Section 2- Structural (reinforced concrete) wall with and without gabions at toe
- Section 3- A reinforced concrete apron on CFA piles

The wall was interrupted at a number of locations by access stairs and a timber jetty. These structures were assessed only so as far to determine whether they posed any influence on the stability of the flood defence structures.

Where access was limited to parts of the structure, these areas have been highlighted in the relevant section of the report and are summarised below:

- There were no stairs to safely access the foreshore to the east side of the old Borax jetty from block 24 to block 30 and it was unsuitable to access this area from the river bed due to the soft mud.

- The sheet piles in Section 2 and 3 were embedded within the structure so it was not possible to inspect them.

Metal thickness testing was undertaken on sheet piles using an ultrasonic thickness gauge.

2.4 Scope of Inspection Report

The primary objective of the inspection was to identify defects and any signs of deterioration that will be significant to the safety and management of the structure, and to provide information as to the structures condition, likely residual design life and recommendations on maintaining the structures.

The location, extent, severity and type of all significant defects on the structural elements are recorded in Section 4 and include, where appropriate, detailed descriptions, photographs, or sketches of the defects. These clearly identify the location, and illustrate the severity and the extent of the damage to the structure. When reporting on the condition of the various structural elements, a recommendation on the need for any remedial work has been stated in Section 5.

In Section 5 of this report, each of the components of the structures have been assigned a condition grade in line with the Condition Assessment Manual, (Environment Agency, 2006) shown below in Table 1.

Grade	Description of condition	Extent of defects
1	Very good	Cosmetic defects that will have no effect on performance
2	Good	Minor defects that will not reduce overall performance of asset
3	Fair	Defects that could reduce performance of asset
4	Poor	Defects that would significantly reduce performance of asset
5	Very Poor	Sever defects resulting in complete performance failure

Table 1. Condition grade (Condition Assessment Manual, Environment Agency, 2006)

The condition grades established have been used to inform of the residual life of the flood defence structures. This has been calculated using information included in Environment Agency's (EA) Guidance on Determining Asset Deterioration and the Use of Condition Grade Deterioration Curves (2009). These grades and the residual life estimates have been used when recommending any remedial and maintenance work required on the structures.

This report assesses the condition of the flood defence structure based on a design life of between 70 and 100 years. Recommendations for work required have been based on this period.

2.5 Site address

Riverside Resource Recovery Ltd
Norman Road North
Belvedere
DA17 6JY

STRUCTURE AND MAINTENANCE

2.6 Levels

The design crest level of the defence is +7.1mOD, this is consistent with the Thames Tidal Defence Statutory Levels from 1971. This has since been backed up by the EA's Thames Estuary 2100 (TE2100) data (2008) which also states flood defence levels at this site should be +7.1mOD

The nearest tide data for the site is upstream at North Woolwich, the approximate mean high water springs (MHWS) there is +3.85mOD. This data was from the Port of London Authority Handbook (2018) (http://www.pla.co.uk/assets/platidetablesmaster2018v46.pdf).

From the TE2100 levels, the nearest data to the site is slightly upriver at node 3.9, the extreme water level (i.e. a 0.1% AEP) is +6mOD. This is below the +7.1mOD crest level of the river defences.

This does not take into account any future rises in sea levels caused by climate change.

Recent EA condition surveys show the recorded level of the crest of the flood defence wall to be between +7.10 and +7.13mOD.

2.7 Details of Structures

Record drawings suggest that the flood defences were constructed circa 1984, designed by C.H. Dobbies & Partners. The defence structures lie on the southern bank of the River Thames, downstream from the Thames Barrier. The location of the site places it within an area of tidal flood risk, flood zone 3. This results in there being a 0.5% AEP of sea flooding. The river defences have been designed to provide a standard of protection up to the 0.1% AEP tidal flood event.

Figure 2. View of the flood defence structure looking east of New Jetty

Figure 3. View of the flood defence structure looking west of New Jetty

Previously, that the structure was assessed in 2007 by Royal Haskoning (RH) during the planning stages for the existing Riverside Resource Recovery. The EA also inspects the flood defences twice a year. Details of the October 2017 EA assessment and the RH assessments have been reviewed by TG in preparing this report

A general view of the structure is shown in photographs 1 and 2, these photographs were taken from the New Jetty of the RRRF.

The 420m length of wall has been split into 3 distinct parts of different construction in order to help the investigation:

- Section 1 (approximate length 140m) – Tied sheet pile wall (A118035-TG-XX-00-DR-C-0111)
- Section 2 (approximate length 160m) – Structural wall (with and without gabion basket bank stabilisation) (A118035-TG-XX-00-DR-C-0112)
- Section 3 (approximate length 120m) – Reinforced concrete apron on CFA piles (A118035-TG-XX-00-DR-C-0113)

On the landward side of the wall, an embankment runs along the entire length of the wall (A118035-TG-XX-00-DR-C-0110). The majority of this embankment runs inside the RRRF site boundary, however, roughly 40m is outside of this boundary.

Drawing A118035-TG-XX-00-DR-C-0100 shows the overall plan of the flood defence structure. Drawings A118035-TG-XX-00-DR-C-0110, A118035-TG-XX-00-DR-C-0111, A118035-TG-XX-00-DR-C-0112, and A118035-TG-XX-00-DR-C-0113 show Sections 1, 2, 3, and the landward embankment respectively.

2.7.1 Section 1 – Tied Sheet Pile Wall

This section of wall is shown on record drawing HE/R/4/72/K5/001A and is approximately 140m long. Figure 4 shows a typical cross-section through this section of wall.

The front wall consists of Frodingham 3N sheet piles installed to a toe depth of -10.0 mOD, the top of pile level is +6.7mOD. A concrete capping beam forms the flood defence. The drawings state that the top level of this defence is +7.10mOD. This is confirmed in the 2017 assessment records that state that this level varies from +7.10mOD to +7.12mOD. The wall is tied back at 4.83m centres with 75mm diameter tie rods to 6no. Frodingham 1N sheet piles (central pair installed to a toe depth of -9.2 mOD and outer pair installed to +1.95mOD, top of pile level at +4.45mOD). The record drawing states that the reinforcement consists of sulphate resisting Portland cement. The records describe the wall being broken up into bays. For each bay there are two tie rods, with each bay typically being 9660mm in length.

The ground behind the wall consists of a 3m wide footpath with a bitumen macadam surfacing sloping down to a level of +4.8mOD. From the record drawings, the top level of the ground in front of the wall is +6mOD.

No details are shown on record drawings for the capping beam. The foreshore in front of this section of the wall is not described in detail on the record drawings. The only information about the foreshore on the drawings is a note stating that the existing banks are to be finished neatly to the wall face. From the record drawing, it appears as though the riverward embankment meets the wall at around +5.40mOD.

A staircase is present along this section of wall, supported on the same Frodingham 3N sheet piles that support the capping beam and also 2no. 305 x 305 x 110 H piles. The stairs lead to the Old Ford Jetty. This is a wooden structure located in bay 46. There is access up to three quarters of the way along the jetty where a gate blocks access.

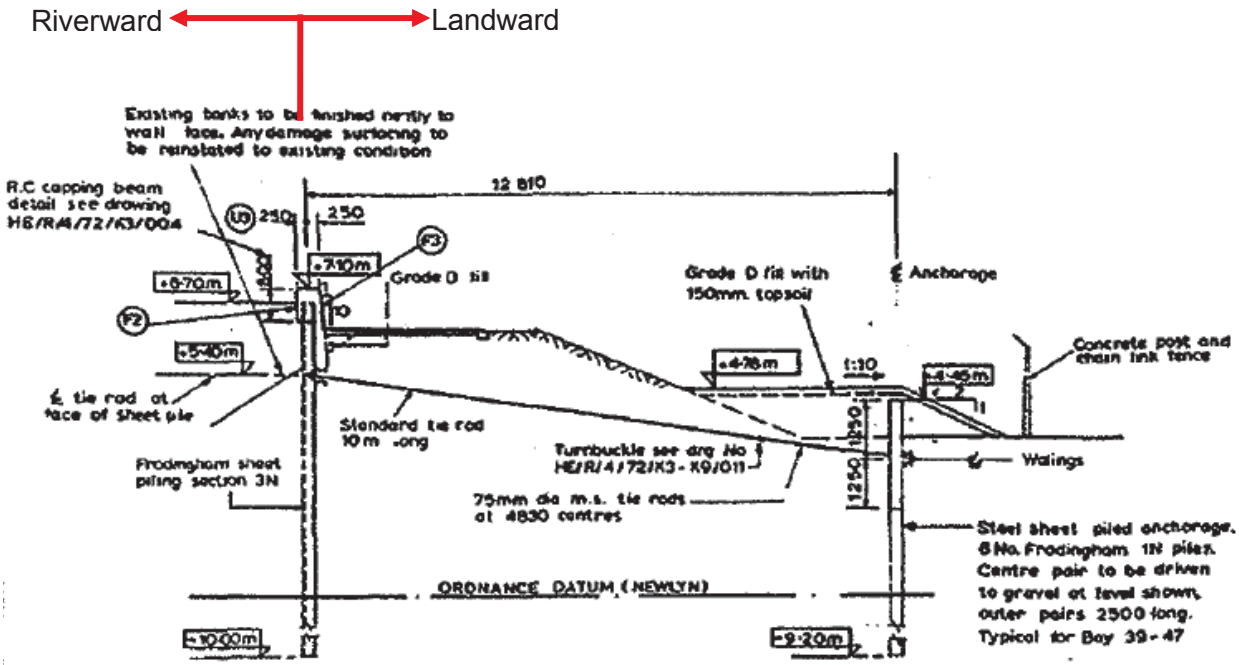


Figure 4. Extract from record drawing HE/R/4/72/K5/003A showing typical section through Tied Sheet Pile Wall

Type of assets included in structure

Based on categories as listed in Table 2.1 of 'Guidance on determining asset deterioration and the use of condition grade curves (Environment Agency, 2009):

- Vertical concrete wall in fluvial environment (normal maintenance assumed)
- Sheet piles in fluvial environment (no maintenance assumed)
- Rigid embankment in fluvial environment (no maintenance assumed)

2.7.2 Section 2 – Structural Wall

This section of wall is shown on record drawings HE/R/4/72/K5/002 and 004B and is approximately 160m long. Figure 5 shows a typical cross-section through this section of wall.

Similarly to Section 1, the flood defence wall is supported on Frodingham 3N sheet piles installed to a toe depth of -10.0mOD and a top of pile level of +5.45mOD. A 600mm thick concrete slab extends 3.4m behind the front face of the wall, integral to the upstand wall and supported on one vertical and one raking 305 x 305 x 110 H-piles at 3.54m centres. The record drawing states that the reinforcement consists of sulphate resisting Portland cement. The original drawings show that the top level of this defence at +7.10mOD. This is confirmed in the 2017 assessment of the wall that shows the top level of the wall varies from +7.11mOD to +7.12mOD.

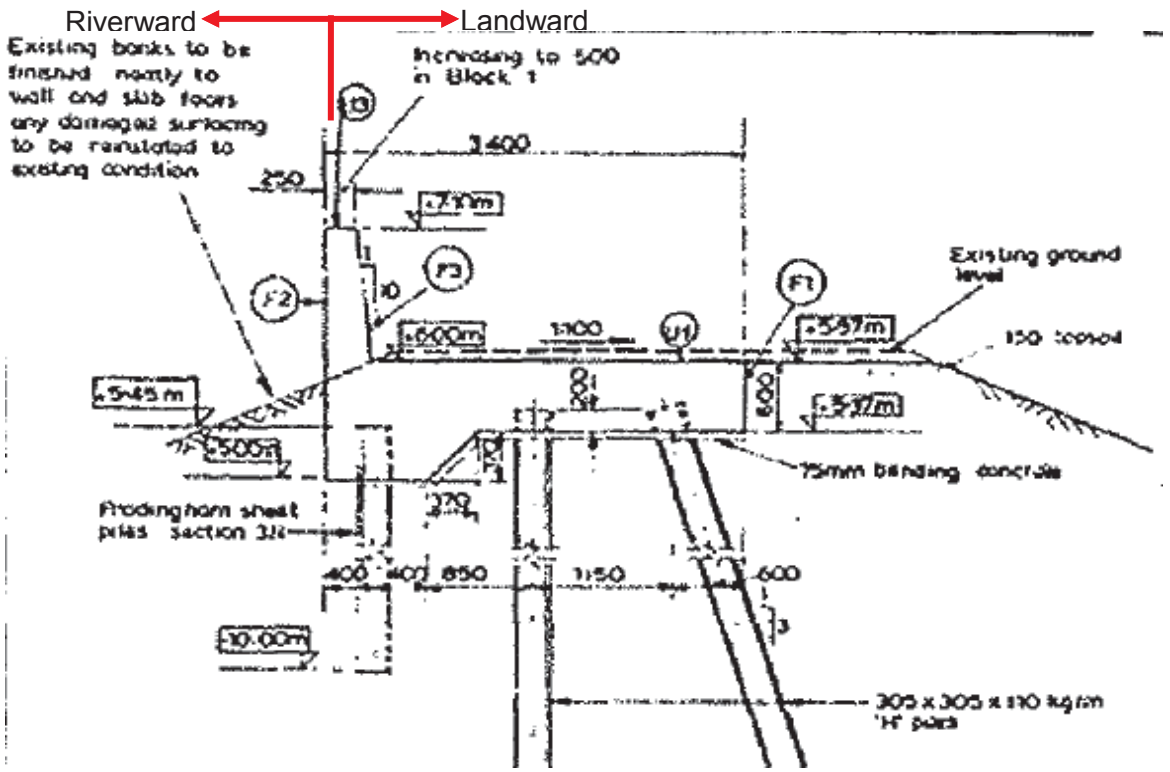


Figure 5. Extract from record drawing HE/R/4/72/K5/004B showing typical section through Structural Wall.

According to the record drawings, approximately 100m of riverward embankment is covered in stone pitching at the top of the foreshore slope, with the remainder left as a grass bank. Where the embankment is covered in stone pitching, this extends to +2.0mOD. The 100m length runs from block 7 to block 17. At the base of the foreshore slope, below the stone pitching, a 108m length of wall features gabion baskets with compacted stone fill present at the toe of the structure. Refer to Figure 6. The top level of the gabion baskets varies from -1.40mOD to -0.50mOD and the top of the compacted stone fill varies from +1.20mOD to +2.0mOD.

Located in block 4 is a staircase used to access a timber jetty and the foreshore. The staircase is supported by the typical Frodingham 3N sheet pile section as well as 2no. 305 x 305 x 110 H piles. The bottom level of the stairs is at +4.72mOD. From looking on Google Earth, it can be seen that the Timber Jetty has been demolished. The stairs and two concrete support piers still remain on the site, however.

A large new jetty has since been constructed as part of the RRRF. This New Jetty emerges from the site above block 10. The supports for the New Jetty do not affect the flood defence structures as it does not come into contact with the structure.

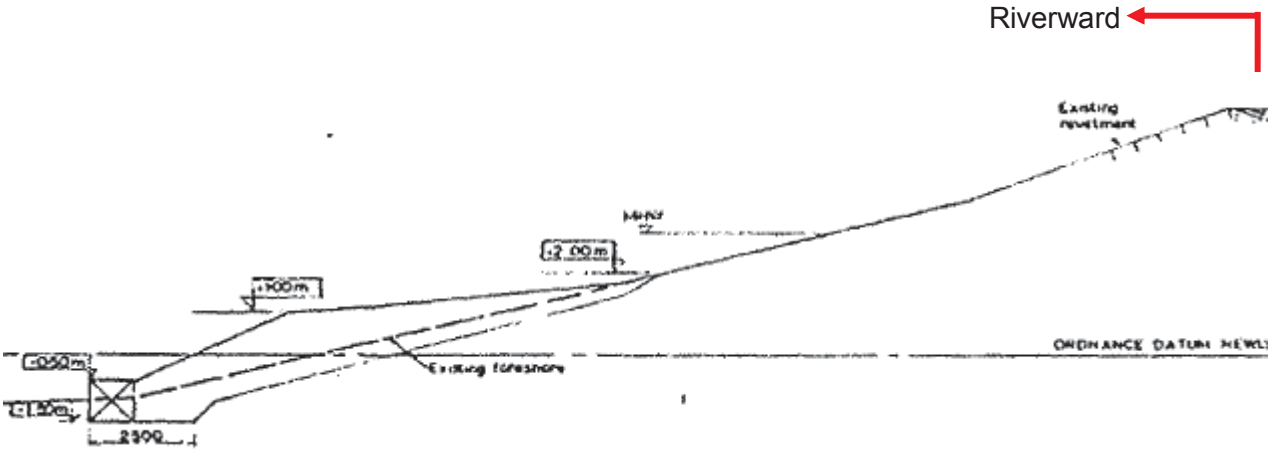


Figure 6. Extract from record drawing HE/R/4/72/K5/002 showing typical section through bank stabilisation works.

Type of assets included in structure

Based on categories as listed in Table 2.1 of 'Guidance on determining asset deterioration and the use of condition grade curves (Environment Agency):

- Vertical concrete wall in fluvial environment (normal maintenance assumed)
- Sheet piles in fluvial environment (no maintenance assumed)
- Rigid embankment in fluvial environment (no maintenance assumed)

2.7.3 Section 3 – Reinforced concrete apron on CFA piles

This section of wall is shown on record drawing HE/R/4/72/K5/005C and is approximately 120m long. Figure 7 shows a typical cross-section through this section of wall.

Similarly to Sections 1 and 2, the flood defence wall is supported on Frodingham 3N sheet piles installed to toe depths varying from -9.0mOD to -10.0mOD and a top of pile level of +4.40mOD. A 600mm thick concrete apron integral to the upstand wall extends onto the foreshore approximately 6m from the front face of the wall. The apron is supported on 600mm diameter concrete bored piles at varying centres. The record drawing states that the reinforcement consists of sulphate resisting Portland cement. The original drawings show that the top level of this defence at +7.10mOD. This is confirmed in the 2017 assessment of the wall that shows the top level of the wall varies from +7.10mOD to +7.13mOD. The top level of the ground in front of the wall, from the record drawings is +5.35mOD.

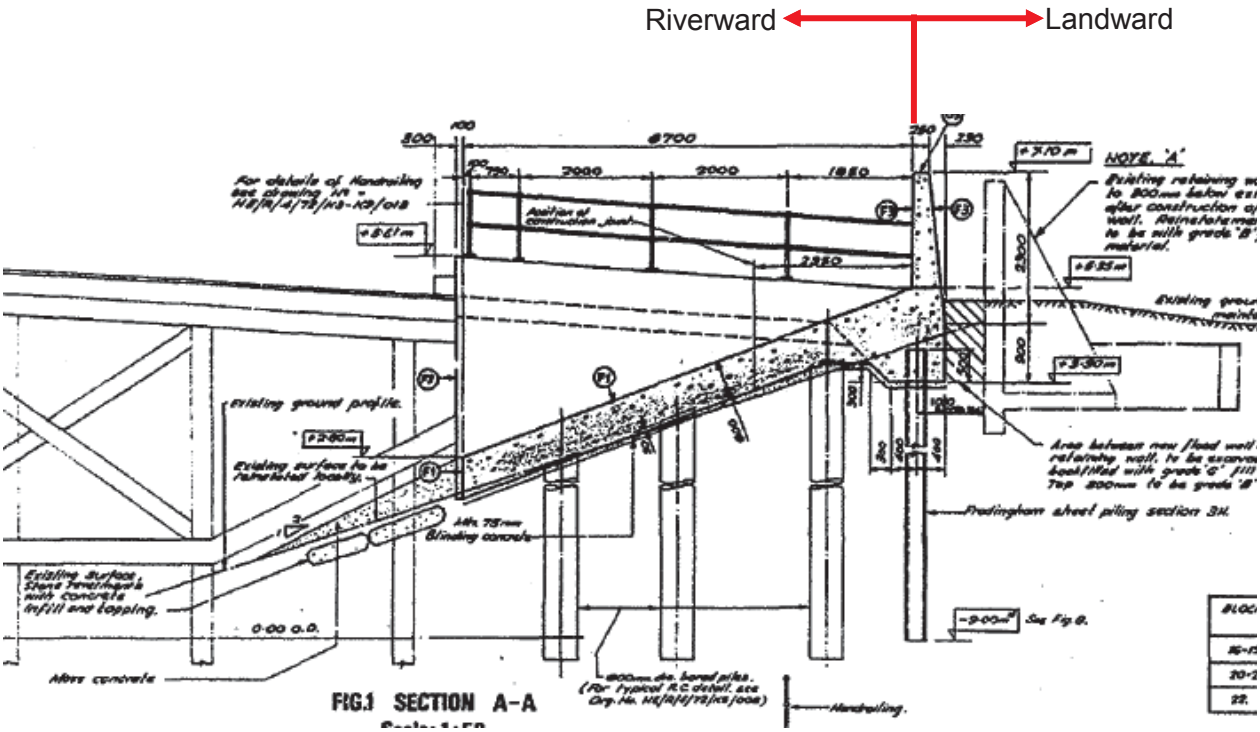


Figure 7. Extract from HE/R/4/72/K5/005C showing typical section through reinforced concrete apron on CFA piles

The Borax Jetty is located within Section 3. From the record drawings, the Borax Jetty consisted of a concrete platform that extended over the concrete apron by 6.7m. In block 20, the concrete platform extends a further 2m into the river. Typically the flood wall follows the southern side of the concrete platform, except in block 20 where it follows the northern edge. A timber jetty structure runs along the concrete platform. When this section of wall was constructed, a 600mm thick suspended concrete deck was provided above the existing jetty. This timber jetty structure has since been demolished leaving behind the concrete platform structure and 2no rows of 6no piles to in front of block 21 and 22.

Type of assets included in structure

Based on categories as listed in Table 2.1 of 'Guidance on determining asset deterioration and the use of condition grade curves (Environment Agency):

- Vertical concrete wall in fluvial environment (normal maintenance assumed)

- Sheet piles in fluvial environment (no maintenance assumed)
- Rigid embankment in fluvial environment (no maintenance assumed)

2.8 Maintenance and Inspection History

The flood defence structure has previously been surveyed by RH in August 2006 and the findings are summarised in report reference 9S0072/R/307922/Hayw. The report found that there were some areas of the flood defence structure that needed remedial attention. Areas where remedial work was recommended was to the stone pitching in Sections 1 and 2, the concrete screed in Section 2, and to the reinforced concrete apron in Section 3. For the stone pitching and concrete screed, it was recommended that repairs were undertaken and that the frontage should be monitored once every 2 years. To the concrete apron, it was recommended that existing voids at the toe were filled with concrete bagwork and that this should be monitored biennially. If these recommendations were undertaken, the structure should have a further design life of 40 to 50 years, assuming 2006 water levels and that maintenance is carried out. This design life does not take into account rising sea levels, however, applying the Defra guidelines that RH used in the 2007 report, in the worst case scenario, this still left a freeboard of around 1 metre after 30 years.

Asset record details shows that the EA rated the flood defence wall condition as grade 2 (good) in 2018. In a subsequent meeting the EA later downgraded some areas to grades 3 and 4. Recommendations for remediation steps were put in place for these locations.

In October 2017, a survey of the crest of the flood wall was carried out by the EA, with levels ranging from +7.10 to +7.13mOD.

2.9 Record Drawings

Record drawings have been provided for the flood defence structure:

Drawing Number	Drawing Title	
HE/R/4/72/K5/001A	General Layout of Flood Defences	C.H. Dobbie & Partners
HE/R/4/72/K5/002	Bank Stabilisation Works	C.H. Dobbie & Partners
HE/R/4/72/K5/003A	*No Title*	C.H. Dobbie & Partners
HE/R/4/72/K5/004B	Sections and Details Blocks 1 to 15	C.H. Dobbie & Partners
HE/R/4/72/K5/005C	*No Title*	C.H. Dobbie & Partners
9S0072/HH/001 C	Key Plan	Royal Haskoning

The drawings prepared by C.H. Dobbie & Partners are from the early 1980's. These give the outline arrangement for the upper wall construction. The Riverside Resource Recovery Facility was constructed to the east of the site around the year 2009.

2.10 Inspection Procedures

Detailed information relating to the method of inspection and inspection personnel can be found in the method statement document ref. A118035-TG-GEN-XX-MS-C-0001 Rev P03.

3. STRUCTURAL OBSERVATIONS

The initial inspection of the river flood defences were undertaken on 2nd August 2018. A secondary, follow up inspection was undertaken on 12th October 2018. Both of these inspections were completed by Marc Babin and Nick Armstrong of Tony Gee (TG). The weather at the time was hot and the tide was low.

Photographs are included in Appendix B and the location of each photo is noted on drawings no. A118035-TG-XX-00-DR-C-0110, A118035-TG-XX-00-DR-C-0111, A118035-TG-XX-00-DR-C-0112, and A118035-TG-XX-00-DR-C-0113 in Appendix A.

3.1 Foreshore and Top of Embankment

Figure 8. Photograph of section 1 from the RRRF New Jetty.

3.1.1 Section 1 – Tied Sheet Pile Wall

3.1.1.1 Foreshore

The record drawings do not show the width of the foreshore in Section 1, neither do they show the composition of the foreshore. On site it was found that the foreshore was constructed of stone pitching. The distance from the toe of the exposed stone pitching to the concrete flood wall was measured at around 9m. At the toe of the stone pitching there was very soft sediment.

Generally, there was dense vegetation growth along the upper 2m of the foreshore embankment. The vegetation was typically bramble bushes. However, there were several instances where the brambles cleared and small trees were present. An example of this is in bay 35 where over a length of approximately 10m, trees were

growing (photo 64). There was evidence of small stone pitching beneath the vegetation. Some of these stones were dislodged (Photos 6 and 65).

In the middle section of the wall, long grass was present. The bottom 1m of stone pitching was covered in seaweed (photo 1). The river bed itself was flat and consisted of very soft sediment. Evidence of algae growth was present 1m above the seaweed level suggesting this was the mean high water level.

It was not possible to inspect the bottom 1 metre of the wall due to the dense seaweed coverage. There were no obvious signs of loose rocks and it appeared as though the bottom section of the foreshore was in good condition. Above the dense seaweed coverage, it was estimated that around 40% of the stone pitching was sufficiently exposed, a further 30% could be exposed by lifting vegetation, and the remaining 30% was unable to be inspected due to dense vegetation.

The gradient of the foreshore was observed to be linear and there were no obvious signs of movement, such as, bulging, toe failure or undercutting from the river. Around 10m east of the Old Ford Jetty the gradient of the foreshore steepened, this shallowed again around 5m to the west of the Old Ford Jetty.

For the exposed section of foreshore, the overall condition of the stone pitching appeared to be good (photo 2) with only some minor, superficial cracking (photo 3). This minor cracking was generally no more than 2mm wide. The joints in the stone pitching appeared to be in good condition with no mortar loss and the stones were solid and not loose. The vegetated areas of the foreshore were in poor condition. When the long grass was lifted, it was found that stones had been displaced by the roots (photo 4).

Close to the Old Ford Jetty, the brambles cleared, enabling access for inspection. It was seen that the top 3.7m of the foreshore, up to the base of the concrete wall, was constructed from small stone work (photo 5). This stonework was in worse condition then the larger stone pitching with some of the stones missing (photo 6). Around 5m east of the Old Ford Jetty some large trees were growing with an approximate girth of 100mm.

East of the Old Ford Jetty, the sheet piles became visible (photo 7). These are discussed in Section 4.1.3. Where the Old Ford Jetty joins to the foreshore, the foreshore appeared to be in good condition, however, the condition of the small stonework wall was bad in this area with many loose bricks (photo 8).

Approximately 7m west of the Old Ford Jetty there was a small concrete block (photo 9). There were signs of some cracks being patched up around this block. These repairs were in poor condition with the repair mortar breaking away easily (photo 10).

Approximately 25m west of the Old Ford Jetty there was a large crack in the stone pitching (photo 11 and 12). This crack was 50mm wide and 700mm long. It is likely that this is the crack that was identified on the RH survey that was undertaken in 2006. Lots of vegetation was growing from the crack although no stones in the vicinity were found to be loose.

Roughly 35m west of the Old Ford Jetty there was a localised area of exposed soil on the foreshore with a plan area of 500mmx500mm (photo 13) There were also more patches of missing stonework around this area (photo 14).

Around bay 35 a thin concrete covering of the blockwork was observed (photo 66). The majority of this concrete covering appeared to be in good condition. However, 8m west of where the cover began there was a small piece of loose concrete (photo 67). Underneath the cover the foreshore appeared to be in good condition.

Beyond bay 35, travelling west along the foreshore, there was minimal vegetation. There were large stones that appeared to be in good condition, however, the mortar between the stones was missing (photo 68). Some vegetation was observed growing in the gaps between the stones (photo 69).

3.1.1.2 Concrete Wall

The concrete wall in this section was wider than those of Section 2 and 3. The top of the wall was measured at 500mm wide. There was a large amount of vegetation covering the wall. Some of this vegetation was able to be moved, this led to around 50% of the wall being able to be inspected in this section (Photo 15).

The majority of the expansion joints were in average condition. In the joints along the top of the wall there was some small vegetation growth (photo 16). In the expansion joint between bays 34 and 35 there was evidence of a large amount of vegetation growing (photo 70).

Along the bottom of the wall there was a large amount of long grass growing (photo 17).

Over the visible length of the wall, there were no obvious signs of damage from the wall being struck or hit. Neither were there any signs of honeycombing, rust staining, or spalling of the wall.

Along the length of the wall there were evidence of blow holes. The blow holes were typically 10mm in diameter and were superficial (photo 16).

The height of this section of the wall above the footpath at the end of bay 33 was approximately 0.95m, at bay 39 it was approximately 0.91m and at the end of bay 44 it was approximately 1.1m. When inspecting each concrete block relative to one another, the wall showed no sign of movement between each block.

There was a gap in the wall at bay 44 for the access stairs to the Old Ford Jetty (photo 18).

3.1.1.3 Footpath

There are two sections to the footpath in this part of the wall. From the western edge of block 1 to the western edge of bay 44 the footpath was gravel. West of bay 44 the footpath was tarmac (photo 19). Both the gravel and tarmac footpaths were in good condition and were around 3m wide. At the western most part of the footpath there is a pedestrian gate (photo 71).

The gravel footpath was uneven in parts, with some large rocks pointing through. In heavy rainfall, puddles are likely to form in this part of the footpath.

The tarmac footpath had some minor cracking. These cracks appeared to have only formed in the top section of the footpath (photo 20). There was a small amount of vegetation beginning to grow from these. In bay 33, next to the pedestrian gate there was a circular crack in the footpath. Through this crack there was a breakthrough of vegetation (photo 72).

There was no sign of bulging or unevenness in the top of the tarmac section of the footpath.

3.1.1.4 Sheet Piles

The visible sheet piles looked to be in good condition. There were no obvious signs of corrosion and the paint was mostly intact (photo 7). It is estimated that 95% of the paint is still intact. There was some algae growth on the piles. Thickness testing was undertaken on these sheet piles. A total of 4no tests were undertaken, 2 tests in the flange with thicknesses of 11.2 and 11.4mm being measured and 2 tests in the web with thicknesses of 9.4 and 9.4mm. The original dimensions of the Frodingham 3N sheet piles were a flange thickness of 11.7mm and a web thickness of 8.9mm. Note, the discrepancy in the web thickness was likely due to rolling tolerances during manufacture.

3.1.2 Section 2 – Structural Wall

Figure 9. Photograph of eastern side of Section 2

Figure 10. Photograph of middle part of Section 2

Figure 11. Photograph of western side of Section 2

3.1.2.1 Foreshore

The record drawings show the foreshore of Section 2 between the middle of block 5 to the eastern edge of block 15 was constructed from stone blockwork and the foreshore to the west of this section was a grass embankment. However, when the visual inspection took place, it was found that the entirety of the foreshore of Section 2 had been constructed of stone pitching.

Similar to the tied sheet pile wall the top 2m of the foreshore was covered in brambles, the middle section had dense vegetation growth and the bottom meter section was covered in seaweed. However, the middle section of vegetation growth was much denser in this section compared to the tied sheet pile wall foreshore in Section 1 (photo 21).

The upper section of the foreshore was constructed of concrete blockwork (photo 22). This extended roughly 3.5m from the top of the foreshore, the bottom 5 rows of the blockwork were visible. It appeared as though it was generally in good condition. There was some vegetation growth in the gaps between these blocks. As with Section 1 of the wall, the middle section of the foreshore was constructed of stone pitching. Adjacent to the stairs of the demolished jetty, some of the stones were loose (photo 23). As the

vegetation got denser the condition of the stone pitching deteriorated. There were lots of gaps in the stonework (photo 24). The condition of the stone pitching improved when the vegetation thinned out (photo 25). In this area, there were no signs of mortar loss or any loose stones.

Underneath the New Jetty there was a broken concrete block (photo 26 and 27), this block was around 500mm high. The foreshore below the block had a large crack running in line with the east side of the New Jetty (photo 28). This crack was likely to have been superficial. Attached to the concrete block was an old mooring ring that had been heavily corroded (photo 29).

East of the New Jetty, from block 12, the foreshore became uniform and was covered in a concrete screed (photo 30). It was likely that this screed had been placed on top of the stone pitching as there was a 50mm step up from the stone pitching at the west of this section. The condition of the screed was good with some superficial cracking (photo 31). 6m from the top of the wall there was a crack 5mm wide and 9m long (photo 32 and 33), again this was likely to be superficial.

Around 5m west from the third, reinforced concrete apron section, in block 15, there was a gap in the concrete screed and this revealed the stone pitching underneath (photo 34).

The record drawings show that stone filled gabions were placed at the toe of the wall between block 7 and 17 (see figure 6). These were placed 13m from the mean high water level. These gabions were not visible during the inspection, they were likely to have been covered by the river bed sediment. There were however, no obvious signs of toe failure of the foreshore wall.

3.1.2.2 Concrete Wall

The concrete wall on Section 2 was narrower and taller than that of Section 1. On the landward side of the wall, it was 1.3m tall. The width of the top of the wall was 250mm. Due to the vegetation on the riverward side of the wall, it was not possible to measure the height of the wall on this side. There were no obvious signs of there being any differential crest height. There also didn't appear to be any sign of the wall leaning.

The wall itself was in good structural condition (photo 35). Along the length of the wall there was evidence of blow holes. The blow holes were typically 10mm in diameter and superficial (photo 36). The largest blow holes were towards the top of the wall. At the bottom of the wall there were clusters of smaller blow holes.

The expansion joints in the wall appeared to be in good condition with only minor cracking. Unlike in Section 1, there wasn't any vegetation growth from the joints (photo 37).

There were no signs of rust staining, honeycombing, or signs of damage from the wall being hit or struck.

3.1.2.3 Concrete Footpath

From the eastern edge of block 1 to the western edge of block 15, the footpath was constructed of concrete. The path was 3m wide and appeared to be in good condition (photo 36). The expansion joints in the concrete footpath appeared to be in good condition with only some minor superficial cracking.

The footpath showed no obvious signs of settlement and no major cracking was seen.

3.1.2.4 Sheet Piles

The sheet piles for this section of wall were not visible without excavation work which was outside of the scope of this investigation (see figure 5).

3.1.3 Section 3 – Reinforced concrete apron on CFA piles

Figure 12. Photograph of Section 3 from RRRF New Jetty.

3.1.3.1 Foreshore

The concrete apron transitioned from the previous sections height over a width of 1m (photo 38). From there the concrete apron was uniform (photo 39). The slab of the concrete apron was raised above the linear foreshore by around 50mm (photo 40). There doesn't seem to have been any differential settlement between the concrete apron and the top wall.

The concrete apron was mostly clear of vegetation although there was some growth in the expansion joints and in the bottom 1 meter there was some algae growth.

In block 17 there was a stainless steel mooring bollard (photo 41). This had no structural impact on the flood defences.

The Old Borax Jetty structure appeared to be in good condition with no obvious signs of structural defects (photo 42). There was however, some evidence of concrete spalling around the bottom of the structure (photo 43).

It was not possible to access the east side of the Old Borax Jetty so the visual inspection was undertaken from the footpath at the top of the wall.

On the eastern side of the Old Borax Jetty, the same concrete apron structure continues (photo 44). At the bottom of block 25 the toe of the foreshore structure looked to have settled by around 50mm. There was also evidence some stones being displaced and gaps in the lower concrete between blocks 27 and 28 (photo 45).

At the west corner of block 26 there was a sheet pile protruding from the bottom of the toe (photo 46). It appeared as though the sheet pile had been bent and moved out of place. Record drawings show that existing sheet piles were in this area pre 1984.

3.1.3.2 Concrete Wall

The concrete wall in this section looked to be in good condition with no obvious signs of structural defects. There were some small superficial blow holes on the landward side of the wall (photo 47), this continued along the whole length of this section of the wall. The majority of the expansion joints in the concrete wall were in reasonable condition with some minor gaps. The expansion joint between blocks 28 and 29, and 29 and 30, however, were in poor condition (photos 77 and 48 respectively).

The distance from the top of the foreshore to the top of the concrete wall on the riverward side was 1.75m. The distance from the top of the wall on the landward side to the top of the footpath was a maximum of 1.3m and minimum of 1.19m due to the settlement of the tarmac (see Section 4.1.3.3). Between the intersection of blocks 23 and 24, and 28 and 29, there appeared to have been some small differential movement between the blocks.

There was no sign of honeycombing, rust staining, damage to the wall, or any concrete spalling.

A new brick wall had been built across block 20 blocking off access to the stairs leading to the riverward side of the wall (photo 49). The new brick wall appeared to be in good condition with expansion joints at the intersections with the existing wall.

Along some parts of the wall there appeared to be some painted sections (photo 50), this is likely to have occurred to cover up areas of vandalism on the wall.

3.1.3.3 Tarmac Footpath

The footpath on the landward side of the wall, in this section, was covered in tarmac (photo 50). Along the length of the tarmac, it appeared as though the path had settled by approximately 100mm. There were signs of a previous sealant on the wall roughly 100mm higher than the level of the tarmac footpath (photo 51). This sealant level was at the same level as the concrete slabs either side of this section, possibly indicating

the top level of a previous concrete slab. At the join of the footpath on both the east (photo 52) and west (photo 53) edge the tarmac appeared to have settled by around 50mm. At both of these joins there was a rubber expansion joint that had twisted and now no longer in contact with the tarmac cover (photo 53). It appeared as though the tarmac footpath had settled uniformly as no rises or falls were observed along the path.

In block 24 there was some localised bulging of the tarmac at the bottom of the wall (photo 54).

On the western half of the new wall, there was a continuous gap between the tarmac footpath and the bottom of the wall (photo 55). The gap was approximately 50mm wide.

From the middle of block 18 to the western edge of block 16 (the intersection between Section 2 and 3), there was a continuous gap between the footpath and the bottom of the wall (photo 56). The gap was typically 600mm deep with a maximum depth of 650mm in the middle of block 18 (photo 57 and 58).

The size of each bay of tarmac (i.e. the distance between each expansion joint) was around 6m and the expansion joints appeared to be in good condition apart from those at the ends of the section.

3.1.3.4 Sheet Piles

The sheet piles for Section 3 were covered by the concrete apron (see figure 6) so it was not possible to inspect them without carrying out excavation work which was outside of the scope of this investigation.

3.2 Landward Embankment

The landward side of the flood defences was an earth embankment. There were two sections of the landward embankment, a section outside of the RRRF site boundary and a section inside of the site boundary.

3.2.1 Section 1- Outside of the RRRF Site Boundary

The landward embankment located outside of the RRRF site boundary was overgrown with brambles (photo 73). There were no fences preventing access to this part of the embankment, however, due to the dense vegetation it was not possible to walk on this section of the embankment. Therefore, observations were taken from the public footpath.

Starting roughly 1m landward of the footpath, there was a 2m level drop over a 2m horizontal distance. On the west side of this section of embankment, there was a metal staircase leading down the embankment (photo 74). Access down the staircase was prevented by the heavy vegetation growth.

At the bottom of the embankment there were 2no. lampposts and a lighting bollard that appeared to be broken (photo 75).

Along the line of the new western site boundary, there was a low level fence and line of bollards (photo 76). This fence was in line with the pedestrian gate along the footpath.

3.2.2 Section 2- Inside of the RRRF Site Boundary

The landward side of the flood defences located inside of the RRRF site boundary was covered in vegetation. This part of the was separated from the public footpath by a security fence. The fence was located approximately 4.7m from the landward face of the concrete flood wall. Towards the east of the site there was a flat section on top of the embankment inside the site boundary of around 3.6m (photo 59), therefore making the total flat section on the top of the embankment 8.3m. Around 50m to the east of the site boundary, the embankment steepened and the bank narrowed (photo 60). West of the New Jetty the embankment began to shallow and there was no flat section on the site side of the security fence. At the west site boundary the slop was very gradual (photo 61).

Due to the prolonged hot and dry weather over the past 6 weeks, the ground was very dry. The embankment was covered in grass and felt firm. There were no obvious signs of bulging or movement within the structure.

Looking at a section through the embankment, there was roughly 1 meter of clear ground from the security fence. This was followed by around 1 meter of dense shrubbery before the rest of the embankment was covered in long grass. Around 70m from the east site boundary the vegetation got larger and bushes were growing (photo 62). These bushes continued along the embankment until around 40m from the west site boundary.

The landward embankment that was running alongside Section 1 of the flood defence wall contained a sheet pile anchor wall (top level +4.45mOD for the tie rods (see figure 4). There were no signs of the sheet piles protruding through the surface of the embankment.

As can be seen in figure 4 the embankment was originally designed to have a double slope section. This was not seen on the visual inspection. The embankment had a much smoother, linear section (photo 60). This was likely to have been altered during the construction of the RRRF. On the original drawings for Sections 2 and 3 (figures 4 and 7), no detail was given for the landward embankment, only that it was to be made to the existing ground level.

Along the bottom of the landward embankment ran the service road for the RRRF (photo 63). The toe of the embankment followed the line of the service road.

4. DISCUSSION AND FINDINGS

The following section discusses the condition of the key elements of the river defence structure in more detail and should be read in conjunction with Section 4 where the specific defects have been identified.

The condition grade and the deterioration time have been calculated using the EA's *Guidance on Determining Asset Deterioration and the Use of Condition Grade deterioration Curves.* The condition grades are described in Table 1 of this report.

The locations of the recommended remedial works are shown on the drawing no. 172067-DC-XX-XX-SK-C-109.

4.1 Section 1 – Tied Sheet Pile Wall

Section 1 of the wall was constructed from sheet piles with a capping beam, which forms the crest of the flood wall, constructed located on top of the sheet piles. The sheet piles are tied back to an anchor pile, 12.81m back, on the landward side. The tie rods are at 4.85m centres. The foreshore embankment meets the sheet piles at around +5.40mOD. The sheet piles and anchor system give this section of the structure its structural rigidity. The foreshore provides passive resistance to the structure which in turn supports the concrete wall. However, if the foreshore is not maintained in a good condition it could cause loss of passive resistance and lead to water to ingress, accelerating the corrosion of the sheet piles.

4.1.1 Interpretation of Structural Observations

Overall Section 1 of the flood defence structure was in fair condition. The majority of the stone pitching appeared to be in a good condition (photo 2), however, there was some superficial cracking (photo 3) that if not monitored could develop into more structurally significant damage. The crack found 25m west of the Old Ford Jetty (photo 11 and 12) could also be a cause for concern.

The missing stones found 35m west of the Old Ford Jetty (photo 13 and 14), in the small stonework around the Old Ford Jetty (photo 5, 6, and 8), and around bay 35 (photo 65) could cause problems with seepage and erosion, and could lead to the progressive displacement of stones.

Vegetation growth along the foreshore has created gaps in the stone pitching. Due to the location of the site, vegetation growth is hard to prevent. The purpose of the stone pitching is to prevent erosion and movement of the foreshore. Continued cracking could lead to the loss of bank material, reducing the passive resistance. It is likely that the vegetation is increasing the stability of the embankment.

Overall it can be said that the foreshore to the east of the Old Ford Jetty was in better condition than the foreshore to the west of the jetty. This coincides with the fact that there was less vegetation growth on the east than west side.

Where the sheet piles were visible, they were observed to be in good condition. The paint system seemed to be intact resulting in no corrosion being observed on the exposed face. Embedded lengths of the sheet piles should experience very low

corrosion rates. According to guidance included in EN1997, the anticipated corrosion rate for the sheet piles should be 0.012mm/year/face therefore over 38 years resulting in 0.456mm of corrosion loss per face. This will lead to a reduction in bending capacity of less than 10%.

The concrete wall itself appeared to be in good condition with only some minor blow holing (photo 16), however, the expansion joints in the wall were only in a fair condition (photo 70). The vegetation growing on the top of the wall, from the joints, could cause deterioration of the condition of the joints. The prolonged hot weather experienced around the time of the inspection could have caused the condition of the joints to deteriorate.

The tarmac section of the footpath was observed to be in good condition, showing no obvious signs of structural defects. The gravel section was also in good condition, however, this could become downgraded with heavy rainfall (photo 19).

In the Royal Hanskoning survey, it was recommended that the stone pitching was to be repaired. It is unlikely that this remedial work was carried out as the crack found on the foreshore 25m west of the Old Ford Jetty is likely to be the same crack found in the 2006 report.

4.1.2 Condition Grade

Based on EA guidance the following condition grades are proposed for each asset type:

- Vertical concrete wall in fluvial environment: Grade 3 (Fair)
- Sheet piles in fluvial environment: Grade 2 (Good)
- Rigid embankment in fluvial environment: Grade 3 (Fair)

The overall suggested EA grading: Grade 3 (Fair)

4.1.3 Residual Life

Based on EA guidance and the following deterioration curve for best estimate, the time for the asset to deteriorate from its current condition grade to condition grade 5 is:

- Vertical concrete wall in fluvial environment: 45 – 90 years (70 years best estimate)
- Sheet piles in fluvial environment: 65 – 140 years (120 years best estimate)
- Rigid embankment in fluvial environment: 10 – 50 years (34 years best estimate)
- Section 1 composite structure: 10 – 50 years (34 years best estimate)

Asset	Best estimate					Fastest estimate					Slowest Estimate				
	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5
Concrete wall	0	20	50	100	120	0	10	30	60	75	0	20	60	120	150
Sheet piles	0	20	80	120	140	0	10	30	60	75	0	20	100	140	160
Rigid embankment	0	3	6	25	40	0	4	10	14	20	0	5	10	40	60

Table 2. Section 1 Individual asset deterioration curves

Asset	Best estimate					Fastest estimate					Slowest Estimate				
	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5
Composite structure	0	3	6	25	40	0	4	10	14	20	0	5	10	40	60

Table 3. Section 1 Composite structure deterioration curves

The limiting asset for the composite structure was the rigid, riverside embankment.

4.1.4 Remedial works / maintenance recommendations

Remedial Works

As noted above, there were areas of Section 1 of the flood defence structure which require remedial work to ensure the condition grade does not deteriorate. To best prolong the life of the wall to the required 70-100 years design life, the following recommended remedial work should be carried out within two years.

As mentioned in section 5.1.3, the condition of the rigid foreshore embankment is key to the future life of the structure. In order to prevent the further deterioration of the foreshore embankment, it is recommended that the cracks and missing stones in non-vegetated or minimally vegetated areas of the stone pitching are repaired.

It is also recommended that the vegetation is removed from the expansion joints and the expansion joints in the wall are repaired to prevent further vegetation growth in the joints. This will enable the condition of the wall to be upgraded to grade 2 (good).

Maintenance Works

It is recommended that the flood defence structure is monitored regularly, if the remedial work recommendations are undertaken, then a visual inspection by a charted civil engineer every 2-5 years should be sufficient to ensure the upkeep of the structure. The inspections will be able to identify if the vegetation on the foreshore is causing deterioration as opposed to aiding stability.

The vegetation on the riverward embankment should maintained to a level where it will allow for easy access to the structure for monitoring purposes.

4.2 Section 2 – Structural Wall

Record drawings show that sheet piles were used in the construction of Section 2, placed on top of the sheet piles is a 600mm thick concrete slab, extending 3.4m behind the face of the upstand wall. The slab is integral to the upstand wall. The slab is sitting on two piles, one vertical and one raking, at 3.4m centres. Within Section 2, there is a 100m length where the toe is reinforced by gabion baskets, although this wasn't visible in the inspection. The foreshore was constructed of stone pitching and met the flood wall at around +6.0mOD. East of block 12, a concrete screed has been laid over the stone pitching foreshore.

As the structure consists of the sheet piles and bearing piles, the foreshore provides only passive resistance to the structure which in turn supports the concrete wall. However, if the foreshore is not maintained in a good condition it could cause loss of

passive resistance and lead to water to ingress, accelerating the corrosion of the sheet piles.

4.2.1 Interpretation of Structural Observations

Much like Section 1, Section 2 was in fair condition. There was some cracking of the stone pitching as well as some stones missing (photo 23 and 24). The majority of the missing stones were located in areas of dense vegetation so it is likely that the roots of this vegetation has caused the stones to become displaced.

The minor cracking in the concrete screed covering the stone pitching is superficial at the moment (photo 32). If this is allowed to develop it could cause problems arising from seepage and erosion of the embankment. However, the screed appears to be an additional protection layer for the stone pitching, therefore, any defects are unlikely to affect the structural stability, providing the majority of the original stone pitching is still present beneath the screed. There was also a larger section of the screed missing, revealing some of the stone pitching underneath (photo 34). This defect is within the waterline so it is likely that this will deteriorate in condition.

Vegetation growth along the foreshore has created gaps in the stone pitching. Due to the location of the site, vegetation growth is hard to prevent. The purpose of the stone pitching is to prevent erosion and movement of the foreshore. It is likely that the vegetation is increasing the stability of the embankment. However, as this section of wall is supported on sheet piles and bearing piles, it is likely to be less reliant on the foreshore embankment for stability then Section 1.

The concrete wall was observed to be in good condition (photo 35), again there was some evidence of blow holes, although these had a maximum diameter of 10mm so are not structurally significant. The expansion joints in the wall also appeared to be in good condition with only some minor cracking (photo 37).

The concrete footpath appeared to be in a good condition (photo 36), there was no obvious evidence of settlement and the expansion joints between the blocks appeared to be in good condition too.

In the Royal Hanskoning survey, it was recommended that the stone pitching and the concrete screed were to be repaired. It is unlikely that this remedial work was carried out as cracks in the stone pitching and concrete screed are still visible.

4.2.2 Condition Grade

Based on EA guidance the following condition grades are proposed for each asset type:

- Vertical concrete wall in fluvial environment: Grade 2 (Good)
- Sheet piles in fluvial environment: Unable to be inspected (Below Ground)
- Rigid embankment in fluvial environment: Grade 3 (Fair)

The overall suggested EA grading: Grade 3 (Fair)

4.2.3 Residual Life

Based on EA guidance and the following deterioration curve for best estimate, the time for the asset to deteriorate from its current condition grade to Condition grade 5 are:

- Vertical concrete wall in fluvial environment: 65 – 130 years (100 years best estimate)
- Sheet piles in fluvial environment: Unable to be inspected
- Rigid embankment in fluvial environment: 10 – 50 years (34 years best estimate)
- Section 2 composite structure: – 10-50 years (34 years best estimate)

Asset	Best estimate					Fastest estimate					Slowest Estimate				
	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5
Concrete wall	0	20	50	100	120	0	10	30	60	75	0	20	60	120	150
Sheet piles	0	20	80	120	140	0	10	30	60	75	0	20	100	140	160
Rigid embankment	0	3	6	25	40	0	4	10	14	20	0	5	10	40	60

Table 4. Section 2 Individual asset deterioration curves

Asset	Best estimate					Fastest estimate					Slowest Estimate				
	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5
Composite structure	0	3	6	25	40	0	4	10	14	20	0	5	10	40	60

Table 5. Section 2 Composite structure deterioration curves

The limiting asset for the composite structure was the rigid, riverside embankment. Note that although the sheet piles were below ground and not able to be inspected, due to low expected corrosion, it is likely to be grade 2 (Good) and therefore not a critical element.

4.2.4 Remedial works / maintenance recommendations

Remedial Works

As noted above, there were areas of Section 2 of the flood defence structure which require remedial work to ensure the condition grade does not deteriorate. To best prolong the life of the wall to the required 70-100 years design life, the following recommended remedial work should be carried out within two years.

As mentioned in section 5.2.3, the condition of the rigid foreshore embankment is key to the future life of the structure. In order to prevent the further deterioration of the foreshore embankment, it is recommended that the cracks and missing stones in non-vegetated or minimally vegetated areas of the stone pitching and screeding are repaired.

Maintenance Works

It is recommended that the flood defence structure is monitored regularly, if the remedial work recommendations are undertaken, then a visual inspection by a charted civil engineer every 2-5 years should be sufficient to ensure the upkeep of the structure.

The inspections will be able to identify if the vegetation on the foreshore is causing deterioration as opposed to aiding stability.

The vegetation on the riverward embankment should maintained to a level where it will allow for easy access to the structure for monitoring purposes.

The expansion joints in the concrete wall should be monitored closely as vegetation growth could begin to develop quickly within the minor cracks that have developed.

4.3 Section 3 – Reinforced concrete apron on CFA piles

Section 3 of the flood defence structure is constructed from a reinforced concrete apron foreshore, supported by CFA piles. At the toe of the concrete apron, there is a further section of concrete, placed on top of a stone revetment. At the top of the apron a concrete wall is located, providing the flood defence. The wall is supported by a sheet piling. In the middle of Section 3, a concrete platform is located that projects out over the concrete apron. Due to the composition of this section of the structure, the foreshore is integral to the structural rigidity of the structure as a whole and therefore it is important that the foreshore is maintained in good condition. Section 3 differs from Sections 1 and 2 as the foreshore embankment is constructed of reinforced concrete as opposed to stone pitching.

4.3.1 Interpretation of Structural Observations

The concrete apron was in a fair condition (photo 39). There was some superficial cracking across the surface of the concrete apron although this is unlikely to affect the performance of the structure.

Although the concrete apron was approximately 50mm higher than the lower foreshore concrete, it is supported rigidly on CFA piles, so movement is unlikely. Due to the composition of the structure, it is likely that the lower concrete section, not supported on piles has settled slightly (photo 40). This is unlikely to affect the stability of the structure due to the rigid support provided by the CFA piles.

The Old Borax Jetty structure showed signs of minor concrete spalling (photo 43), if left to continue this will likely accelerate, leading to structural degradation.

To the east side of the Old Borax Jetty there were signs missing stones and some erosion to the concrete below the apron, specifically in blocks 27 and 28 (photo 45). If this continues, the concrete apron may be more exposed to the elements. As the apron is supported on CFA piles, slope instability due to loss of material at the toe is not likely to occur.

There appeared to be a sheet pile that was protruding from the toe of the embankment (photo 46). From the record drawings this appears to be pre 1984 so it is unlikely to be an issue.

The concrete wall appeared to be in good condition, similar to the walls in Section 1 and 2, there was evidence of blow holes along the length of the wall (photo 46). The expansion joints in Section 3 of the concrete wall were in the worse condition compared

to the rest of the wall. Specifically the joint between blocks 29 and 30 is in poor condition (photo 48).

The edges of the tarmac footpath were in poor condition. At the edges of tarmac footpath, the footpath had settled by around 100mm (photo 53). There was also bulging around the bottom of the wall (photo 54) and large gaps had formed along the bottom of the wall and the footpath (photo 55 and 56). It is possible that these gaps could have been exasperated due to the consistent warm temperatures experienced around the time of the inspection.

The evidence of previous sealant at approximately 100mm above the current tarmac level indicates that the previous concrete slab had a finished surface level 100mm above that of the current tarmac level. The sealant line runs at the same level as the concrete footpath on neighbouring sections of the flood defence structure. Therefore, it is likely that the original concrete slab has been removed and replaced with tarmac surfacing. Due to the uniform settlement along the path, it is likely that the tarmac has been poured onto a new concrete slab which was built on uncompacted material. The landward embankment in the vicinity of the footpath showed no signs of settlement movement which leads to the assumption that the settlement is due to the reconstruction of the footpath.

In the Royal Hanskoning survey, it was recommended that the undermining to the toe of Section 3 was to be repaired. It is unlikely that this remedial work was carried out as the void caused by the undermining is still present and the protruding sheet pile identified in the report is also still present.

4.3.2 Condition Grade

Based on EA guidance the following condition grades are proposed for each asset type:

- Vertical concrete wall in fluvial environment: Grade 3 (Fair)
- Sheet piles in fluvial environment: Unable to be inspected (Below Ground)
- Rigid embankment in fluvial environment: Grade 3 (Fair)

The overall suggested EA grading: Grade 3 (Fair)

4.3.3 Residual Life

Based on EA guidance and the following deterioration curve for best estimate, the time for the asset to deteriorate from its current condition grade to Condition grade 5 are:

- Vertical concrete wall in fluvial environment: 45 – 90 years (70 years best estimate)
- Sheet piles in fluvial environment: Unable to be inspected
- Rigid embankment in fluvial environment: 10 – 50 years (34 years best estimate)
- Section 3 composite structure: 10 – 50 years (34 years best estimate)

Asset	Best estimate					Fastest estimate					Slowest Estimate				
	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5
Concrete wall	0	20	50	100	120	0	10	30	60	75	0	20	60	120	150

Asset	Best estimate					Fastest estimate					Slowest Estimate				
	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5
Sheet piles	0	20	80	120	140	0	10	30	60	75	0	20	100	140	160
Rigid embankment	0	3	6	25	40	0	4	10	14	20	0	5	10	40	60

Table 6. Section 3 Individual asset deterioration curves

Asset	Best estimate					Fastest estimate					Slowest Estimate				
	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5
Composite structure	0	3	6	25	40	0	4	10	14	20	0	5	10	40	60

Table 7. Section 3 Composite structure deterioration curves

The limiting assets for the composite structure were the concrete wall and the rigid embankment. Note that although the sheet piles were below ground and not able to be inspected, due to low expected corrosion, it is likely to be grade 2 (Good) and therefore not a critical element.

4.3.4 Remedial works / maintenance recommendations

Remedial Works

As noted above, there were areas of Section 3 of the flood defence structure which require remedial work to ensure the condition grade does not deteriorate. To best prolong the life of the wall to the required 70-100 years design life, the following recommended remedial work should be carried out within the time frames stated.

It is recommended that the minor concrete spalling, found on the Old Borax Jetty Structure, is repaired within two years.

The expansion joints in the concrete wall should be repaired where the cracking has become substantial. This should be completed within two years.

To prevent water ingress behind and under the wall through the gap between the footpath and the wall, it is recommended that the gap is filled with a suitable concrete grout. From a safety point of view, the level of the tarmac footpath should be raised to remove trip hazards at each end of the footpath. For cost savings it is suggested that the step between the adjacent footpath sections is removed by sloping the footpath down to meet the tarmac footpath section level using a suitable gradient. Due to the safety implications, this should be carried out within the next 6 months.

Maintenance Works

It is recommended that the flood defence structure is monitored regularly, if the remedial work recommendations are undertaken, then a visual inspection by a charted civil engineer every 2-5 years should be sufficient to ensure the upkeep of the structure.

If the level of the tarmac footpath is raised to reduce the trip hazards, then this will need to be monitored to ensure further settlement does not occur.

It is suggested that the voids in the lower concrete foreshore in blocks 27 and 28 are monitored. If the voids continue to grow it is recommended that they are filled in. This

should help to prevent or at least significantly reduce the risk undermining of the structure.

4.4 Landward Embankment

4.4.1 Interpretation of Structural Observations

The landward embankment within the site boundary appears to be in good condition.

The landward embankment outside of the site boundary also appears to be in good condition.

The high levels of vegetation appear not to be a problem due to the embankment being covered in turf. The vegetation is likely to be increasing the stability of the structure.

Due to the consistently hot weather the ground on the embankment was especially dry, this could result in cracks forming in the surface.

The landward embankment inside of the site boundary appears to have been shaped by the service road found at the toe of the embankment. Therefore, it is likely that this part of the embankment was reconstructed during the construction of the RRRF to accommodate this service road.

The redundant lighting structures along with the staircase found on the embankment outside of the RRRF site boundary suggest that there was a historic footpath on this section of the embankment.

4.4.2 Condition Grade

Based on EA guidance the following condition grades are proposed for each asset type:

- Turf embankment in fluvial environment: Grade 2 (Good)

4.4.3 Residual Life

Based on EA guidance and the following deterioration curve for best estimate, the time for the asset to deteriorate from its current condition grade to Condition grade 5 are:

- Turf embankment in fluvial environment: 12 – 55 years (37 years best estimate)

Asset	Best estimate					Fastest estimate					Slowest Estimate				
	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5
Turf embankment	0	3	6	25	40	0	2	6	10	14	0	5	10	40	60

Table 8. Landward embankment deterioration curves

4.4.4 Remedial works / maintenance recommendations

Remedial Works

No remedial works are necessary.

Maintenance Works

It is recommended that the landward embankment is monitored regularly, a visual inspection by a charted civil engineer every 2-5 years should be sufficient to ensure the upkeep of the structure.

The vegetation on the embankment should maintained to a level where it will allow for easy access to the structure for monitoring purposes.

It should also be noted that tie rods and anchor piles are located in the landward embankment behind Section 1 of the wall. It is important that the land behind the rear anchor walls is not overloaded during the construction of the REP as the increased active pressure on the anchor piles could compromise the stability of the wall.

5. CONCLUSION AND RECOMMENDATIONS

The visual inspections of the flood defence structure were undertaken on 2nd August 2018 and 12th October 2018 and have identified a number of defects of varying severity.

The specific defects for each of the elements of the structure were identified and described in Section 4 of this report. Where required, recommendations have been made as to what is considered the most appropriate action to ensure that the short and long term safety and integrity of the structure is maintained. These recommendations were described in full in Section 5. All of the elements of the wall which were accessible to be inspected have been scored using the EA guidance on determining asset deterioration to provide a grade for the condition of the structure.

5.1 Recommendations and outline work schedule

The recommendations outlined in section 5 are outlined in order of importance below.

- Repair the tarmac footpath in Section 3 (within 6 months).
- Repair any expansion joints that are in poor conditions (within 2 years).
- Repair cracks and missing stones in the stone pitching (within 2 years).
- Monitor the structure at regular intervals including:
    - The void in the lower concrete foreshore at the toe of the riverward embankment at blocks 27 and 28.
    - Repairs to the tarmac footpath in Section 3.
    - The expansion joints throughout the structure.
- Maintain vegetation to a level to allow easy monitoring and maintenance of the structures.

5.2 Residual Life

If no remedial work is carried out and the current maintenance levels are maintained, the residual life, as calculated from the EA guidance of each section of the structure, is estimated as follows:

- Section 1- Tied Sheet Pile Wall: 10 – 50 years (34 years best estimate)
- Section 2- Structural wall: 10 – 50 years (34 years best estimate)
- Section 3- Reinforced Concrete Apron on CFA Piles: 10 – 50 years (34 years best estimate)
- Turf embankment in fluvial environment: 12 – 55 years (37 years best estimate)

5.3 Sea Level rise

As mentioned in Section 3.1, there has been no accounting for the rise of sea levels in the extreme water level. In the TE2100 there are some climate change levels that do take into account sea level rise. For the year 2120, past the design life of the structure, the extreme water level is +6.90mOD. The top level of the concrete wall is +7.10mOD. Therefore, if the recommended works and maintenance are undertaken, the river

defences should still be adequate. This is, however, just an estimate of the sea level rise and work may be required to increase the height of the defences if this is an underestimation.

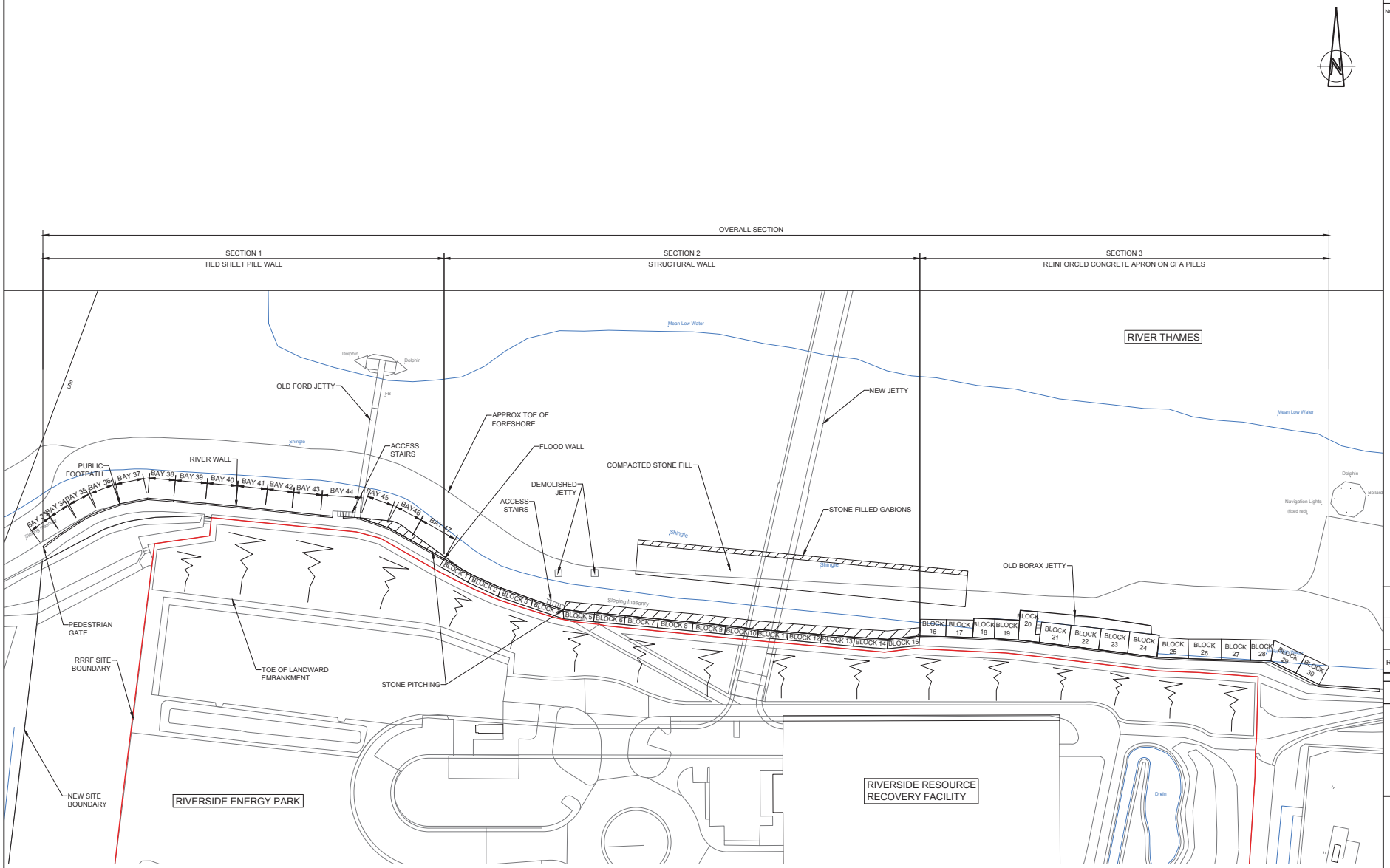
5.4 Conclusions

The main points to arise from this survey are:

- The riverward embankment in Section 1 and 2 was in fair condition with some remedial work suggested. The remedial work includes repairing cracks and missing stonework.
- The riverward embankment in Section 3 was in fair condition with monitoring of the void in the lower concrete foreshore at the toe of the riverward embankment at blocks 27 and 28 being recommended.
- The concrete wall was in fair condition in Section 1. Its condition has been worsened due to the vegetation growth in the expansion joints.
- The concrete wall was in good condition in Section 2.
- The concrete wall was in fair condition in Section 3 with recommended work to be done to improve the condition of the expansion joints.
- The landward embankment was in good condition.
- The joints between adjacent sections and the concrete wall to the tarmac footpath in Section 3 were in poor condition, it has been recommended that this is repaired.
- It has been suggested that the structure is monitored at regular intervals and that vegetation levels are kept such that monitoring and maintenance can easily be carried out.

Appendix A

Inspection Drawings



DO NOT SCALE FROM THIS DRAWING

NOTES:

1. ALL DIMENSIONS ARE IN MILLIMETRES UNLESS NOTED OTHERWISE
2. ALL LEVELS ARE IN METRES AOD UNLESS NOTED OTHERWISE.

REV.	BY	CHKD	APPD	DATE	DESCRIPTION
P2	JHB	MJB	OAA	16/10/18	UPDATED FOR NEW BOUNDARY
P1	JHB	MJB	OAA	10/08/18	FIRST ISSUE

CODE	DRAWING STATUS
S2	FOR INFORMATION

Tony Gee and Partners LLP
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Tel: 01233 639787

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Consulting Civil, Structural and Geotechnical Engineers

ON BEHALF OF

HITACHI ZOSEN INOVA

RIVERSIDE ENERGY PARK FLOOD DEFENSE CONDITION SURVEY

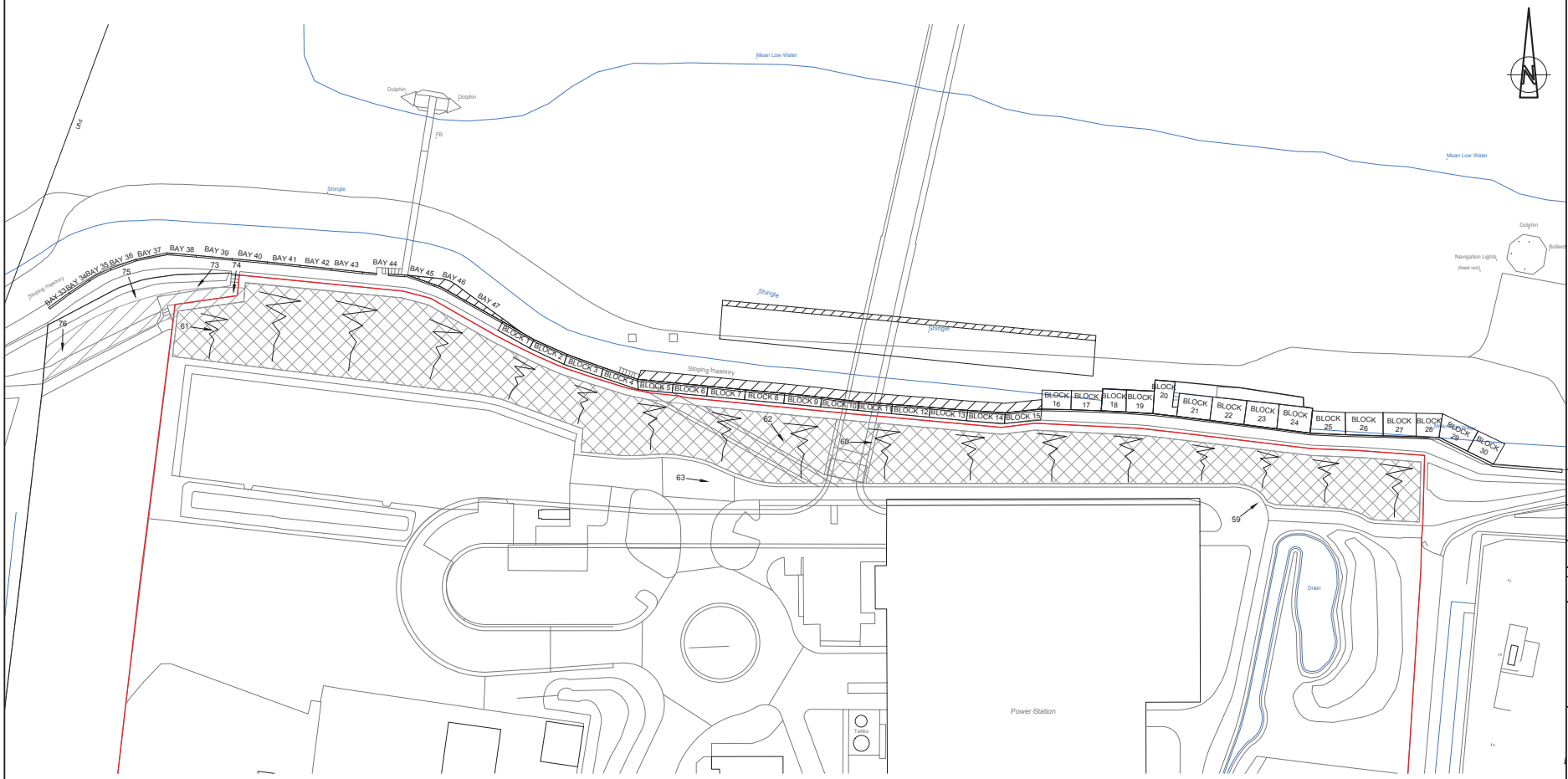
GENERAL ARRANGEMENT

DRAWING. No.
A118035-TG-XX-00-DR-C-0100

DRAWN : JHB	DESIGNED : NA	REVISION P2
SCALE : 1:650	ORIGINAL SIZE : A1	

PHOTO KEY:

59- EASTERN LANDWARD EMBANKMENT
60- MIDDLE SECTION OF LANDWARD EMBANKMENT
61- WESTERN LANDWARD EMBANKMENT
62- BUSHES ON LANDWARD EMBANKMENT
63- SERVICE ROAD AT BOTTOM OF LANDWARD EMBANKMENT
73- OVERGROWN EMBANKMENT
74- OLD METAL STAIRCASE
75- LIGHTING BOLLARD
76- FENCE AND LINE OF BOLLARDS



LANDSIDE EMBANKMENT

AREA KEY:

OUTSIDE RRRF SITE BOUNDARY

INSIDE RRRF SITE BOUNDARY

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NOTES:

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REV.	BY	CHK'D	APP'D	DATE	DESCRIPTION
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RIVERSIDE ENERGY PARK FLOOD DEFENSE CONDITION SURVEY

LANDSIDE EMBANKMENT

DRAWING. No.
A118035-TG-XX-00-DR-C-0110

DRAWN : JHB	DESIGNED : NA	REVISION
SCALE : 1:650	ORIGINAL SIZE : A1	P2

SECTION 1 - TIED SHEET PILE WALL

PHOTO KEY:

1- VEGETATION GROWTH ON FORESHORE
2- GOOD CONDITION STONE PITCHING
3- MINOR, SUPERFICIAL CRACKING
4- VEGETATION GROWTH FROM CRACKS
5- SMALL STONEWORK
6- MISSING SMALL STONES
7- EXPOSED SHEET PILES
8- DISLODGED STONES BY OLD FORD FERRY
9- CONCRETE BLOCK
10- POOR CONDITION STONE PITCHING REPAIRS
11- LARGE CRACK
12- LARGE CRACK
13- MISSING STONES
14- MISSING STONES
15- BAY 47/BLOCK 1 INTERSECTION
16- CONCRETE WALL EXPANSION JOINT
17- VEGETATION GROWTH FROM BOTTOM OF WALL
18- OLD FORD JETTY ACCESS STAIRS
19- GRAVEL/TARMAC INTERSECTION
20- SHALLOW CRACKS IN TARMAC FOOTPATH
64- TREES GROWING IN TOP 2m OF FORESHORE WALL
65-DISLODGED SMALL STONEWORK
66- CONCRETE COVER
67- LOOSE PIECE OF CONCRETE COVER
68- MORTAR LOOSE BETWEEN STONE PITCHING
69- VEGETATION GROWTH IN MORTAR GAPS
70- VEGATATION GROWING FROM EXPANSION JOINT
71- PEDESTRIAN GATE
72- VEGETATION BREAKOUT IN FOOTPATH

DO NOT SCALE FROM THIS DRAWING

NOTES:

1. ALL DIMENSIONS ARE IN MILLIMETRES UNLESS NOTED OTHERWISE
2. ALL LEVELS ARE IN METRES AOD UNLESS NOTED OTHERWISE.
3. BAY DIMENSIONS SHOWN FROM RECORD DRAWINGS ARE APPROXIMATE

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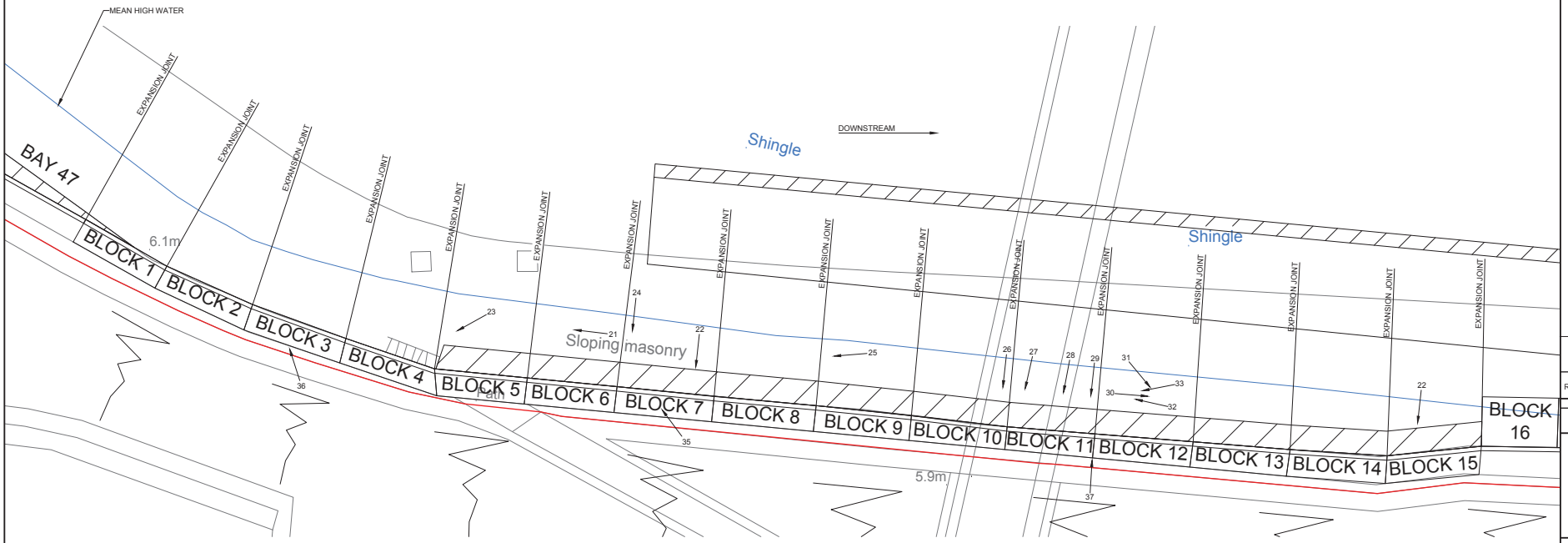
RIVERSIDE ENERGY PARK FLOOD DEFENSE CONDITION SURVEY

SECTION 1 DETAILED PLAN

DRAWING. No.
A118035-TG-XX-00-DR-C-0111

DRAWN : JHB	DESIGNED : NA	REVISION
SCALE : 1:200	ORIGINAL SIZE : A1	P2



SECTION 2 - STRUCTURAL WALL

PHOTO KEY:

21- VEGETATION GROWTH ON FORESHORE
22- LARGE CONCRETE BLOCKWORK
23- LOOSE STONES BY DEMOLISHED JETTY
24- MISSING STONES
25- AREA OF LOW VEGETATION
26- CONCRETE BLOCK
27- CONCRETE BLOCK
28- LARGE CRACK BY CONCRETE BLOCK
29- CORRODED MOORING RING
30- CONCRETE SCREED
31- CONCRETE SCREED
32- CRACK IN CONCRETE SCREED
33- CRACK IN CONCRETE SCREED
34- GAP IN CONCRETE SCREED
35- CONCRETE WALL
36- CONCRETE FOOTPATH
37- CONCRETE WALL EXPANSION JOINT

DO NOT SCALE FROM THIS DRAWING

NOTES:

1. ALL DIMENSIONS ARE IN MILLIMETRES UNLESS NOTED OTHERWISE
2. ALL LEVELS ARE IN METRES AOD UNLESS NOTED OTHERWISE.
3. BLOCK 1-14 DIMENSIONS FROM RECORD DRAWINGS ARE 10.626m AND BLOCK 15 IS 10.63m

REV.	BY	CHK'D	APP'D	DATE	DESCRIPTION
P1	JHB	MJB	OAA	10/08/18	FIRST ISSUE

CODE	DRAWING STATUS
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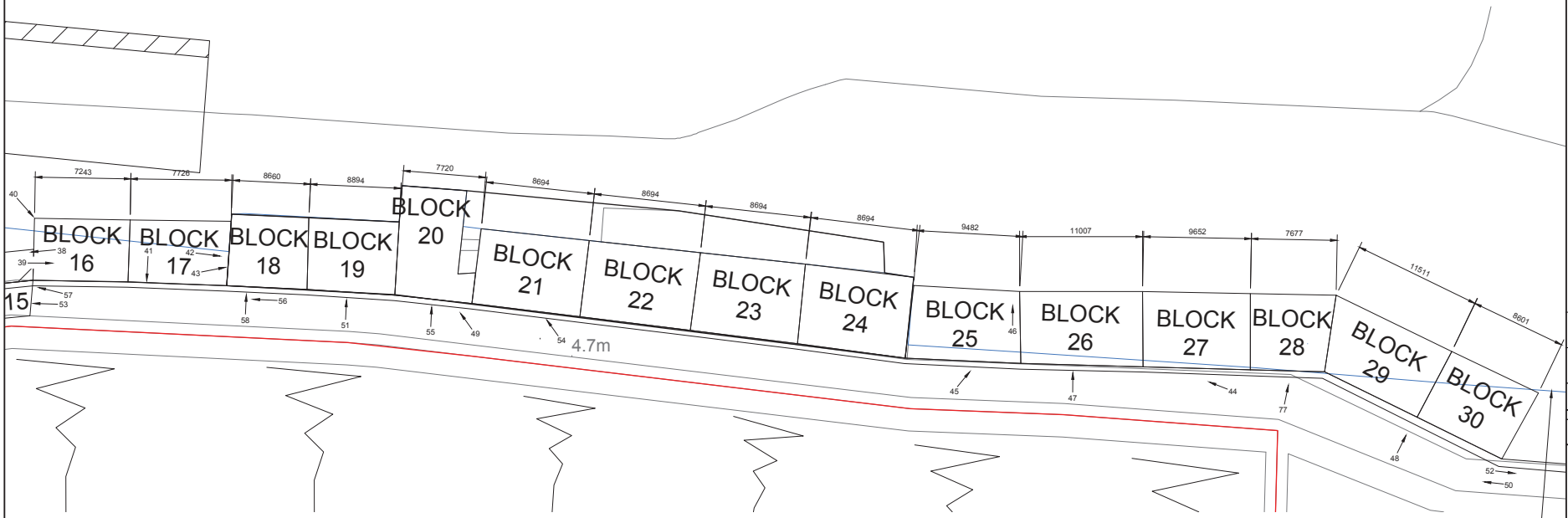
RIVERSIDE ENERGY PARK FLOOD DEFENSE CONDITION SURVEY

SECTION 2 DETAILED PLAN

DRAWING. No.
A118035-TG-XX-00-DR-C-0112

DRAWN : JHB	DESIGNED : NA	REVISION
SCALE : 1:250	ORIGINAL SIZE : A1	P2



SECTION 3 - REINFORCED CONCRETE APRON ON CFA PILES

PHOTO KEY:

- 38- CURVE ONTO CONCRETE APRON
- 39- WESTERN CONCRETE APRON
- 40- HEIGHT CHANGE IN CONCRETE APRON
- 41- WESTERN STAINLESS STEEL MOORING BOLLARD
- 42- WESTERN SIDE ON CONCRETE PLATFORM
- 43- CONCRETE SPALLING
- 44- EASTERN SIDE ON CONCRETE APRON
- 45- GAPS IN LOWER CONCRETE FORESHORE
- 46- OLD SHEET PILE
- 47- BLOW HOLE ON CONCRETE WALL
- 48 BLOCK 29 AND 30 EXPANSION JOINT
- 49- NEW BRICK WALL
- 50- TARMAC FOOTPATH
- 51- PREVIOUS SEALANT LEVEL
- 52- EASTERN FOOTPATH SETTLEMENT
- 53- WESTERN FOOTPATH SETTLEMENT
- 54- TARMAC BULGING
- 55- FOOTPATH GAP AT NEW BRICK WALL
- 56- GAP BETWEEN BOTTOM OF WALL AND
- 57- GAP BETWEEN BOTTOM OF WALL AND FOOTPATH
- 58- DEPTH OF GAP
- 77- BLOCK 28 AND 29 EXPANSION JOINT

DO NOT SCALE FROM THIS DRAWING

NOTES:

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2. ALL LEVELS ARE IN METRES AOD UNLESS NOTED OTHERWISE.
3. ALL BAY DIMENSIONS SHOWN FROM RECORD DRAWINGS ARE APPROXIMATE.

REV.	BY	CHK'D	APP'D	DATE	DESCRIPTION
P2	JHB	MJB	OAA	16/10/18	UPDATED FOR NEW BOUNDARY
P1	JHB	MJB	OAA	10/08/18	FIRST ISSUE

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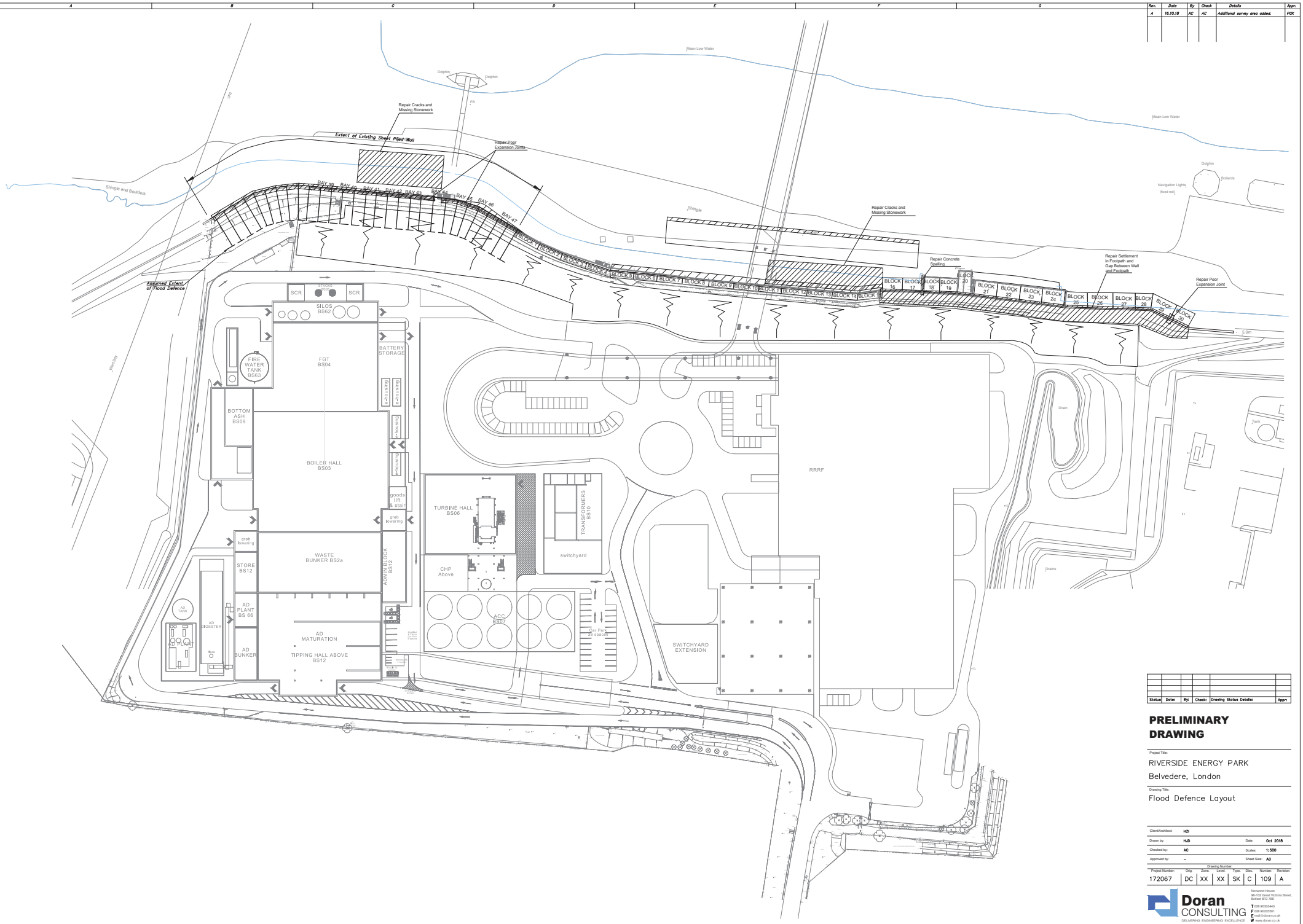
RIVERSIDE ENERGY PARK FLOOD DEFENSE CONDITION SURVEY

SECTION 3 DETAILED PLAN

DRAWING. No.
A118035-TG-XX-00-DR-C-0113

DRAWN : JHB	DESIGNED : NA	REVISION
SCALE : 1:200	ORIGINAL SIZE : A1	P2



Rev.	Date	By	Check	Details	Appr.
A	16.10.18	AC	AC	Additional survey area added.	PGK

Status	Date:	By:	Check:	Drawing Status Details:	Appr:

PRELIMINARY DRAWING

Project Title:

RIVERSIDE ENERGY PARK

Belvedere, London

Drawing Title:

Flood Defence Layout

Client/Architect:	HZI		
Drawn by:	HJD	Date:	Oct 2018
Checked by:	AC	Scales:	1:500
Approved by:	--	Sheet Size:	A0

Drawing Number:

Project Number:	Orig.	Zone	Level	Type	Disc.	Number	Revision:
172067	DC	XX	XX	SK	C	109	A

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W www.doran.co.uk

Appendix B

Additional Photographs

Photo 1

Photo 2

Photo 3

Photo 4

Photo 5

Photo 6

Photo 7

Photo 8

Photo 9

Photo 10

Photo 11

Photo 12

Photo 13

Photo 14

Photo 15

Photo 16

Photo 17

Photo 18

Photo 19

Photo 20

Photo 21

Photo 22

Photo 23

Photo 24

Photo 25

Photo 26

Photo 27

Photo 28

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Photo 54

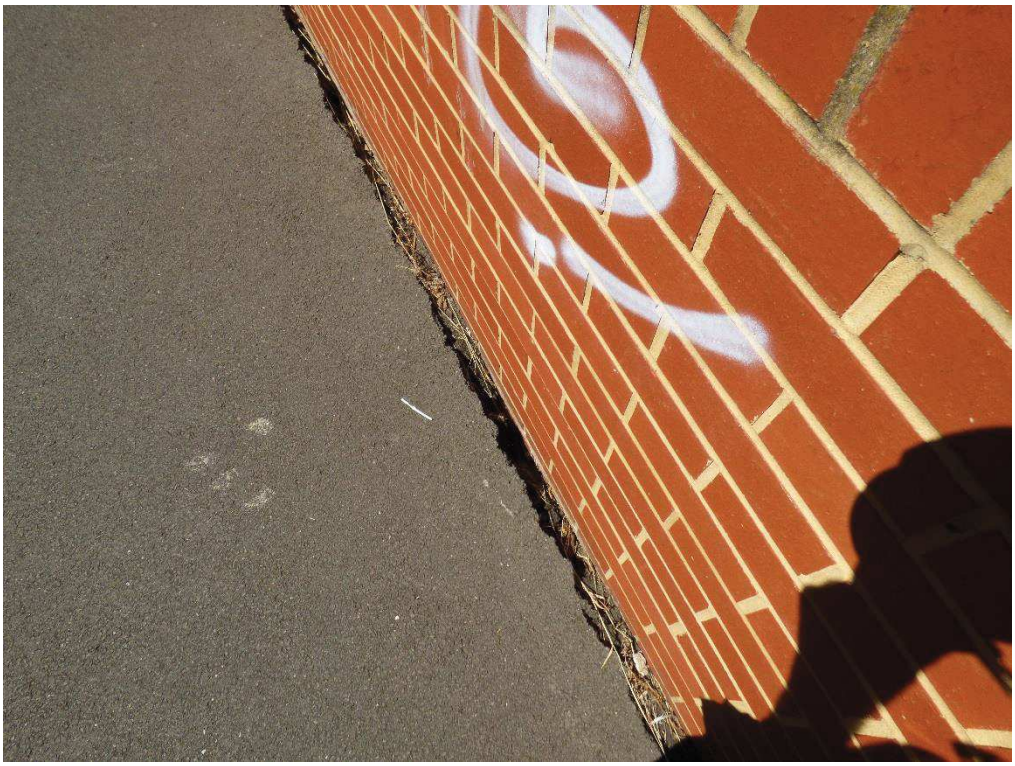

Photo 55

Photo 56

Photo 57

Photo 58

Photo 59

Photo 60

Photo 61

Photo 62

Photo 63

Photo 64

Photo 65

Photo 66

Photo 67

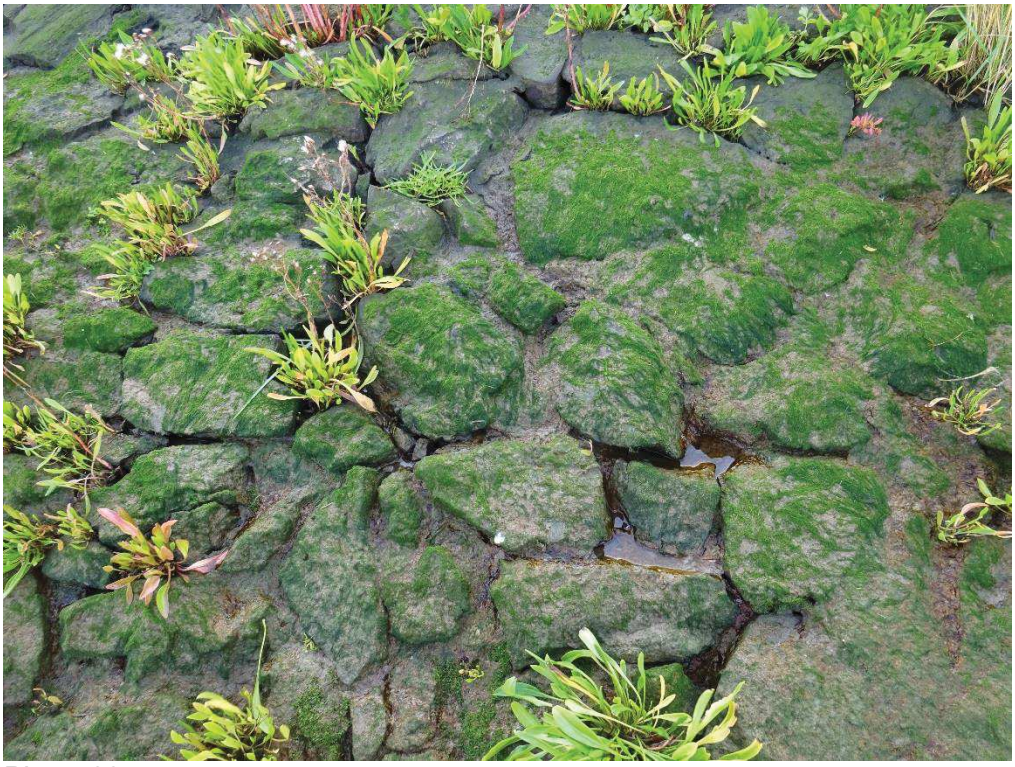

Photo 68

Photo 69

Photo 70

Photo 71

Photo 72

Photo 73

Photo 74

Photo 75

Photo 76

Photo 77

Appendix C

Record Drawings

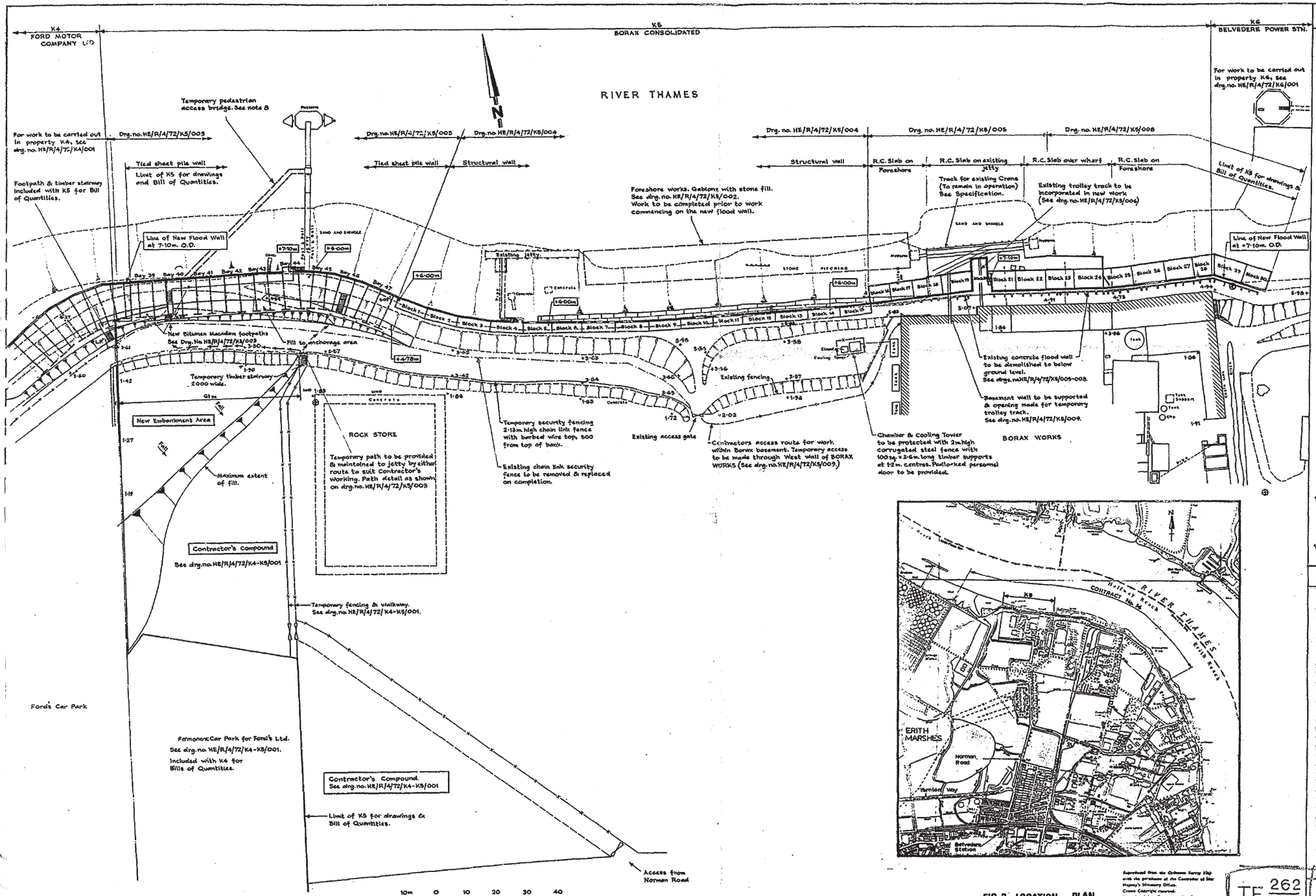

FIG 1. SITE PLAN
Scale: 1:500

FIG. 2 LOCATION PLAN
Scale 1:10560

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HE/R/4/72/K5/001 A

NOTES

1. All levels to Ordnance Datum N
2. Levels of new work shown thus
   In section
   On plan
3. Existing levels shown thus :
   In section
   On plan
4. Interim flood defence level of f to be maintained at all times.
5. SPECIAL CAUTION
   The material that the frontag handling on the jetty & in the has an extremly deleterious on wet concrete. Special care taken to prevent contaminatio
6. See Specification Appendix C loading restrictions on the embankment.
7. Where the waterfront piling subject to permanent exposur on completion of the works, t faces are to be painted befo driving with an approved bla ter epoxy from 1m. below G.L. the concrete level.
8. The Contractor shall design, pr maintain & remove on completic temporary pedestrian bridge f embankment to the main appro structure to the existing jetty approach to provide continuou for the use of Ford Motor Comp
   The bridge shall be positioned Contractors piling operations pl so that Ford's personnel do no to pass nearer than 16m. from pi operations. For the duration of of the temporary bridge the exi jetty approach shall be closed pedestrian traffic.
   The access bridge shall have a clear width of 1500mm. between handrails & shall be designed carry pedestrian loading in ac with B.S. CP3 chapter V & shall be at least as sturdy as the exi jetty approach. A security gate barbed wire surround similar t existing shall be provided.
   The Contractor's design for the bridge & supports shall be sub to the Engineer for approval at four weeks before required.
9. Fill to the new embankment is t consist of a total dry weight o tonnes of grade 'D' material. The Contractor shall provide a r record of fill as note 7 on drg. HE/R/4/72/K5/002.
10. Fill to the anchorage area is to c of grade 'D' material with 150mm of

REFERENCE DRAWING

This drawing to be read in conjun with :-

HE/R/4/72/K5/002
Bank Stabilisation Works.

HE/R/4/72/K5/003
Sections & Details Says 39-47

HE/R/4/72/K5/004
Sections & Details Blocks 1-15

HE/R/4/72/K5/005
Sections & Details Blocks 16-32

HE/R/4/72/K5/006
Details of Offloading Bay (Block 20

HE/R/4/72/K5/007
Permanent Bracing to Jetty at Offloading Bay (Block 20)

HE/R/4/72/K5/008
Sections & Details Blocks 23-30

HE/R/4/72/K3/003
Fill requirements Landward of Flood Defences.

HE/R/4/72/K4-K5/001
Temporary Car Park & Contractor's compound.

HE/R/4/72/K5/009
Basement Wall Shoring Details.

TF 262 1984

C. H. DOBBIE & PARTNE
CONSULTING ENGINEERS
Francis House, Francis Street, London, S

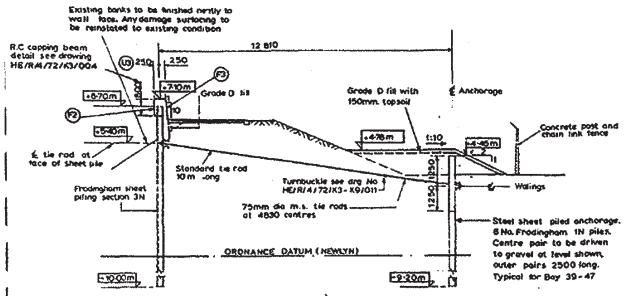

FIG.2 SECTION A-A TYPICAL (BAYS 39-43 & 45-47)
Scale:1:100

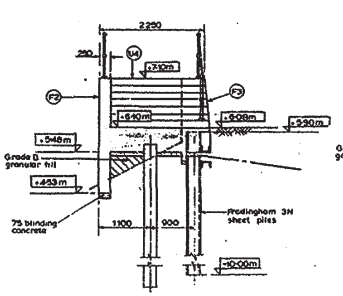

FIG.3 SECTION B-B
Scale:1:50

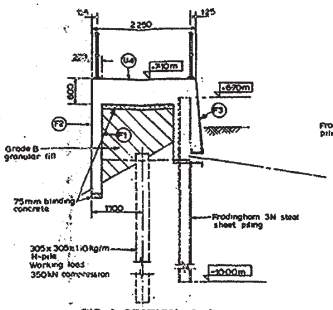

FIG.4 SECTION C-C
Scale:1:50

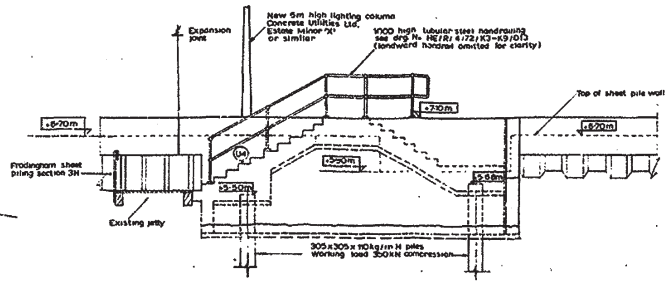

FIG.5 ELEVATION X-X
Scale:1:50

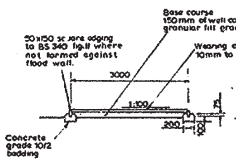

FIG.6 SECTION THROUGH NEW FOOTPATHS - TYPICAL DETAIL
Scale:1:50

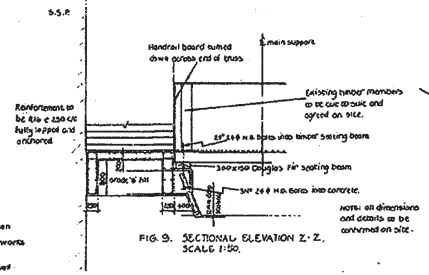

FIG.9. SECTIONAL ELEVATION Z-Z.
SCALE 1:50.

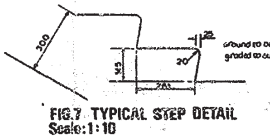

FIG.7 TYPICAL STEP DETAIL
Scale:1:10

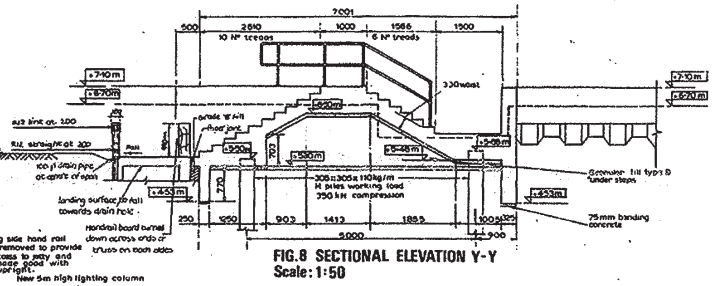

FIG.8 SECTIONAL ELEVATION Y-Y
Scale:1:50

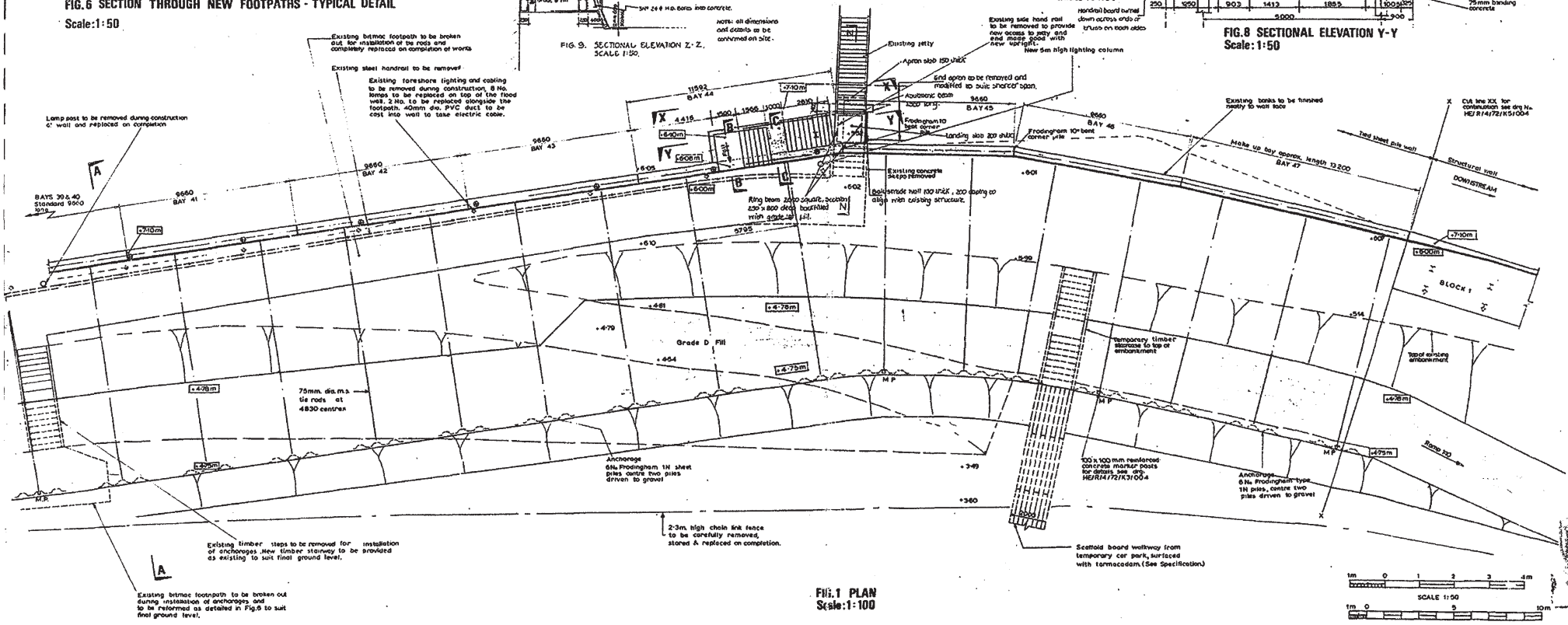

FIG.1 PLAN
Scale:1:100

HE/R/4/72/K5/003 A

NOTES

1. All levels to Ordnance Datum (Newlyn).
2. Levels of new works shown thus:-
   in section +4.50m
   on plan +4.50m
3. Existing levels shown thus:-
   in section +4.50m
   on plan +4.50m
4. Structural concrete to be grade 30/2
5. Blinding concrete to be grade 10/2
6. Reinforcement to be mild steel to
7. Surface finishes shown thus F3 for details of finishes see Specification.
8. Expansion joints to be located at riv pile clutches.
9. All exposed corners to have a 30x30 chamfer.
10. Cement to be Sulphate Resisting Po cement.
11. Steel sheet piling to be grade 50 steel. H piles to be grade 43A st. All tie rods to be 75 dia. mild steel g Anti-corrosion protection to tie rods Specification.
12. The minimum interim flood defence l +5·45m is to be maintained at all ti during construction.

REFERENCE DRAWING

This drg. to be read in conjunction wi
HE/R/4/72/K5/001 General Layout of Flood Defences
HE/R/4/72/K3-K9/010 Concrete Joint Details
HE/R/4/72/K3-K9/011 Tie Rod end Anchorage Details
HE/R/4/72/K5/004 Sections and Details Blocks 1-45
HE/R/4/72/K3/004 Sections and Details
HE/R/4/72/K3-K9/013 Handrail Details

TF 264 1984

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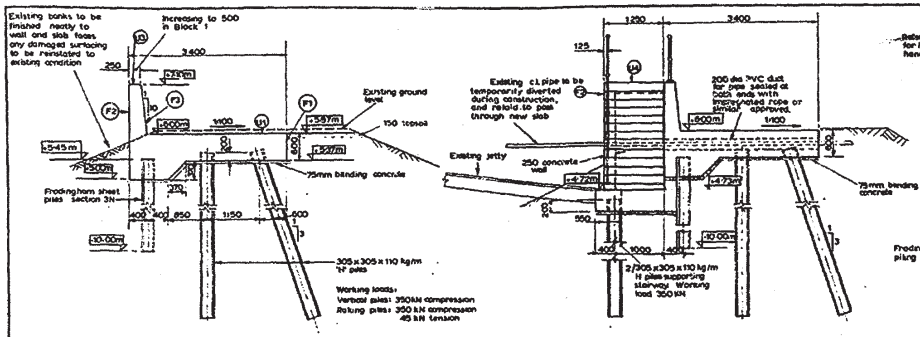

FIG.3 SECTION A-A-TYPICAL DETAIL
Scale: 1:50 (BLOCKS 1-3 & 5-15)

FIG.4 SECTION B-B
Scale: 1:50

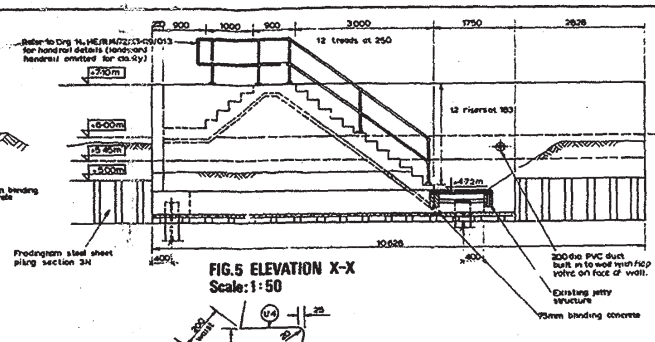

FIG.5 ELEVATION X-X
Scale: 1:50

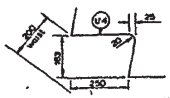

FIG.6 TYPICAL STEP DETAIL
Scale: 1:10

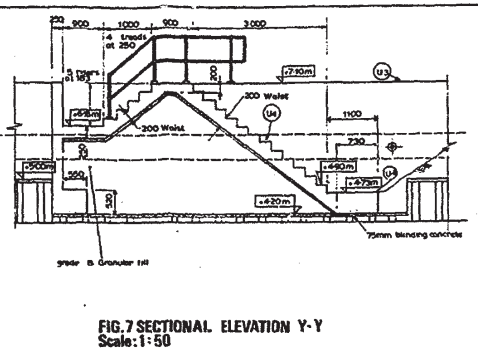

FIG.7 SECTIONAL ELEVATION Y-Y
Scale: 1:50

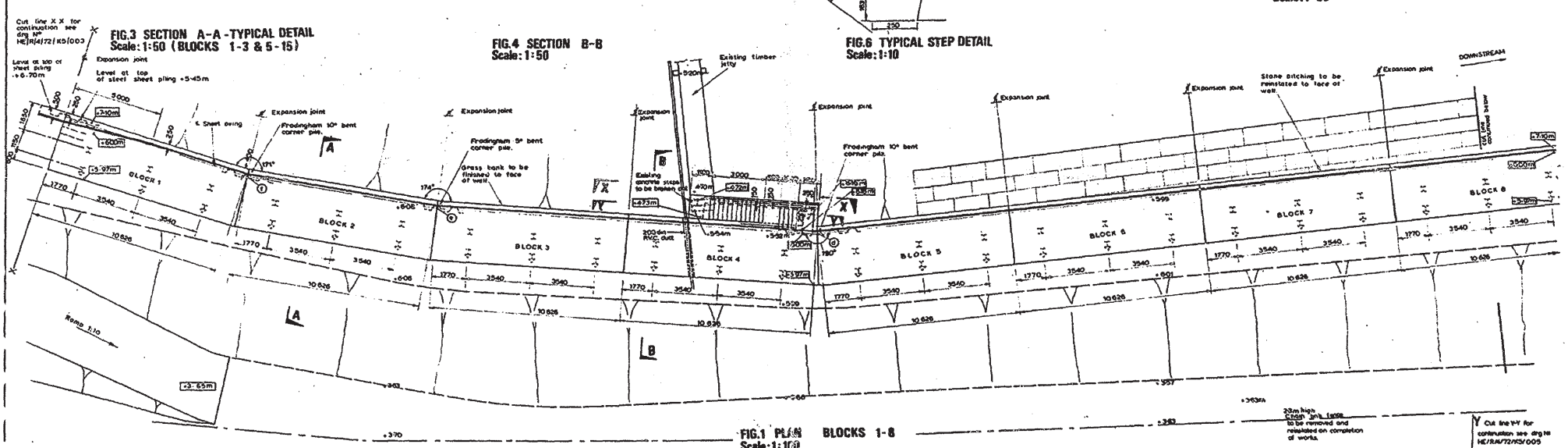

FIG.1 PLAN BLOCKS 1-8
Scale: 1:100

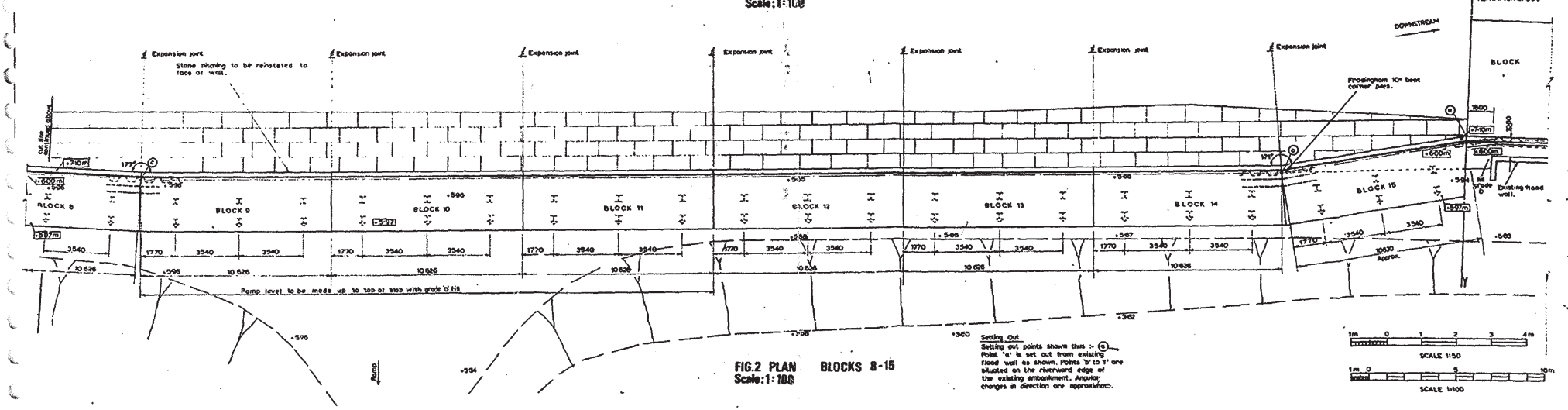

FIG.2 PLAN BLOCKS 8-15
Scale: 1:100

HE/R/4/72/K5/004 B.

NOTES

1. All levels to Ordnance Datum Newlyn
2. Levels of new works shown thus:
   in section +4.50m
   on plan +4.50m
3. Existing levels shown thus:
   in section +4.90m
   on plan +4.90m
4. Structural concrete to be grade 30/2
5. Blinding concrete to be grade 10/2
6. Reinforcement to be mild steel to
7. Surface finishes shown thus (F2)—for details of finishes see Specification
8. Expansion joints to be located at p
9. All exposed corners to have a 30x
10. Cement to be Sulphate Resisting Por Cement.
11. Steel sheet piling to be grade 50B st H-piles to be grade 43A. The steel sheet piling is to be driv levels shown.
12. The minimum interim flood defence +5.45m is to be maintained at all during construction.

REFERENCE DRAWINGS

This drg. to be read in conjunction wit

HE/R/4/72/K5/001
General layout of Flood Defences

HE/R/4/72/K3-K9/010
Concrete Joint Details

HE/R/4/72/K5/003
Sections and Details Bays 39-47

HE/R/4/72/K5/005
Sections and Details Blocks 16-20

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16-12-20

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Francis Street London SW1P 1DD.

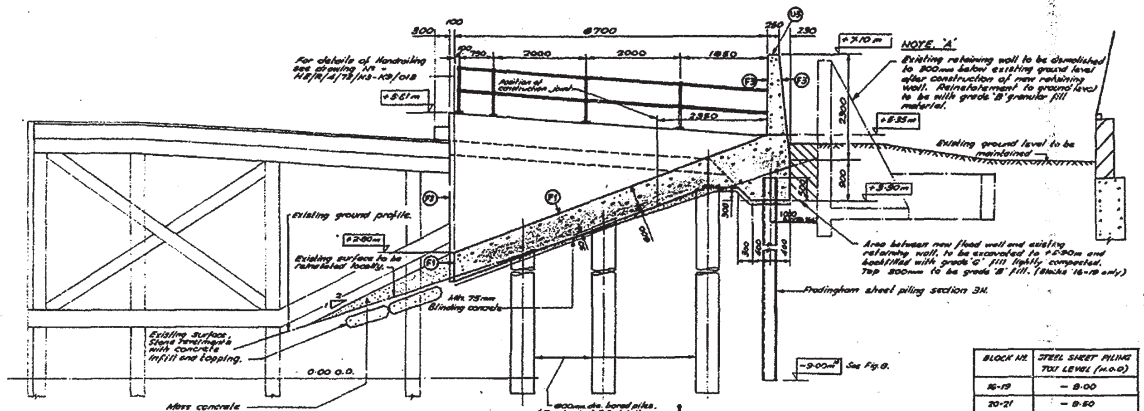

FIG.1 SECTION A-A
Scale: 1:50

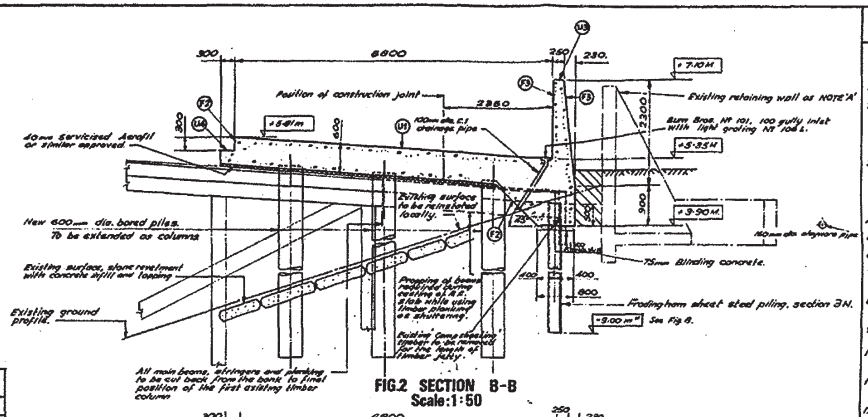

FIG.2 SECTION B-B
Scale: 1:50

BLOCK NR	STEEL SHEET PILING TOP LEVEL (m.o.d.)
16-19	- 8.00
20-21	- 8.50
22	- 10.00

FIG.8 STEEL SHEET PILING SCHEDULE

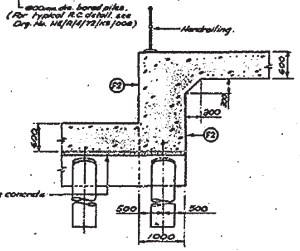

FIG.3 SECTION C-C
Scale: 1:50

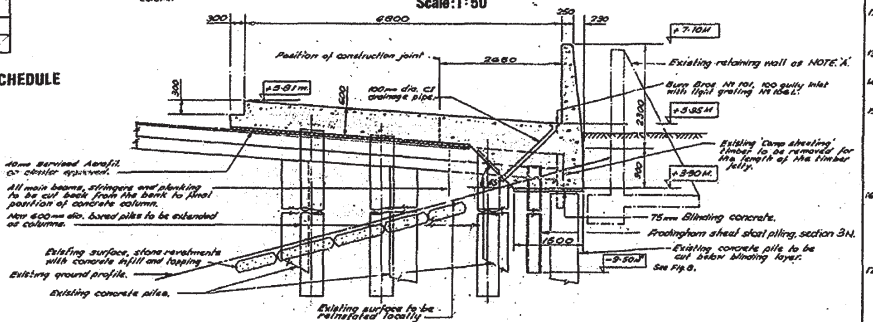

FIG.4 SECTION D-D
Scale: 1:50

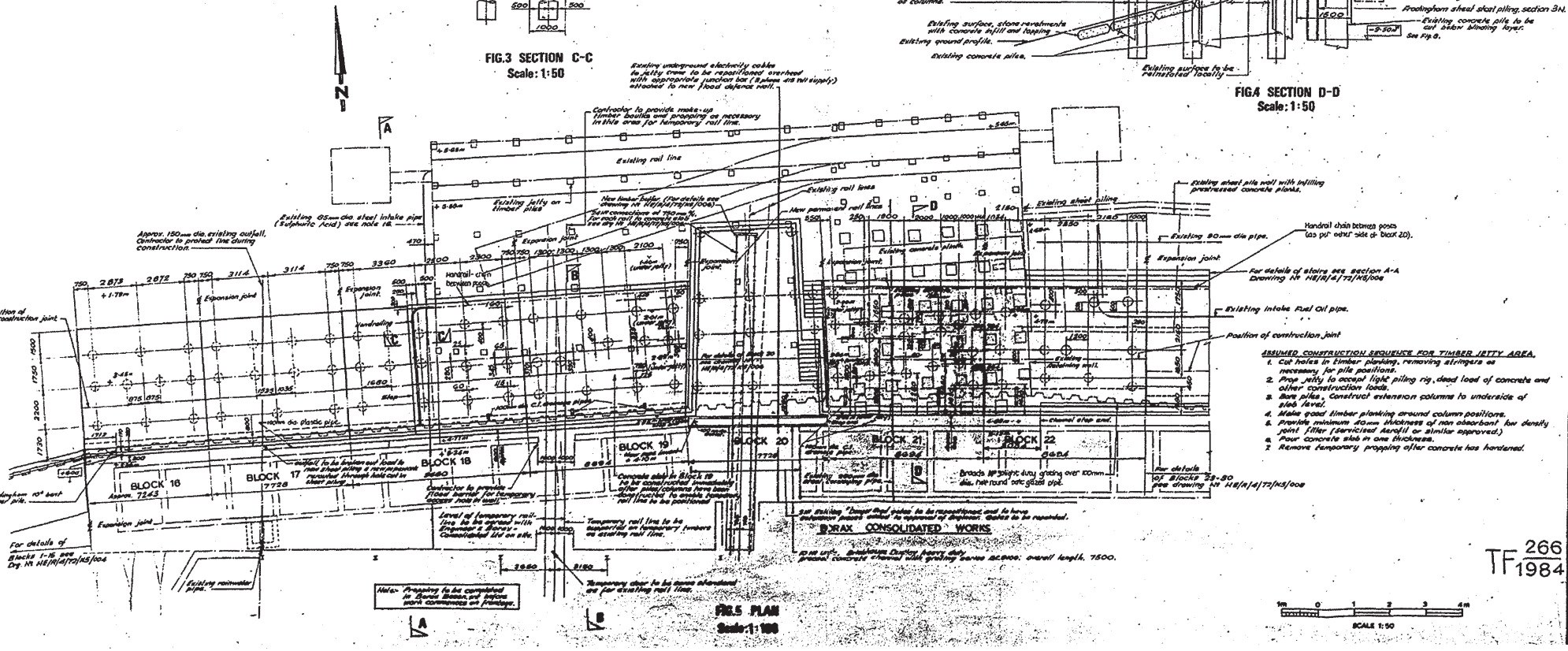

FIG.5 PLAN
Scale: 1:100

ASSUMED CONSTRUCTION SEQUENCE FOR TIMBER JETTY AREA.
1. Cut holes in timber planking, removing stringers as necessary for pile positions.
2. Prop jetty to accept light piling rig, dead load of concrete and other construction loads.
3. Bore piles, Construct extension columns to underside of slab level.
4. Make good timber planking around column positions.
5. Provide minimum 40mm thickness of non absorbant low density joint filler (servicised Aerofil or similar approved.)
6. Pour concrete slab in one thickness.
7. Remove temporary propping after concrete has hardened.

SCALE 1:50

TF 266/1984

HE/R/4/72/K5/005 C

NOTES

1. All levels to Ordnance Datum
2. Levels of new work shown thus
   In section
   On Plan.
3. Existing levels shown thus
   In section
   On Plan.
4. Structural concrete to be grad
5. Blinding concrete to be grade
6. Reinforcement to be mild steel
7. Surface finishes shown thus
   For details of finishes see spe
8. Expansion joints to be locate
   riverward pile clusters.
9. All exposed corners to have 3
   chamfer.
10. Cement to be Sulphate Resist
    Portland cement.
11. Steel sheet piling to be grade
    steel to B.S. 4360.
12. The minimum interim flood de
    level of 5.45m is to be mainta
    times during construction.
13. New 600mm dia. bored piles a
    shown thus on plan, the
    loads to be
14. Existing timber & concrete pi
    shown thus on plan.
15. The use of existing pipelines sh
    maintained by contractor. Any
    temporary supports etc. during
    construction shall be agreed w
    Engineer and the owner, and
    supports provided to the same
    on their estate.
16. Positions of existing piles, sheet
    anchor blocks and electricity ca
    be fully investigated by the co
    before attempting to bore pil
    The final positions of bored pi
    be agreed with the Engineer.
17. Assumed Max Stab a Retaining W
    Construction Sequence.
    a. Construct slab to construction
       as shown
    b. When concrete has hardened,
       be used to support light rig
       driving sheet piling under ne
    c. Construct final part of slab
       near wall.
    d. Remove existing retaining w
       described in NOTE 'A' on ele

REFERENCE DRAWINGS

This drawing to be read in conjunctio with:-

Drg. Nr HE/R/4/72/K5/001. General Layout of Flood De

Drg. Nr HE/R/4/72/K5/004. Sections and Details. Blocks

Drg. Nr HE/R/4/72/K5/006. Details of Offloading Bay (

Drg. Nr HE/R/4/72/K5/007. Sections and Details. Blocks

Drg. Nr HE/R/4/72/K5/008. Basement Wall Shoring Detail

C.H. DOBBIE & PARTN
CONSULTING ENGINEERS

Appendix F Stakeholder Consultation

creating a better place

Environment Agency

Mr Richard Wilkinson
Cory Environmental Ltd
2 Coldbath Square
London
EC1R 5HL

Our ref: SL/2018/117950/01-L01

Date: 11 April 2018

Dear Richard

Meeting for an integrated energy park of up to 96 megawatts generating capacity (comprising waste energy recovery, waste anaerobic digestion, battery storage and solar generation) and associated electrical connection.

Riverside Energy Park, Belvedere

Thank you for forwarding the minutes from our meeting dated the 19 February for our review.

We agree that the minutes broadly reflect our discussion and have provided a suggested amendments below. We have also provided an update on the actions we took from the meeting.

Suggested amendments to minutes

The minutes do not make reference to the letters sent by our Asset Performance Tidal Walls and Embankments Team regarding the poor conditions of the Tidal Defences and requirements to upgrade the defences (letters were sent on the 28th March 2017 to The Company Secretary, Riverside Resource Recovery Limited 2 Coldbath Square London, EC1R 5HL and no response has been received from Cory Environmental).

We recommend that the meeting minutes are amended to reflect the concerns we raised of the siting of the temporary offices over the flood defences during the construction phases. As stated in the meeting our position is that no development should be located over the defences with all new development including temporary structures being sent back from the defences.

We understand that the site is constrained with limited space for construction facilities. However, as stated in the meeting the current condition of the Thames Tidal Flood Defence assets at the Cory Riverside Energy site are Condition Grade 3 (fair) apart from one that is Condition Grade 4 (poor); as such a flood defence condition survey would have to be undertaken and remedial works identified carried out to improve the flood defences.

We agreed that we would review any proposal for building the offices over the flood defences but do not feel the meeting minutes currently reflect our stance on the siting of temporary units over them. Any development will need to consider the impacts on the flood defences and how the condition and crest level of the defences can be maintained / enhanced (and raised where required as per the Thames Estuary 2100 Plan) for the lifetime of the development.

We have checked the approach taken previously on Nationally Significant Infrastructure Projects which have required a Flood Risk Activities Permit (FRAP) on the Tidal Thames.

While disapplying the FRAP process within the DCO process can be beneficial in some cases, we recommend that further consideration and discussion on this process is undertaken as our agreement to this will be required.

Actions

Latest Tidal Breach Modeling
There is currently no confirmed date for the publication of the breach modelling for this stretch of the Tidal Thames. We will continue to check with the team leading on the modelling and update you once a date has been confirmed. As stated in the meeting when a site is at residual risk of flooding we do not require freeboard to be included when setting finished floor levels.

Details of the Thames Tidal Flood Defences
We have provided the details we hold on the construction of tidal flood defence to our customers and engagement team (KSLenquires@environment-agency.gov.uk) and requested that they are sent to you along with the inspection details and our letter dated the 28th March 2017.

Water Framework Directive (WFD) air quality assessment requirements
Following discussion between our Marine Team Officer Mark Davision and Environmental Permitting Teams we are satisfied emissions impacts to water quality will not need to form part of the WDF assessment as the potential emissions should be regulated to an acceptable level under the EPR.

Further information received

We have received the letter from Peter Brett Associates LLP dated 23 March (received 28 March) PBA ref 42166.

We also have received the following document from Doran Consulting.

- Flood Defence Condition Survey, Specification Proposed Riverside Energy Park, Norman Road, Belvedere, March 2018
- Riverside Energy Park, Finished Floor Level Strategy – Executive Summary
- Riverside Energy Park Drainage Design Strategy – Executive Summary

These are currently under review with our technical teams and we will respond shortly.

I hope our comments are helpful, if you have any questions please contact me.

Yours sincerely

Joe Martyn
Planning Specialist

Direct dial 020 3025 5546
Direct e-mail kslplanning@environment-agency.gov.uk

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Environment Agency

Mr Richard Wilkinson
Cory Environmental Ltd
2 Coldbath Square
London
EC1R 5HL

Our ref: SL/2018/117950/02-L02

Date: 27 April 2018

Dear Mr Wilkinson

Additional information: for an integrated energy park of up to 96 megawatts generating capacity (comprising waste energy recovery, waste anaerobic digestion, battery storage and solar generation) and associated electrical connection.

Riverside Energy Park, Belvedere.

We have received and reviewed the following documents

- Updated Cover Letter and appendices from Peter Brett Associates LLP dated 23 March (received 28 March) PBA ref 42166.
- Flood Defence Condition Survey, Specification Proposed Riverside Energy Park, Norman Road, Belvedere, March 2018 by Doran Consulting
- Riverside Energy Park, Finished Floor Level Strategy – Executive Summary by Doran Consulting
- Riverside Energy Park, Drainage Design Strategy – Executive Summary, by Doran Consulting

Updated Cover Letter and appendices
We note that the in-river works component of the development, including dredging has now been removed from the proposal.

We therefore have no Water Framework Directive (WFD) water quality interests to consider, as the airborne deposition levels will be regulated by air quality legislation.

Works which would have been appropriate to assess under the current WFD guidance have been removed from current application proposals, though should in-river works later be proposed again we will require them to be assessed for WFD compliance.

Flood Defence Condition Survey
Following review of the Flood Defence Condition Survey Specification report, we have the following comments.

Page 2 Section 1.6 of the Flood Defence Condition Survey Specification report outlines the objectives of the flood defence condition survey; the objective should include ascertaining the required remedial works to ensure the flood defences are commensurate with the lifetime of the development rather than the probability of breaching and overtopping. We have no issues if the survey wishes to determine the latter, you may want to consider further points for breaches to meet this aspect of the objective.

Page 5 Section 3.4.3 of the Flood Defence Condition Survey Specification report states “Consultation with the EA dated 12/02/2018 stated the current condition grade for defences in the area is 2 (good)”, in the meeting held on 19/02/2018 we mentioned that the defences were condition grade 3 and 4 in some places. Subsequently, the survey report and an enforcement letter advising that maintenance to the flood defences would be required were provided to the applicant.

We note that the site red line boundary in Appendix C Flood Defence Condition Survey Extent ref: DCXXXXSIC001 appears to differ from the redline boundary to Appendix A – Indicative Application Boundary (Figure 1b Rev A) of correspondence dated 23 March 2018 reference: 42166. The proposed redline boundary should be confirmed and the documents updated to reflect this.

We note that the condition survey does not confirm if the recommendations previous 2007 condition survey report were carried out.

The Asset Performance team can provide further information on our recommendation on the requirements of the Flood Defence conditions survey and the condition of the wall. Please email TTWEAPT@environment-agency.gov.uk and mark you request from the attention of Tony Davis

Finished Floor Level Strategy

We are support the plan for the finished floor levels in regards to them being set well above the current breach model. It is expected that the new downriver breach model will be released in late spring/early summer.

Drainage Design Strategy

We note and agree with the proposal to dismiss the use of SUDs for surface water disposal due to the high water table and potential risk of groundwater contamination. Consequently, surface water is proposed to be pumped from an underground sealed attenuation tank and discharged to a nearby watercourse. Surface water draining from vehicle routes and oil/fuel delivery areas will pass through appropriate pollution prevention installations. Foul water is proposed to be subjected to a packaged treatment plant and, providing acceptable quality limits are achieved, subsequently discharged to ground. This process will likely require an Environmental Permit. Spent firewater will be retained in the surface water attenuation tank(s) and

subsequently tankered offsite for treatment. The document makes clear that there will be no discharges from the site of any potentially contaminated water/effluent. We accepts these proposals, but would like to see and review confirmed details in due course.

Information requested on the Tidal Defences

In our meeting dated 19th February you requested that we supply you with the information we hold on the Tidal Defences at this site including confirmation of the landward extent of the flood defences. Drawings, inspection report and the letter we previous sent to you regarding the condition of the wall can be found via the fileshare link in the accompanying email. The drawings should allow you to appropriately ascertain the landward extent of the landward extent of the tidal defences.

I hope our comments are helpful, if you have any questions please contact me.

Yours sincerely

Joe Martyn
Planning Specialist

Direct dial 020 3025 5546
Direct e-mail kslplanning@environment-agency.gov.uk

Please note that the view expressed in this letter by the Environment Agency is a response to a pre application enquiry only and does not represent our final view in relation to any future planning application made in relation to this site.

We reserve the right to change our position in relation to any such application. You should seek your own expert advice in relation to technical matters relevant to any planning application before submission.

This opinion is based on the information submitted and current planning policy and guidance.

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Environment Agency

Richard Wilkinson
Cory Environmental Ltd
2 Coldbath Square
London
EC1R 5HL

Our ref: SL/2018/117950/03-L01

Date: 21 August 2018

Dear Richard

Additional information: for an integrated energy park of up to 96 megawatts generating capacity (comprising waste energy recovery, waste anaerobic digestion, battery storage and solar generation) and associated electrical connection.

Riverside Energy Park, Belvedere.

Thank you for submitting the following documents for your review under cost recovery agreement number ENVPAC/KNTSLN/00629.

- Floor Level Strategy Report by Doran Consulting dated January 2018.
- Flood Defence Condition Survey Specification by Doran Consulting dated March 2018.
- Drainage Design Strategy by Doran Consulting dated February 2018.

We have reviewed the revised Floor Level Strategy and support the approach to set most of the finished floor level of the new developed area above the modelled breach level.

We have reviewed the Flood Defence Condition Survey Specification Report and agree with the scope and specifications of this report. We confirm that we accept the landward extent of the tie bar and anchorage plate arrangement being identified as the landward extent of the flood defences. We would recommend that the results of the survey are submitted to us for review once completed so that we can comment on the conclusions and recommendations (replacement, remedial and maintenance works).

We have not reviewed the Drainage Design Strategy as the issues related to our remit will be covered under the Environmental Permit. We understand that you have submitted a request for an Enhanced Pre-Application service. We recommend that you submit the drainage strategy to our National Permitting Service as part of this

consultation. We understand that you have undertaken consultation of this document with the London Borough of Bexley Drainage Team as the Lead Local Flood Authority.

I hope our comments are helpful, if you have any questions please contact me.

Yours sincerely

Joe Martyn
Planning Specialist

Direct dial 020 3025 5546
Direct e-mail t fax kslplanning@environment-agency.gov.uk

Please note that the view expressed in this letter by the Environment Agency is a response to a pre application enquiry only and does not represent our final view in relation to any future planning application made in relation to this site.

We reserve the right to change our position in relation to any such application. You should seek your own expert advice in relation to technical matters relevant to any planning application before submission.

This opinion is based on the information submitted and current planning policy and guidance

Appendix G Drainage Design Strategy

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DELIVERING ENGINEERING EXCELLENCE

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OUTLINE DRAINAGE DESIGN STRATEGY

FOR

HITACHI ZOSEN INOVA

PROPOSED RIVERSIDE ENERGY PARK
NORMAN ROAD, BELVEDERE

NOVEMBER 2018

Doran CONSULTING
DELIVERING ENGINEERING EXCELLENCE

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OUTLINE DRAINAGE DESIGN STRATEGY

FOR

HITACHI ZOSEN INOVA

PROPOSED RIVERSIDE ENERGY PARK
NORMAN ROAD, BELVEDERE

NOVEMBER 2018

172067	NB	AC	PGK	3rd Issue	HZI	*e	01/11/18
172067	AC	PGK	PGK	2nd issue	HZI	*e	26/10/18
172067	AC	PGK	PGK	1st issue	HZI	*e	14/02/18
Job No	**Prepared by**	**Checked by**	**Approved by**	**Status**	**Issued to**	**No of copies**	**Date**

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Electronic Copy

OUTLINE DRAINAGE DESIGN STRATEGY
RIVERSIDE REP, NORMAN ROAD, BELVEDERE

CONTENTS PAGE

1.0	Introduction	3
2.0	Approach to Drainage Design	4
3.0	Surface Water Drainage Objectives	5
4.0	Existing Site Arrangement	6
5.0	Greenfield Run-off Calculation	8
6.0	Proposed Outline Surface Water Strategy	9
7.0	Proposed Outline Foul Drainage Strategy	11
8.0	Approvals/Permissions	13
9.0	Conclusions	14

Appendices

Appendix A - Micro-drainage Calculations

Appendix B - Proposed Drainage Drawings

1.0 Introduction

1.1 Doran Consulting Ltd. have been commissioned by Hitachi Zosen Inova to produce a proposed outline drainage strategy for the development of an energy recovery facility at Norman Road, Belvedere referred to as the Riverside Energy Park (REP).

1.2 The REP development is proposed to be an integrated energy park comprising an Energy Recovery Facility, anaerobic digestion facility, battery storage, roof mounted solar photovoltaic installation and associated electrical connection.

1.3 This report aims to summarise the proposed outline drainage design strategy for the development. A preliminary drainage design for the site has been undertaken with a responsible and innovative approach, incorporating best practice and sustainable drainage techniques, wherever possible, in order to minimise the facility's impact on the local environment and watercourses.

1.4 The proposed development is noted to be within Flood Zone 3; but falls within an area that benefits from flood defences; and therefore is only likely to be flooded in the event of a breach.

2.0 Approach to Drainage Design

2.1 All drainage has been designed in accordance with the following current British Standards: BS EN 752 'Drain and Sewer Systems Outside Buildings', BS EN 12056 'Gravity Drainage Inside Buildings' and best practice guidelines; such as, 'Drainage of Development Sites - A Guide by HR Wallingford/CIRIA','The CIRIA SUDs Manual' and WRc Sewers for Adoption 7th Edition.

2.2 In line with national requirements, the drainage design has been completed in accordance with the National Planning Policy Framework (NPPF). The NPPF encourages the implementation of SuDS in the surface water drainage strategy for new developments. Furthermore, it stipulates that in areas at risk of flooding, the use of SuDS is given priority.

2.3 In line with local requirements, design works have been undertaken in consideration to recommendations published in the Bexley Sustainable Design & Construction Guide (October 2007) and the London Plan, Policy 5.13, Sustainable Drainage.

2.4 Specifically to the site use, all drainage to oil/chemical storage and delivery areas shall be designed to adhere to the relevant Environment Agency Pollution Prevention Guidelines.

3.0 Surface Water Drainage Objectives

3.1 The National Planning Policy Framework and SuDS design best practice guidance sets out the following principle surface water drainage requirements:

- The development proposals should mimic greenfield conditions as far as possible.
- Surface water run-off from the developed site shall be no greater than that from the pre-developed site for storm events up to and including the 1 in 100 year return period with suitable allowance made for climate change.
- A range of sustainable drainage techniques shall be adopted to promote surface water treatment, reuse, reduction and retention.
- An assessment of the behaviour of surface water in the event of a critical 1 in 100 year rainfall event, with an allowance of 40% for climate change will be undertaken. This assessment needs to demonstrate that in the event of such a storm, buildings shall be protected, and that excess surface water can be retained on site.

4.0 Existing Site Arrangement

4.1 The proposed site is located on lands to the immediate west of the existing Riverside Resource Recovery Ltd. (RRRL) facility, bounded to the north by the River Thames, to the west by the Crossness Sewage Treatment Works and to the south by the Crossness Nature Reserve.

4.2 The site is located within EA Flood Zone 3 (figure 4.1) but is noted to benefit from existing flood defences. As such the site is only at risk of flooding in the event of a breach to the defences.

Figure 4.1 – EA Flood Zone

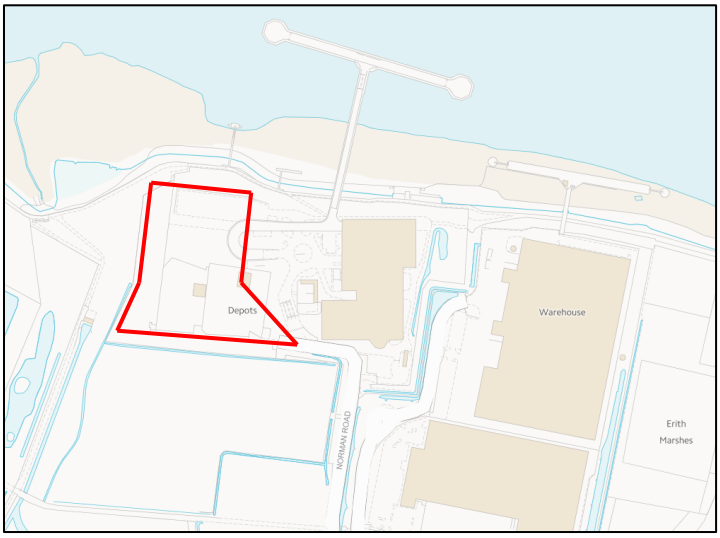

Figure 4.2 – Extent of Local Watercourses

4.3 Figure 4.3 below indicates the current site arrangement. Much of the proposed site is noted to consist of existing hardstanding. Most of the hardstandings relate to existing depot buildings, located on the southern extent of the site, whilst some of the hardstanding relate to car parking associated with previous site use (former chemical plant). It is unknown how these areas are currently drained, however it is assumed that they ultimately discharge to the adjacent watercourse network, as indicated within figure 4.2.

Figure 4.3 – Current Site Arrangement

4.4 An area of hardstanding located in the northern extent of the site is understood to be currently used to facilitate ash storage in relation to the existing RRRL facility. This area is currently drained through the RRRL site drainage and attenuation system before ultimately discharging to the watercourse located to the south of the site.

4.5 The existing site is conservatively estimated to have 60% impermeable surfacing. An estimated 1 in 2 year brownfield surface water flow from the site, based on the methods outlined within BS EN 752, is 200.00l/s.

5.0 Greenfield Run-Off Calculation

5.1 In line with current best practice guidelines, the equivalent greenfield run-off flow for the site has been calculated using the methods outlined within the Institute of Hydrology Report no 124 (IH124) – Flood Estimation for Small Catchments. The results in relation to the relevant storm events as summarised as follows:

Rainfall Event	Greenfield Runoff rate (l/s)
Qbar	11.1
Q1	9.4
Q10	17.9
Q30	25.1
Q100	35.3

Table 5.1 – Greenfield Run-off Calculation

5.2 Current best practice would target a proposed flow limit for the site based an equivalent 1 in 1 year (Q1) greenfield run-off. However in the case of the proposed Riverside REP project, this value is considered to be unfeasible due to the likely magnitude of the required attenuation volume. Rather it is considered more viable to propose a flow limit based on the equivalent 1 in 100 year (Q100) greenfield run-off; a value of 35.3l/s. This value is deemed to comply with the relevant planning policy framework and represents a significant reduction to the pre-development surface water run-off.

6.0 Proposed Outline Surface Water Strategy

6.1 The proposed outline drainage strategy for the proposed project is illustrated on drawing number 172067-DC-XX-XX-GA-301C, included within Appendix B.

6.2 The drainage design has been developed, based on the principles set out in the NPPF and local policy guidelines. It is proposed to restrict the peak surface water run-off rate from the site to 35.3l/s, which has been calculated to be the equivalent 1 in 100 year greenfield run-off flow for the pre-development site.

6.3 The general storm water system will collect surface water from the roads and hardstanding areas via heavy duty gullies and proprietary drainage channels. Proprietary drainage kerbs will also be adopted in areas of road where half battered kerbing is required. All channels and gullies specified will be suitable for the intended site use, and shall be fitted with heavy duty covers and gratings to accommodate heavy vehicle loading.

6.4 Surface water drainage collection from roof areas is proposed to be undertaken using rainwater downpipes of minimum diameter 110mm. The preliminary locations of downpipes are illustrated in the proposed drainage layout.

6.5 In areas of landscaping, land drainage will be provided with the use of perforated pipework. Drainage of this nature will drain through silt collection pits prior to discharge to the storm water system to prevent siltation of the main drainage networks.

6.6 Generally, below ground drainage systems will consist of uPVC, polypropylene and concrete pipework, with pre-cast concrete manholes located at changes in direction and gradient. Ultimate discharge shall be to the adjacent open watercourse, located to the south of the site. To allow connection from the development, surface water will be required to be pumped via a proposed packaged pumping station. The station shall be fitted with both duty/standby pump sets and all appropriate alarm systems. Outlet flows shall be limited to 35.3l/s.

6.7 In accordance with best practice guidelines, surface water attenuation systems must accommodate the storage of surface water generated in a 1 in 100 year storm event +40% climate change factor. Attenuation is proposed to be provided via an underground tank system similar to that illustrated within figure 6.1. The total volume of attenuation to be provided for the project is 1,650m^3. For further information, please see surface water attenuation calculations, presented within Appendix A.

6.8 In line with appropriate legislation and regulations, surface water draining from proposed vehicle routes and circulation areas shall pass through appropriately sized class 1 full retention separators.

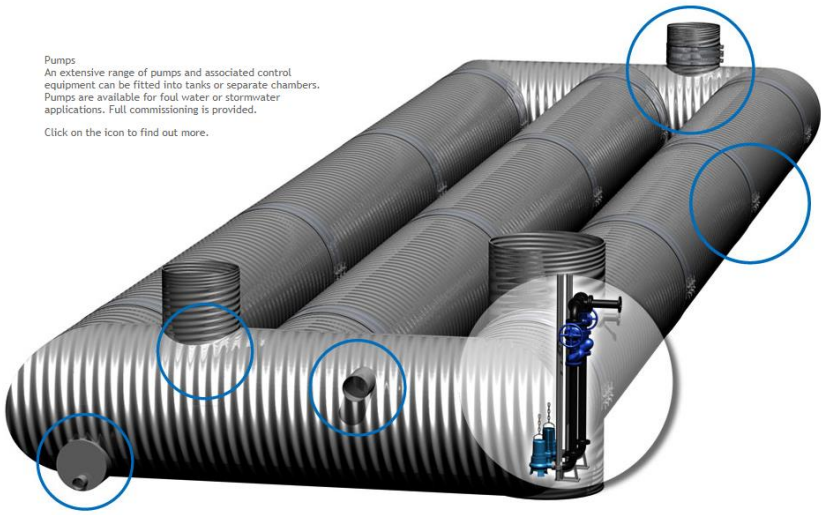

Figure 6.1 – Proposed Attenuation Tank (and Integrated Pump)

6.9 Furthermore, a forecourt separator is required to serve the dedicated oil delivery area. This shall have provision to store an emergency volume of tanker spillage.

6.10 It is noted that site constraints provide limited options for further implementation of a SuDS management train. SuDS items which operate groundwater infiltration methods have not been incorporated into the design for two reasons. Firstly, the high water table observed within the site may render infiltration methods ineffective and result in negative impacts such as an increased risk of groundwater flooding in critical storm events. Secondly, the site use involves industrial processes and high heavy goods vehicle traffic, as well as fuel storage. Infiltration methods in this case therefore present a risk of groundwater contamination which could impact on ecology and wildlife in the area.

7.0 Proposed Outline Foul Drainage Strategy

7.1 Foul drainage for the proposed development shall be generated by a combination of industrial process and by the welfare facilities serving the facility. A different drainage strategy is proposed to cater for each.

Foul Generated from Industrial Processes

7.2 Effluent, process water, washdown water and potentially contaminated surface water could be generated from the proposed site activities. A foul drainage network has been incorporated into the drainage design to accommodate such flows.

7.3 Industrial wastewater in the form of washdown water within the boiler hall and flue gas treatment area shall be collected via a series of reinforced concrete gully sumps and drainage channels. Wastewater from this area will drain to a reinforced concrete 'dirty water' storage/sedimentation tank constructed below the boiler hall.

7.4 Drainage from the Ash Storage building is also considered industrial wastewater, where heavy ash siltation is expected within surface water run-off. Drainage from this area shall also be collected via a series of reinforced concrete gully sumps and drainage channels before being routed to the Boiler Hall sedimentation tank, discussed above.

7.5 Drainage from the AD maturation area shall be treated in a similar manner to the areas above, where water shall be collected and pumped to the Boiler Hall sedimentation tank.

7.6 It is envisaged that all of the wastewater collected in the sedimentation tank from the above sources will generally be reused in processes within the building.

Spent Fire Fighting Water

7.7 In the event of activation of the sprinkler system or deluge, an overflow sewer from the sedimentation tank will allow discharge from the building when the tank reaches capacity. The overflow facility shall convey excess water to the surface water attenuation tanks, located beneath the Air Cooled Condensers (ACC) in the south east of the site. An automated gate valve system shall be installed to operate and control the overflow facility. Upon opening the valve, allowing water to flow from the sedimentation tank, the system shall be arranged so that the surface water pumped outflow from the attenuation tanks is automatically dis-engaged,

thus ensuring that no potentially contaminated water is inadvertently discharged to the local watercourse. The spent firefighting water collected in the attenuation tanks shall be held until collected and transported for treatment offsite by tanker.

Foul Generated From Welfare Facilities

7.8 The development also features the provision of an administration building, with associated welfare facilities required. Foul drainage from this area of the site is proposed to be collected and drained via gravity to a packaged wastewater treatment plant located in the southern region of the site. Effluent is expected to undergo primary settlement, biological treatment and final settlement prior to discharge from the treatment plant system.

7.9 It is proposed that if treated effluent can achieve the required standard after undergoing treatment, the effluent will drain to the underlying groundwater. Sewage sludge generated from this process shall be removed regularly via tanker to the local public wastewater treatment plant.

7.10 Foul sewerage systems shall be designed to the relevant British Standards considering the appropriate flow from the various buildings, and will comply with the appropriate Building Regulations. The sewerage system design shall take into account the calculated peak flows from welfare facilities.

8.0 Approvals and Permissions

8.1 There are a number of approvals and permissions required in association with the implementation of the proposed drainage design.

8.2 Statutory approval shall be required from the Environment Agency (EA) in relation to the proposed surface water outfall to the local watercourse. The EA shall also be required to confirm approval of waste water management across the site.

8.3 Approval shall also be required from the Local Lead Flood Authority (LLFA) in relation to the proposed surface water management strategy for the development.

9.0 Conclusions

9.1 This report and associated proposed outline drainage strategy plan (Appendix B) are considered to comply with the requirements of National Planning Policy Framework, and the London Plan in relation to surface water management.

9.2 The surface water drainage has been designed with a sustainable and innovative approach throughout.

9.3 The total surface water run-off rate from the proposed REP development to the adjacent watercourse shall be limited to 35.3l/s, which has been calculated to be the equivalent 1 in 100 year greenfield run-off rate from the pre-development site.

9.4 The proposed surface water strategy represents a significant reduction to the surface water flow from the pre-development site, which predominantly consists of existing hardstanding areas.

9.5 In line with NPPF requirements, surface water attenuation shall accommodate storm events up to and including the 1 in 100 year storm of critical duration, plus allowance for 40% climate change. Attenuation is proposed in the form of an underground storage tank and pumped outlet system.

9.6 Foul water generated across the proposed facility shall be collected treated and disposed of in a responsible and efficient manner. Re-use of collected 'dirty water' through the Energy from Waste process and for dust/ash suppression use is proposed.

9.7 Domestic foul drainage is proposed to be accommodated via the provision of a packaged treatment plant.

9.8 The proposed drainage strategy for the development is dependent on further discussion and agreement with the statutory bodies.

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Technical Director
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Appendix A

Micro-Drainage Calculations

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Greenfield Run-Off Calculations

ICP SUDS Mean Annual Flood

Input

Return Period (years)	10	Soil	0.450
Area (ha)	3.020	Urban	0.000
SAAR (mm)	600	Region Number	Region 6

Results l/s

QBAR Rural	11.1
QBAR Urban	11.1
Q10 years	17.9
Q1 year	9.4
Q30 years	25.1
Q100 years	35.3

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Surface Water Attenuation Calculations

Summary of Results for 100 year Return Period (+40%)

Storm Event	Max Level (m)	Max Depth (m)	Max Control (l/s)	Max Volume (m³)	Status
15 min Summer	-1.649	0.951	33.6	792.0	O K
30 min Summer	-1.393	1.207	35.3	1005.3	O K
60 min Summer	-1.157	1.443	35.3	1201.6	O K
120 min Summer	-0.968	1.632	35.3	1359.3	O K
180 min Summer	-0.899	1.701	35.3	1417.2	O K
240 min Summer	-0.880	1.720	35.3	1433.1	O K
360 min Summer	-0.899	1.701	35.3	1417.3	O K
480 min Summer	-0.921	1.679	35.3	1398.9	O K
600 min Summer	-0.948	1.652	35.3	1376.4	O K
720 min Summer	-0.979	1.621	35.3	1350.4	O K
960 min Summer	-1.049	1.551	35.3	1291.7	O K
1440 min Summer	-1.199	1.401	35.3	1167.2	O K
2160 min Summer	-1.405	1.195	35.3	995.4	O K
2880 min Summer	-1.566	1.034	35.3	860.9	O K
4320 min Summer	-1.747	0.853	30.1	710.2	O K
5760 min Summer	-1.868	0.732	25.8	609.6	O K
7200 min Summer	-1.957	0.643	22.7	535.8	O K
8640 min Summer	-2.025	0.575	20.3	479.0	O K
10080 min Summer	-2.080	0.520	18.4	433.5	O K
15 min Winter	-1.534	1.066	35.3	887.9	O K
30 min Winter	-1.243	1.357	35.3	1130.3	O K

Storm Event	Rain (mm/hr)	Flooded Volume (m³)	Discharge Volume (m³)	Time-Peak (mins)
15 min Summer	143.954	0.0	793.6	22
30 min Summer	92.629	0.0	1020.1	36
60 min Summer	56.713	0.0	1283.5	66
120 min Summer	33.583	0.0	1519.9	124
180 min Summer	24.424	0.0	1657.8	182
240 min Summer	19.389	0.0	1754.6	240
360 min Summer	13.924	0.0	1889.5	310
480 min Summer	11.018	0.0	1992.9	370
600 min Summer	9.182	0.0	2075.4	432
720 min Summer	7.908	0.0	2144.3	498
960 min Summer	6.245	0.0	2255.7	634
1440 min Summer	4.471	0.0	2415.5	898
2160 min Summer	3.197	0.0	2606.6	1280
2880 min Summer	2.518	0.0	2736.9	1644
4320 min Summer	1.796	0.0	2926.8	2380
5760 min Summer	1.413	0.0	3071.4	3112
7200 min Summer	1.172	0.0	3185.2	3824
8640 min Summer	1.006	0.0	3280.4	4576
10080 min Summer	0.884	0.0	3361.7	5256
15 min Winter	143.954	0.0	888.8	22
30 min Winter	92.629	0.0	1141.4	36

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Summary of Results for 100 year Return Period (+40%)

Storm Event	Max Level (m)	Max Depth (m)	Max Control (l/s)	Max Volume (m³)	Status
60 min Winter	-0.974	1.626	35.3	1354.5	O K
120 min Winter	-0.753	1.847	35.3	1538.7	O K
180 min Winter	-0.666	1.934	35.3	1611.2	O K
240 min Winter	-0.634	1.966	35.3	1637.3	O K
360 min Winter	-0.647	1.953	35.3	1626.5	O K
480 min Winter	-0.693	1.907	35.3	1588.6	O K
600 min Winter	-0.733	1.867	35.3	1555.3	O K
720 min Winter	-0.780	1.820	35.3	1516.0	O K
960 min Winter	-0.888	1.712	35.3	1426.3	O K
1440 min Winter	-1.116	1.484	35.3	1236.4	O K
2160 min Winter	-1.419	1.181	35.3	983.7	O K
2880 min Winter	-1.622	0.978	34.5	815.0	O K
4320 min Winter	-1.830	0.770	27.2	641.8	O K
5760 min Winter	-1.963	0.637	22.5	530.9	O K
7200 min Winter	-2.055	0.545	19.2	453.7	O K
8640 min Winter	-2.123	0.477	16.8	397.0	O K
10080 min Winter	-2.176	0.424	15.0	353.3	O K

Storm Event	Rain (mm/hr)	Flooded Volume (m³)	Discharge Volume (m³)	Time-Peak (mins)
60 min Winter	56.713	0.0	1437.5	64
120 min Winter	33.583	0.0	1702.1	122
180 min Winter	24.424	0.0	1856.5	178
240 min Winter	19.389	0.0	1964.8	236
360 min Winter	13.924	0.0	2115.9	344
480 min Winter	11.018	0.0	2231.5	398
600 min Winter	9.182	0.0	2323.8	466
720 min Winter	7.908	0.0	2400.8	542
960 min Winter	6.245	0.0	2525.1	692
1440 min Winter	4.471	0.0	2703.7	972
2160 min Winter	3.197	0.0	2919.0	1360
2880 min Winter	2.518	0.0	3065.3	1700
4320 min Winter	1.796	0.0	3278.2	2460
5760 min Winter	1.413	0.0	3440.0	3176
7200 min Winter	1.172	0.0	3567.5	3896
8640 min Winter	1.006	0.0	3674.1	4664
10080 min Winter	0.884	0.0	3765.6	5352

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Rainfall Details

Rainfall Model	FSR	Winter Storms	Yes
Return Period (years)	100	Cv (Summer)	0.750
Region	England and Wales	Cv (Winter)	0.840
M5-60 (mm)	20.000	Shortest Storm (mins)	15
Ratio R	0.450	Longest Storm (mins)	10080
Summer Storms	Yes	Climate Change %	+40

Time Area Diagram

Total Area (ha) 3.020

Time From:	(mins) To:	Area (ha)	Time From:	(mins) To:	Area (ha)
0	4	1.812	4	8	1.208

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Model Details

Storage is Online Cover Level (m) 1.500

Tank or Pond Structure

Invert Level (m) -2.600

Depth (m)	Area (m²)	Depth (m)	Area (m²)	Depth (m)	Area (m²)
0.000	833.0	3.600	833.0	3.601	0.0

Pump Outflow Control

Invert Level (m) -2.600

Depth (m)	Flow (l/s)
1.000	35.3000

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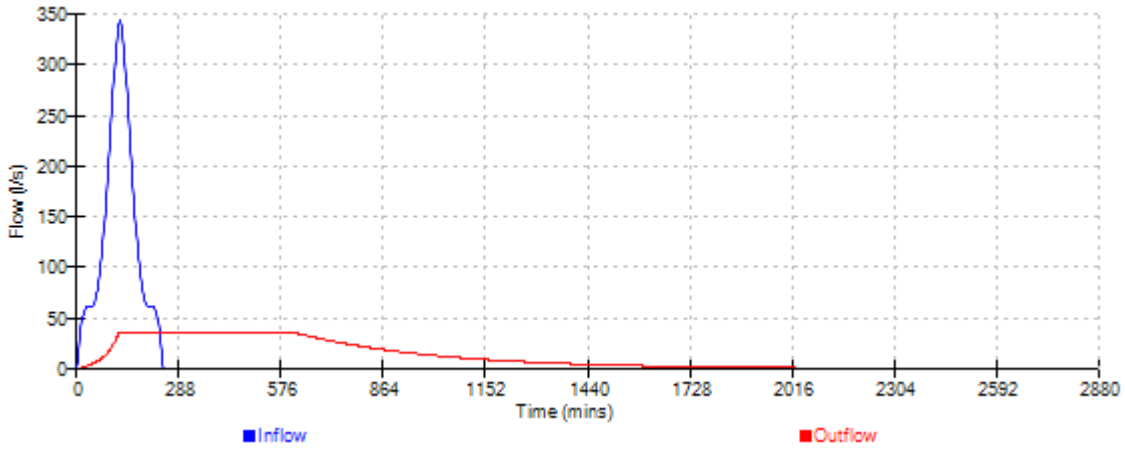
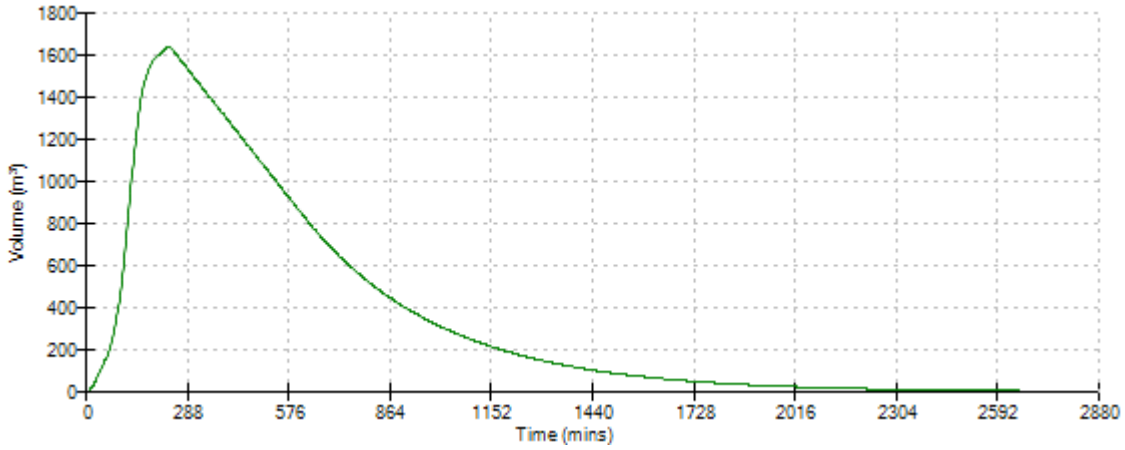
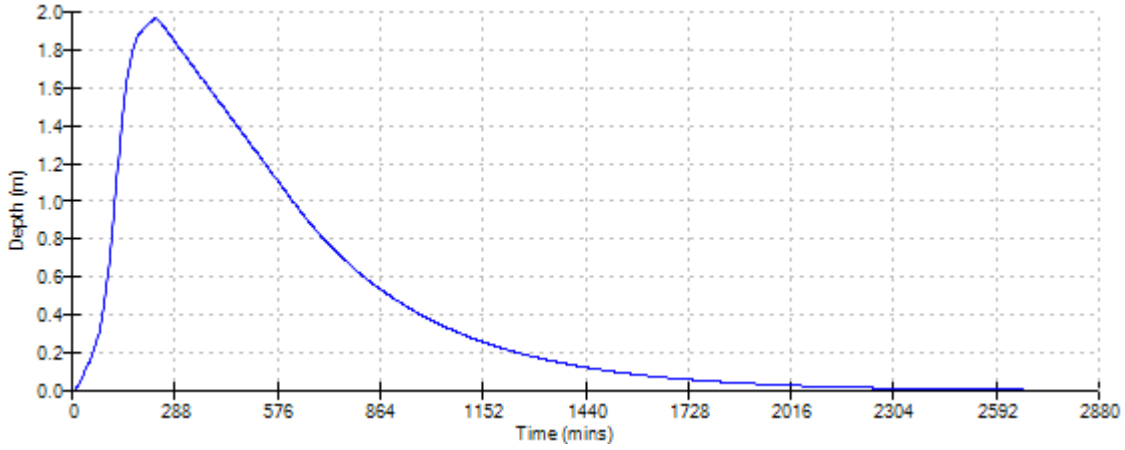
Event: 240 min Winter







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Appendix B

Proposed Site Drainage Strategy Plan

Rev.	Date	By	Check	Details	Appr.
A	28.03.18	MKP	AC	Drainage amended to suit revised layout.	PGK
B	30.08.18	HJD	EF	Drawing title sheet updated as requested.	PGK
C	31.10.18	ENJ	EF	Background layout updated	PGK

Legend:

- Proposed Foul Drainage
- Proposed Storm Drainage
- Storm drainage (uPVC Connection pipework)
- G — Heavy Duty D400 Load Class Road Gully
- Proposed Linear Uniform Depth Drainage Channel.
- Proprietary Drainage Kerb
- S — Proposed Sump Outlet Unit
- Proposed Underground Attenuation Tank (Tubosider system or similar approved)
- Proposed Full Retention Oil Separator
- Proposed Storm Water Pumping Chamber and Pumping Main.
- Proposed 'Dirty Water' Pumping Main.
- Proposed Below Ground Reinforced Concrete Dirty Water/Sedimentation Tank.

Notes:

1. This drawing should be read in conjunction with all relevant Architectural and Engineering drawings.
2. All gullies to be trapped. Road gully grills to be heavy duty ductile iron (Load Class D400).
3. Refer to Architect's drawings for exact locations of all rainwater downpipes.
4. Refer to relevant Architect's and M&E Engineering drawings for exact locations of builder's upstands/ SVPs etc.
5. Contractor to ensure that all conditions of storm and foul drainage discharges are met. All discharge arrangements to be confirmed.
6. All pipework with diameter of 300mm or less to be uPVC pipes unless otherwise stated. All pipes with diameter greater than 300mm to be class H concrete or HDPE twin wall.
7. All pipes with cover exceeding 1.2m in trafficked areas and 0.9m in non-trafficked areas to have class S bedding. All pipes with cover less than 1.2m in trafficked areas and 0.9m in non-trafficked areas to have class Z bedding.
8. Contractor to confirm the location and level of any existing obstructions/structures etc., uncovered during the works.
9. Contractor to confirm the location and level of any existing sewers prior to the commencement of any works. Any discrepancies are to be notified to the engineer immediately.
10. Contractor to confirm the location of all existing services, buried and overhead, prior to the commencement of the works.
11. Drainage channels, indicated at door thresholds etc. to be Marshalls Birco 100 or approved similar. All required fixtures and fittings to be specified by drainage channel manufacturer. D400 gratings to be used in vehicle areas.
12. All drainage to be constructed in accordance with, 'WRc Sewers for Adoption'
13. All setting out shall be in accordance with available Architecture drawings.This drawing shall not be used for setting out purposes.
14. All interceptors to be constructed in strict accordance with manufacturer's guidelines. All vents to be provided in agreed locations. All interceptors to be fitted with high level oil and silt alarms.
15. All works to comply with current British Standards, Codes of Practice, and Building Regulations. The Contractor shall verify all information on site and report any discrepancies immediately to the Architect/Engineer.

Scale 1:500

Fuel storage tanks to be contained within reinforced concrete bund. Bund drainage to be provided via oil detecting de-watering pumps or similar valve system. Water from bund and fueling vehicle hardstanding to pass through full retention forecourt oil separator.

Surface water collected from ash storage area to be conveyed to Boiler Hall sedimentation tank.

Allowance to be made for a series of floor channels and gullies, cast within floor slab to collect wash down water.

Washdown water to drain to proposed underfloor sedimentation tank, via floor drains and channels.

Overflow system to be provided to sedimentation tank to accommodate water from sprinkler deluge or an unplanned boiler drain down event. Overflow to convey water to the attenuation tanks. The system shall have a valved inlet from the sedimentation tank, operated via a float switch system. Upon opening of valve, the pumps within the attenuation tank shall automatically dis-engage, thus ensuring no outlet to the watercourse.

Surface water to be collected via floor drains and sump arrangement. Water to be conveyed to Boiler Hall sedimentation tank via pumpmain.

Surface water attenuation to be provided via a sealed underground tank system. System to be Tubosider 3.6mø tank system or similar approved. Total volume to be provided to be 1650m3.

Surface water to be collected via floor drains and sump arrangement. Water to be conveyed to Boiler Hall sedimentation tank via pumpmain.

Allowance to be made for a series of floor channels and gullies, cast within floor slab to collect wash down water.

Surface water to discharge from attenuation tanks via an incorporated pumping station. Duty and standby pumpsets to be provided. Outlet flow to be restricted to 35.3l/s

All surface water outflows shall drain through a full retention oil separator.

Domestic foul drainage from Administration Building to discharge to a packaged treatment plant.

Surface water to discharge to existing watercourse via new concrete headwall. Flow limit to be limited to 35.3l/s (Q100 Greenfield Run-off).

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HZI

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Owner/Purchaser of Mapping PBA

RIVERSIDE ENERGY PARK
LONDON

Proposed Drainage Layout

Date	30.08.18
A1 Scale	1:500
Drawn by	HJD
Checked by	AC
Drawing Number	172067-DC-XX-XX-GA-C-301

user name: jones, emma | doran consulting

File Location: p:\2017\172\172067 riverside energy park - tender supp\bim\02-civil\04-cad\01-preliminary\172067-dc-xx-xx-ga-c-301 drainage layout.dwg

Appendix H Floor Level Strategy Report

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FLOOR LEVEL STRATEGY REPORT

FOR

HITACHI ZOSEN INOVA

PROPOSED RIVERSIDE ENERGY PARK
NORMAN ROAD, BELVEDERE

NOVEMBER 2018

Electronic Copy

FLOOR LEVEL STRATEGY REPORT

FOR

HITACHI ZOSEN INOVA

PROPOSED RIVERSIDE ENERGY PARK
NORMAN ROAD, BELVEDERE

NOVEMBER 2018

172067 A	NB	AC	CD	5th Issue	HZI	*e	01/11/18
172067 A	NB	AC	CD	4th Issue	HZI	*e	26/06/18
172067 A	NB	AC	CD	3rd Issue	HZI	*e	10/05/18
172067 A	NB	AC	CD	2nd Issue	HZI	*e	09/02/18
172067 A	NB	AC	CD	1st Issue	HZI	*e	22/01/18
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PROPOSED RIVERSIDE ENERGY PARK
NORMAN ROAD, BELVEDERE

FLOOR LEVEL STRATEGY REPORT

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APPENDIX F – EXTRACTS FROM RIVERSIDE DANA CENTRE FLOOD ASSESSMENT

1.0 INTRODUCTION & BRIEF

1.1 Doran Consulting Ltd. have been commissioned by Hitachi Zosen Inova to undertake an assessment to recommend finished floor levels (FFLs) for the development of an energy recovery facility at Norman Road, Belvedere referred to as the Riverside Energy Park (REP).

1.2 The REP development is proposed to be an integrated energy park comprising an Energy Recovery Facility, anaerobic digestion facility, battery storage, roof mounted solar photovoltaic installation and associated electrical connection.

1.3 This report aims to outline the finished floor level strategy for the REP development. This report outlines the peak flood levels used as part of the assessment and proposes finished floor levels for the proposed buildings and equipment.

1.4 The proposed development is noted to be within Flood Zone 3; but falls within an area that benefits from flood defences; and therefore is only likely to be flooded in the event of a breach.

1.5 Due to the level of flood risk that the site faces and the proximity to tidal flood defences; this report has been prepared to ensure the risks are assessed adequately in line with the Environment Agency Standing Advice, and Flood Risk and Coastal Change Planning Practice Guidance (PPG) in order to determine suitable FFLs for the proposed site.

2.0 SITE DESCRIPTION

2.1 The proposed REP site is located at Norman Road, Belvedere along the southern bank of the River Thames within the London Borough of Bexley (British Grid Reference TQ4954780654) adjacent to the existing Riverside Resource Recovery Facility (Riverside 1).

2.2 The REP site is approximately 3.5 Ha in plan area with an irregular site boundary. The site is currently used as an ash storage area / depot for the existing Riverside Resource Recovery Facility to the east.

2.3 The REP site is bounded to the north by the River Thames flood defences and a public footpath, to the east by the existing Riverside Resource Recovery Facility, to the west by the Crossness Sewage Treatment Works and to the south by the Crossness Nature Reserve. A Site Location Plan is included within Appendix A.

2.4 The existing REP site comprises both permeable and impermeable surfaces; approximately 2.5 Ha of hardstanding and 1.0 Ha of rough / grassed areas. Existing drainage assets exist within both the Riverside 1 and part of the REP site. Surface water run-off from the Riverside 1 area and the existing ash storage area in the Riverside 2 area is generally routed via settlement tanks and oil separators to storage tanks within the south east corner of the Riverside 1 site and discharged to the unnamed watercourses located to the south. A rainwater harvesting system is also understood to be in operation within the Riverside 1 facility.

2.5 The Level 1 and Level 2 Strategic Flood Risk Assessment (SFRA) for the London Borough of Bexley indicate that these open watercourses / drains located to the south and west of the site are either discharged under gravity at low tide, along a culvert at the Great Breach Pumping Station, or pumped from one of the adjacent pumping stations.

3.0 PROJECT DESCRIPTION

3.1 The site will contain all site infrastructure required to support the Energy Recovery Activity. This includes buildings, roads, services, offices, amenities, workshops, stores, plant, equipment, security fencing, and surrounding landscaping. It is proposed the Riverside Energy Park will generate a rated electrical output of nominally 96 MW. Illustrative site layout plans (Document Reference 2.4 and 2.6 are included within Appendix A.

3.2 The proposed development is defined by the Environment Agency as Less Vulnerable / Essential Infrastructure. The life expectancy of the proposed development is likely to be 30 years.

3.3 A baseline project brief outlined various elements to be included within the development as detailed in Table 3.1 below. The table also outlines an assumed risk level for each element in relation to flooding based on the type of building/equipment proposed.

Table 3.1: Proposed Elements and Assumed Flood Risk

Proposed Element	Flood Risk to be Applied
Tipping hall	Required to be above Flood Risk Levels.
Administration block	Required to be above Flood Risk Levels.
CHP equipment	Required to be above Flood Risk Levels.
Steam turbine building	To be located at first floor level.
Transformers / switchyard	Required to be above Flood Risk Levels.
Battery storage facility / E-Housing	Required to be above Flood Risk Levels.
Boiler hall	Required to be above Flood Risk Levels.
Fire water tank	Required to be above Flood Risk Levels and all storage bunds to extend above floor level.
AFT - Storage tanks for chemicals / fuel	Required to be above Flood Risk Levels and all storage bunds to extend above floor level.
Flue Gas Treatment	Required to be above Flood Risk Levels.
Silos	Required to be above Flood Risk Levels.

Table 3.1: Proposed Elements and Assumed Flood Risk

Proposed Element	Flood Risk to be Applied
SCR / Stacks	Required to be above Flood Risk Levels.
Bottom Ash hall	FFL of the ash storage areas may be permitted below flood level, subject to appropriate design, operational procedures, and statutory approvals.
Elements of the Anaerobic Digester plant	Some elements of the AD area may be permitted below flood level, such as AD maturation. This would be subject to appropriate design, operational procedures, and statutory approvals. It is noted however that all electrical equipment and staffed areas within the AD plant are required to be placed above flood level. This would include any drying equipment.
Air Cooled Condensers	Supported on a structural frame raised above ground levels; therefore may be permitted below flood level, subject to appropriate design, operational procedures and statutory approvals.
Solid fuel storage bunker	The bunker is a partially buried water tight structure. Construction of the bunker means flood waters could not enter it unless the flood level is higher than tipping floor level which is proposed to be minimum +5m above existing ground levels. Therefore FFL of the waste bunker may be permitted below flood level, subject to appropriate design, operational procedures and statutory approvals.
Workshop areas	Workshop areas will not be regularly staffed and FFL may be permitted below flood level, subject to appropriate design, operational procedures, statutory approvals and an appropriate flood evacuation plan.

4.0 EXISTING STATUTORY FLOOD INFORMATION

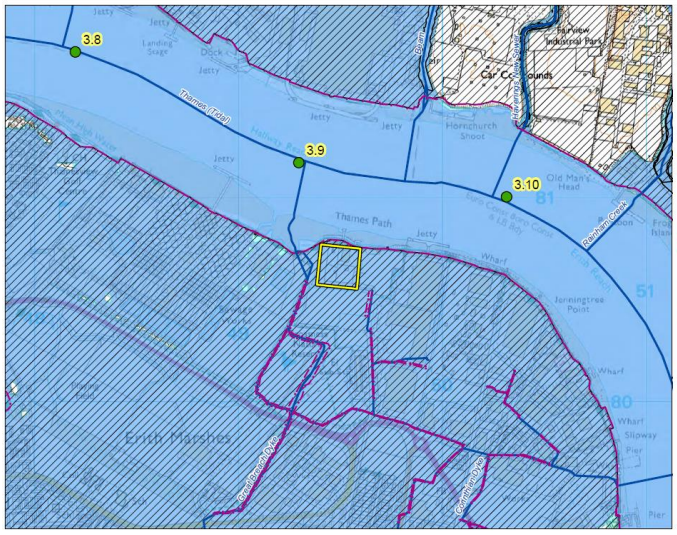
The following flood information has been sourced from the Environment Agency and Bexley Council as part of this strategy report and is considered to be the most up-to-date information available at the time of writing.

4.1 Environment Agency Product 4 (June 2018)

The following ES correspondence was received as part of the REP flood investigation. The EA response comprised Flood Information Product 4 (dated 4th June 2018);

- The site lays within Flood Zone 3 comprising land assessed as having a 0.5% or greater annual probability of tidal flooding based on flood maps created by the Thames Tidal Defences Study completed in 2006 by Harcrow Ltd.
- The site is within an area benefiting from flood defences.
    - The design standard of protection of the flood defences in this area of the Thames is 0.1% AEP; they are designed to defend London up to a 1 in 1000 year tidal flood event.
    - The defences are all raised, man-made and privately owned.
    - It is the riparian owners' responsibility to ensure that they are maintained to a crest level of 7.10m AODN (the Statutory Flood Defence Level in this reach of the Thames).
    - Defences are inspected twice a year to ensure that they remain fit for purpose; current condition grade for defences in the area is 2 (good).
- In-channel flood levels for the tidal river Thames at the nearest adjacent node (3.9) and taken from the Thames Estuary 2100 study completed by HR Wallingford in 2008 note an extreme water levels and defence heights as outlined within Figure 4.1 overleaf.
- Site-specific modelled flood levels taken from the Thames Tidal Downriver Breach Inundation Modelling completed by Atkins Ltd. in May 2015 were provided and are detailed fully within Section 6 of this report.
- One historic flood event has been recorded on site: 30/01/1953-01/02/1935 the site was subject to tidal flooding due to a storm surge in the North Sea. An approximate level in the Thames at the time was 5.10m AODN.

Detailed FRA/FCA Map centred on TQ4946780680 created 4 June 2018 [Ref: KSL 87642 AB]



TE2100 2008 levels:

Levels downriver of the Thames Barrier are 0.1% AEP (1 in 1000) and levels upriver are the highest levels permitted by the Thames Barrier, described as the Maximum Likely Water Levels (MLWLs). The defence levels (left defence, right defence) are the minimum levels to which the defences should be built.

Location	Node	Easting	Northing	Extreme water level (m)	Left defence (m)	Right defence (m)	Allow for future defence raising to a level of...	
							Left Bank (m)	Right Bank (m)
	3.7	547183	181618	6.01	7.30	7.10	8.20	8.20
	3.8	548204	181714	6.01	7.30	7.10	8.20	8.20
Beam River	3.9	549299	181171	6.00	7.20	7.10	8.20	8.20
	3.10	550318	181003	5.98	7.10	7.10	8.10	8.10
	3.11	551166	180048	5.97	7.05	7.10	8.10	8.10

TE2100 climate change levels:

Location	Node	Easting	Northing	1000-year design water levels					
				2000	2040	2070	2100	2120	2170
	3.7	547183	181618	6.01	6.22	6.42	6.75	6.95	7.46
	3.8	548204	181714	6.01	6.22	6.41	6.74	6.94	7.44
Beam River	3.9	549299	181171	6.00	6.21	6.40	6.72	6.92	7.42
	3.10	550318	181003	5.98	6.19	6.37	6.70	6.90	7.40
	3.11	551166	180048	5.97	6.18	6.37	6.70	6.90	7.39

Figure 4.1: TE2100 2008 Levels and node location map

4.2 Environment Agency Scoping Consultation (December 2017)

A consultation response from the Environment Agency (EA) (dated 21/12/2017) following an Environmental Scoping Report for the REP development by Peter Brett Associates has indicated the following:

- The proposed development is defined as Less Vulnerable/Essential Infrastructure.
- The site is within Flood Zone 3 i.e. has a 1 in 200 or greater annual probability of sea flooding.
- The site is protected by the Thames Tidal Defences, with a standard of protection of a 1 in 1000 annual probability of flooding.

- The site is situated within an area that would be flooded if there were to be a breach in the defences.
- The EA expect any new development at this location to have finished floor levels set no lower than the breach flood event.
- The EA Flood Risk Map indicates there is no risk of flooding from reservoirs in the area.

The consultation response and associated Environment Agency flood risk map are included within Appendix B.

4.3 Bexley Local Flood Risk Management Strategy (March 2017)

Bexley council produced a Local Flood Risk Management Strategy and associated mapping in March 2017. The Strategy Report Maps (included within Appendix C) confirm the data and site classification outlined by the Environment Agency:

- The site is within Flood Zone 3 (medium risk of flooding from Rivers and Sea),
- The site is within an area susceptible to groundwater flooding.
- The site is within a critical drainage area / ward (Belvedere Ward);
- There are areas of 1%AEP surface water flooding in the vicinity of the site corresponding to the open watercourses and drains surrounding the site.

4.4 London Borough of Bexley Preliminary Flood Risk Assessment (June 2011)

The report summarises the Preliminary Flood Risk Assessment undertaken for the London Borough of Bexley. The PFRA Maps (included within Appendix D of this report) confirmed the following flood risk classifications:

- The site is within an area which has past coastal flood events; but no reported past sewer flooding events or groundwater flooding events (Map 4.1).
- There are areas of 0.5%AEP and 1%AEP+CC surface water flooding in the vicinity of the site up to depths of 1m corresponding to the watercourses and drains surrounding the site (Maps 5.1-5.5).
- The site is within an area of Permeable superficial deposits resulting in an increased potential for elevated groundwater (Map 5.3).

4.5 London Borough of Bexley Strategic Flood Risk Assessments (Aug 2010 & Oct 2014)

The site is part of an area covered by the Level 1 and Level 2 Strategic Flood Risk Assessment (SFRA) for the London Borough of Bexley.

4.5.1 Strategic Flood Risk Assessment Level 1 (August 2010)

The Level 1 SFRA notes the site lays within a zone of tidal flood risk and is described as an area of residual flood risk as it benefits from the protection offered by flood defences.

The Level 1 SFRA outlined the following FFL related development controls / management through design measures (Section 8.3):

- Internal safe refuge should be provided for all occupied landuses above the design flood level inclusive of an appropriate freeboard allowance.
- FFL of more vulnerable uses should be above the predicted maximum water level resulting from a breach in the defences during the 0.5% AEP (1 in 200 year) + CC tidal event derived from Figure 21 within the SFRA.
- In Fluvial Flood Risk Areas finished floor levels of more vulnerable uses should be above the predicted 1% AEP (1 in 100 year) water levels (plus climate change and inclusive of a freeboard allowance of 300mm).

4.5.2 Strategic Flood Risk Assessment Level 2 (October 2014)

The Level 2 SFRA produced more detailed maps (included within Appendix E of this report) which confirm the food zones, flood depths and flood classifications etc. outlined within the Level 1 assessment.

The Level 1 and 2 SFRA confirmed the following flood zones and flood data:

- The site is located within Floods Zone 3 (Figure 6).
- The site is not within a Groundwater Source Protection Zone (Figure 10).
- There are no historic drainage events within the vicinity of the site (Figure 17).
- The site is located on a high water table area, where the depth to groundwater head is 0-2.5m below existing ground level (Figure 8).
- There are no incidents of surface water flooding recorded at the site; however there are potential flow routes and ponding areas adjacent to the site, correlating to existing watercourses and drains.

4.5.3 Strategic Flood Risk Assessment – Breach Model (August 2010)

A breach modelling report was completed as part of the SFRA, Section 3.2 of the SFRA outlines breach locations of the River Thames with Location 4 noted to be adjacent to the REP Site. The breach modelling concluded the following:

The site is within an area where predicted maximum flood depths from all breaches in the 0.5%AEP (1 in 200 year) tidal event + CC range from 2-3.5m (Figure B3) predicted maximum flood water levels from all breaches in the 0.5%AEP (1 in 200 year) tidal event + CC range from 4.11mOD to 4.40mOD (Figure B5).

Please note a more recent breach assessment; Thames Tidal Downriver Breach Inundation Modelling was completed by Atkins Ltd. in May 2015 and is outlined within Section 6.

5.0 ADJACENT FLOOD RISK ASSESSMENTS

5.1 Riverside Resource Recovery Facility Tidal Flood Risk Assessment (January 2007)

A flood risk assessment was carried out for the Riverside Resource Recovery Facility (Riverside 1) development immediately east of the area proposed for the REP development.

5.1.1 The Tidal Flood Risk Assessment for the existing Riverside 1 site received the following flood information (current at the time of writing):

- The Thames Tidal defences provide protection up to the 0.1%AEP (1 in 1000 year) event up to the year 2030; current tidal defence levels are 7.1mOD.
- A structural inspection of the flood defence covering the length of defences bounding the Riverside site was carried out dated August 2006 by Royal Haskoning.
- The present day extreme water level (2002) for the 0.5%AEP (1 in 200 year) event on the River Thames at the proposed development site is 5.689mOD.
- The future extreme water level (2052) for the 0.5%AEP (1 in 200 year) event + CC on the River Thames at the proposed development site is 5.921mOD; based on updated guidance from the EA published in January 2007 a revised 2052 EWL was determined to be 5.971mOD.

5.1.2 A site specific breach analysis was completed for the existing Riverside 1

- The breach considered was at TQ4970680741, was 20m breach and used the extreme water levels for the 2002 0.5%AEP (1 in 200 year) water level 5.689mOD, and the 2052 0.5%AEP (1 in 200 year) water level (including sea level rise and climate change) 5.971mOD.
- Maximum water levels on the site for the 2002 0.5%AEP (1 in 200 year) sea level in the event of a breach was estimated to be **1.77mOD**.
- Maximum water levels on the site for the 2052 0.5%AEP (1 in 200 year) sea level in the event of a breach was estimated to be **1.81mOD**.

5.1.3 Final Floor Level Conclusions and Recommendations for the existing Riverside 1 site.

The report concluded that buildings, plant and equipment should be constructed so that the finished floor levels are 300mm above the maximum 0.5%AEP (1 in 200 year) flood levels outlined by the breach analysis. Therefore the finished floor level for all buildings were recommended to be **2.11mOD or higher**.

5.2 Riverside Data Centre Flood Risk Assessment and Outline Surface Drainage Strategy (November 2015)

A flood risk assessment was carried out for a data centre development immediately south of the REP site; extracts of information used for the assessment are included within Appendix F of this report.

5.2.1 EA Correspondence

The following ES correspondence was considered as part of the Data Centre Flood Assessment. The EA response included Flood Information Product 4 (dated 13th October 2015) as follows:

- The site lays within Flood Zone 3 comprising land assessed as having a 0.5% or greater annual probability of tidal flooding based on flood maps created by the Thames Tidal Defences Study completed in 2006 by Harcrow Ltd.
- The site is within an area benefiting from flood defences:
    - The design standard of protection of the flood defences in this area of the Thames is 0.1%AEP (designed for a 1 in 1000 year tidal flood event).
    - The defences are all raised, man-made and privately owned.
    - It is the riparian owners' responsibility to ensure they are maintained to a crest level of 7.1mAOD (statutory Flood Defence Level in this reach of the Thames).
    - Flood Defences are inspected by the EA twice a year to ensure they remain fit for purpose.
    - The current condition grade for defences in this area is 2 (good).
- The site is overlaying 2 no. secondary aquifer units (superficial alluvium deposits and the Lambeth group).

5.2.2 Thames Estuary 2100 (TE21000) Study (HR Wallingford, 2008)

Data from the Thames Estuary 2100 (TE21000) Study completed by HR Wallingford in 2008 was considered as part of the Data Centre Flood Assessment. The Data Centre Flood Assessment used TE2100 2008 levels to determine relevant flood levels along the River Thames for the site and to predict the required level the flood defences would need to meet to ensure the same standard of protection in the future.

The Data Centre Assessment noted that in order to maintain the same standard of flood protection in the future flood defences will need to be raised to a level of 8.20mOD based on an increase in flood water levels from 6.00mOD to 7.42mAOD between now and 2170 for the 0.1%AEP scenario.

5.2.3 Bexley Strategic Flood Risk Assessment Level 2

Data from the Bexley Strategic Flood Risk Assessment Level 2 was considered as part of the data centre assessment; specifically highlighting Figure B5 within the SFRA.

The data centre noted that based on the SFRA Level 2 breach analysis; the Maximum Predicted Flood Water Levels from all Breaches in the 1 in 200 Year Tidal Flood event Plus CC) for the data centre site would be **4.11 to 4.40mOD**.

5.2.4 *Thames Tidal Breach Modelling Study (CH2M HILL, March 2015)*

The following data from the Thames Tidal Breach Modelling Study completed by CH2M HILL in March 2015 was used as part of the Data Centre Flood Assessment.

			Thm05					
	National Grid Reference		Modelled levels in mAODN for 0.5% AEP			Modelled levels in mAODN for 0.1% AEP		
Node	Easting	Northing	2014	2065	2100	2014	2065	2100
1	549583	180573	2.01	2.20	2.37	2.08	2.33	2.53
2	549669	180550	2.01	2.20	2.37	2.08	2.33	2.53
3	549651	180431	2.01	2.20	2.37	2.08	2.33	2.53
4	549642	180339	2.01	2.20	2.37	2.08	2.33	2.53
5	549644	180250	2.02	2.20	2.37	2.08	2.33	2.53
6	549648	180110	2.02	2.21	2.37	2.08	2.34	2.53
7	549618	179894	2.02	2.21	2.37	2.08	2.33	2.53
8	549384	179872	2.01	2.20	2.37	2.08	2.33	2.53

Figure 5.1: Data Centre site-specific modelled breach flood levels

Based on the 2008 TE2100 in-channel levels, the 0.5% (1 in 200 year) and 0.1% (1 in 1000 year) annual probability of exceedance tidal events were modelled for all breach locations downriver of the Thames Barrier. These were modelled for the 2014 year epoch, as well as a 2065 and 2100 epoch which included allowances for climate change.

The modelled levels used within the Assessment were based on a breach at location 'Thm05' NGR TQ50275806139 and levels were provided for 8 nodes on the Data centre site. The modelled levels for the 0.5% AEP + CC and 0.1%aep + CC modelled flood events on the data centre site were **2.37 mOD and 2.53 mOD** respectively.

The Data Centre Flood Assessment concluded the EA modelling is expected to be the most up to date and accurate information as it is more recent and likely to be more detailed than the SFRA.

5.2.5 *Final Floor Level Conclusions and Recommendations for the Data Centre Flood Risk Assessment*

In order to minimise any potential risk linked to tidal flooding (breach scenario) and other potential sources of flooding; it was proposed to avoid development at the existing ground levels (apart from the lobby area which will provide access to the floors above).

It was proposed that the development has its lowest operational floor level (level 1 / lobby) set at minimum 4.6 mOD and lowest indicative operational floor levels at 6.0 mOD.

Therefore the proposed Level 1 was over 3 metres higher than the EA predicted breach flood water level at the site in a 0.1% annual probability event assuming a 2100 scenario and 1.6 m higher than the maximum breach flood water level based on the Level 2 SFRA modelling results.

6.0 THAMES TIDAL BREACH MODELLING STUDY (ATKINS, MAY 2018)

6.1 The following data from the Thames Tidal Downriver Breach Inundation Modelling completed by Atkins Ltd. in May 2018 was received as part of this assessment. It is noted that this model has been designed for catchment wide flood risk mapping and was not created to produce flood levels for specific development sites within London.

6.2 Based on the 2008 TE2100 in-channel levels (see Figure 4.1), the 0.5% (1 in 200 year) and 0.1% (1 in 1000 year) annual probability of exceedance tidal events were modelled for the 2014 year epoch (current year) and the 2100 epoch which included allowances for climate change.

6.3 The modelled levels provided at 19 nodes within the REP site. Node locations included and modelled levels are included within Figure 6.1 overleaf.

6.4 It is noted that flood levels at nodes 1 and 4 for the breach are significantly higher that the remainder of the site; this is likely due to localised and isolated level difference as they are located on the adjacent banks. No new infrastructure is proposed adjacent to Node 4.

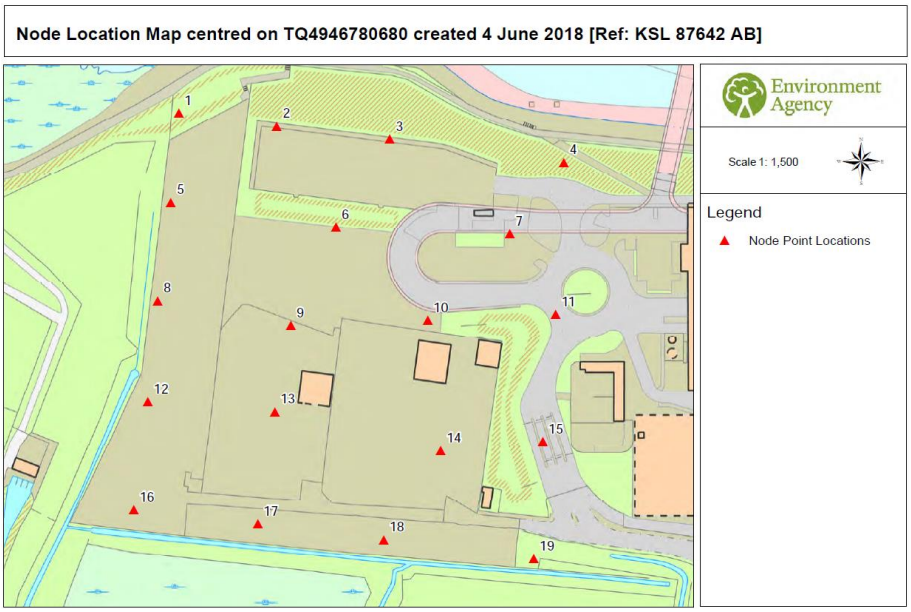


Figure 6.1: Thames Tidal Downriver Breach Inundation Model Node Locations

	National Grid Reference		Modelled levels in mAODN for 0.5% AEP		Modelled levels in mAODN for 0.1% AEP	
Node	Easting	Northing	2014	2115	2014	2115
1	549411	180767	4.82	5.08	4.93	5.14
2	549458	180761	3.58	3.72	3.64	3.77
3	549511	180755	2.30	2.49	2.34	2.63
4	549593	180744	4.30	4.56	4.40	4.63
5	549407	180725	2.92	3.01	2.96	3.04
6	549485	180713	2.28	2.49	2.32	2.63
7	549568	180710	2.51	2.58	2.55	2.63
8	549401	180679	2.37	2.49	2.41	2.63
9	549464	180667	2.03	2.49	2.08	2.63
10	549529	180669	2.45	2.62	2.52	2.67
11	549590	180672	2.37	2.53	2.43	2.63
12	549396	180631	1.92	2.49	1.97	2.63
13	549457	180626	1.97	2.49	2.02	2.63
14	549535	180608	1.97	2.49	2.01	2.63
15	549584	180612	1.99	2.49	2.02	2.63
16	549390	180580	1.87	2.49	1.97	2.63
17	549449	180573	1.87	2.49	1.97	2.63
18	549508	180565	1.87	2.49	1.97	2.63
19	549579	180556	1.87	2.49	1.97	2.63

Figure 6.1: Thames Tidal Downriver Breach Inundation Model Levels

7.0 MANAGING FLOOD RISK

7.1 Maximum Flood Levels

The following flood sources and maximum flood levels were considered as part of the floor level strategy assessment.

7.1.1 Fluvial / Tidal Flood Event

The site is noted to be within Flood Zone 3 (0.5%AEP / 1 in 200 or greater annual probability of sea flooding). Generally the EA recommends FFL are set above the 1 in 200 year tidal level plus an appropriate freeboard.

However as the site is within an area defended up to the 0.1%AEP (1 in 1000 year) flood event it is described as an area of residual flood risk and setting FFLs above the predicted tidal levels is not applicable.

7.1.2 Breach Flood Event

The EA in their consultation note that they expect any new development at this location to have finished floor levels set no lower than the breach flood event at this site.

Based on the Thames Tidal Downriver Breach Inundation Modelling 2018; the future 2100 modelled flood level in the event of a breach for a 0.5%AEP tidal flood event (including climate change) varies from is **2.49mOD** across the majority of the site to **4.56mOD** / **5.08mOD** within the north east and north west corners of the site respectively.

7.1.3 Other Sources

The primary source of flood risk at the REP site is determined to be tidal flooding in the event of a breach event; however the following sources of flooding have been considered based on information within the Bexley PFRA and SFRAs.

The PFRA noted that there were no recorded incidents of groundwater flooding within the vicinity of the site, however it is situated within an area classified as increased potential for elevated groundwater and as having a high water table. A Flood Risk Assessment will be reported separately (by others); flood levels from a groundwater event are unlikely to be higher than the primary source of flooding on the site and will therefore not influence the recommended FFLs.

The Bexley PFRA noted that there were no recorded incidents of sewer flooding within the vicinity of the site; a Flood Risk Assessment will be reported separately (by others); flood levels from a sewer surcharge event are unlikely to be higher than the primary source of flooding on the site and will therefore not influence the recommended FFLs.

There are areas of 1%AEP surface water flooding corresponding to the open watercourses and drains surrounding the site; a Surface Water Strategy Report will be reported separately (by others) and will not influence the recommended FFLs.

The EA Flood Risk Map indicates there is no risk of flooding from reservoirs in the area.

7.2 Freeboard Guidance

The Bexley SFRA noted that in Fluvial Flood Risk Areas finished floor levels of more vulnerable uses should be above the predicted 1% AEP (1 in 100 year) water levels plus climate change and inclusive of a freeboard allowance of 300mm.

PPS25 notes that traditionally, fluvial flood defences are designed incorporating a freeboard of 300mm for hard defences and 500mm for soft defences.

The design life of the REP site is predicted to be 30 years; to approximately 2060. TE2100 study predicted extreme water levels for the 0.1% AEP event within the River Thames will increase by **0.21m between the years 2000-2040**; and 0.41m between 2000-2070.

An appropriate freeboard allowance should be discussed with the Environment Agency and applied where necessary.

7.3 Proposed Finished Floor Levels

The primary source of flood risk at the REP site is determined to be tidal flooding in the event of a breach event. The EA recommend the estimated maximum water level for a tidal event is the 0.5%AEP (1 in 200 year) level.

Data from the Thames Tidal Downriver Breach Inundation Modelling 2018 is deemed to be the most recent breach study available.

The 0.5%AEP flood levels across the proposed site (based on the Thames Tidal Downriver Breach Inundation Modelling 2018 summarised previously within Section 7.1.2) are shown on Figure 7.1 below.

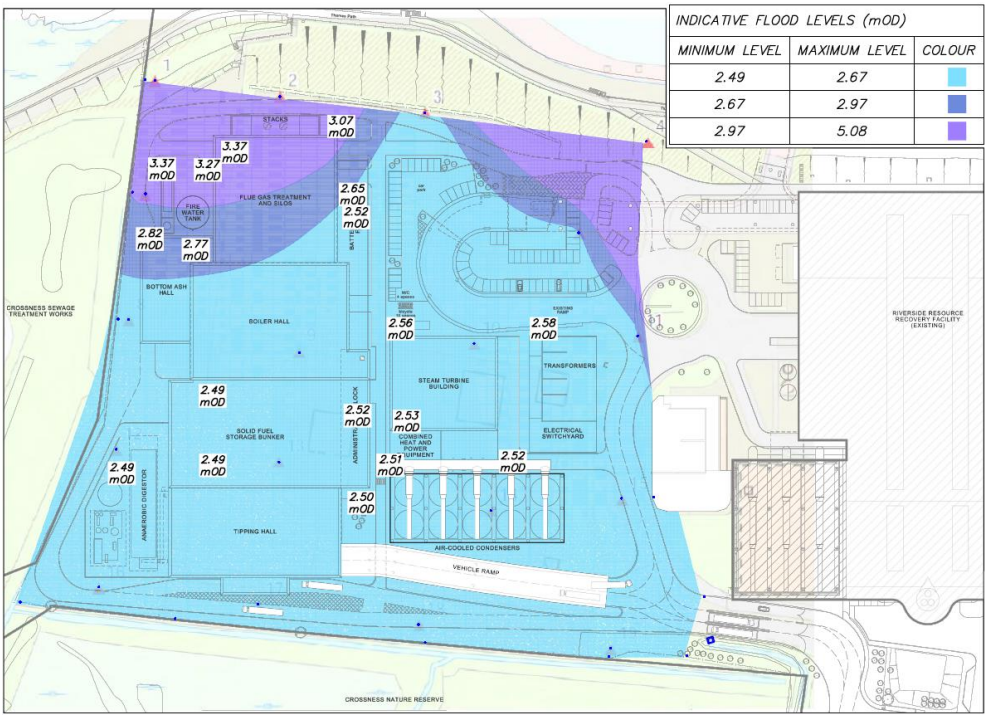


Figure 7.1: Indicative Flood Levels based on nodes from Thames Tidal Downriver Breach Inundation Modelling 2018

It is recommended the finished floor levels are set above the predicted maximum water level resulting from a breach in the defences. Proposed finished floor levels and resulting freeboard levels are summarised within Table 7.1 below. The proposed freeboards are provided to account for modelling tolerances and future climate change.

Higher flood levels are expected within the north west corner in the event of a breach and there is the potential for water to enter the FGT area via the door within the north west corner of the building. It is therefore recommended that within this area all flood sensitive equipment (e.g. silos, SCR/stacks, and equipment / electrical fixtures within the FGT building) are set at a level min. 400mm above the recommended FFL of 2.97mOD to provide additional flood resilience in the event of a breach.

Table 7.1: Proposed Final Floor Levels

Proposed Element	Minimum FFL to be (mOD)	Freeboard Provided
Tipping hall	2.97 mOD	480 mm
Administration block	2.97 mOD	450 mm
CHP equipment	2.97 mOD	440 mm

Table 7.1: Proposed Final Floor Levels

Proposed Element	Minimum FFL to be (mOD)	Freeboard Provided
Steam turbine building	2.97 mOD	410 mm
Transformers / switchyard	2.97 mOD	380 mm
Battery storage facility / E-Housing	2.97 mOD	300 mm
Boiler hall	2.97 mOD	210 mm
Fire water tank	FFL 2.97 mOD & storage bunds to extend above flood level.	-
AFT - Storage tanks for chemicals / fuel	FFL 2.97 mOD & storage bunds to extend above flood level.	-
Flue Gas Treatment	Flood level ~3.26mOD - min. FFL 2.97 mOD and all flood sensitive equipment to be >400mm above FFL.	-
Silos	Flood level ~3.37mOD - min. FFL 2.97 mOD and all flood sensitive equipment to be >400mm above FFL.	-
SCR / Stacks	Flood level ~3.48mOD - min. FFL 2.97 mOD and all flood sensitive equipment to be >400mm above FFL.	-
Bottom Ash hall	To be determined based on site layout and existing ground levels.	-
Elements of the Anaerobic Digester plant	To be determined based on site layout and existing ground levels.	-
Air Cooled Condensers	To be determined based on site layout and existing ground levels.	-
Solid fuel storage bunker	To be determined based on site layout and existing ground levels.	-

8.0 CONCLUSIONS

8.1 This Floor level strategy Report has been prepared by Doran Consulting Ltd. for the development of an energy recovery facility / integrated energy park - the Riverside Energy Park (REP).

8.2 The proposed development is within Flood Zone 3; but falls within an area that benefits from flood defences and therefore can only be flooded from river/sea sources in the event of a breach.

8.3 Proposed FFL for the elements at the REP site outlining as being at risk from flood waters will be set at **minimum 2.97 mOD.**

8.4 In areas to the north west corner where highest flood levels are predicted i.e. the FGT area; equipment is proposed that all flood sensitive equipment is to be located min. 400mm above the FFL of 2.97mOD to provide additional flood resilience.

8.5 As the REP development is an extension to the existing Riverside Resource Recovery Facility and will utilise existing access roads and pathways; the logistics of maintaining the existing access / egress will need to be considered when setting final floor levels for remaining elements of the REP site.

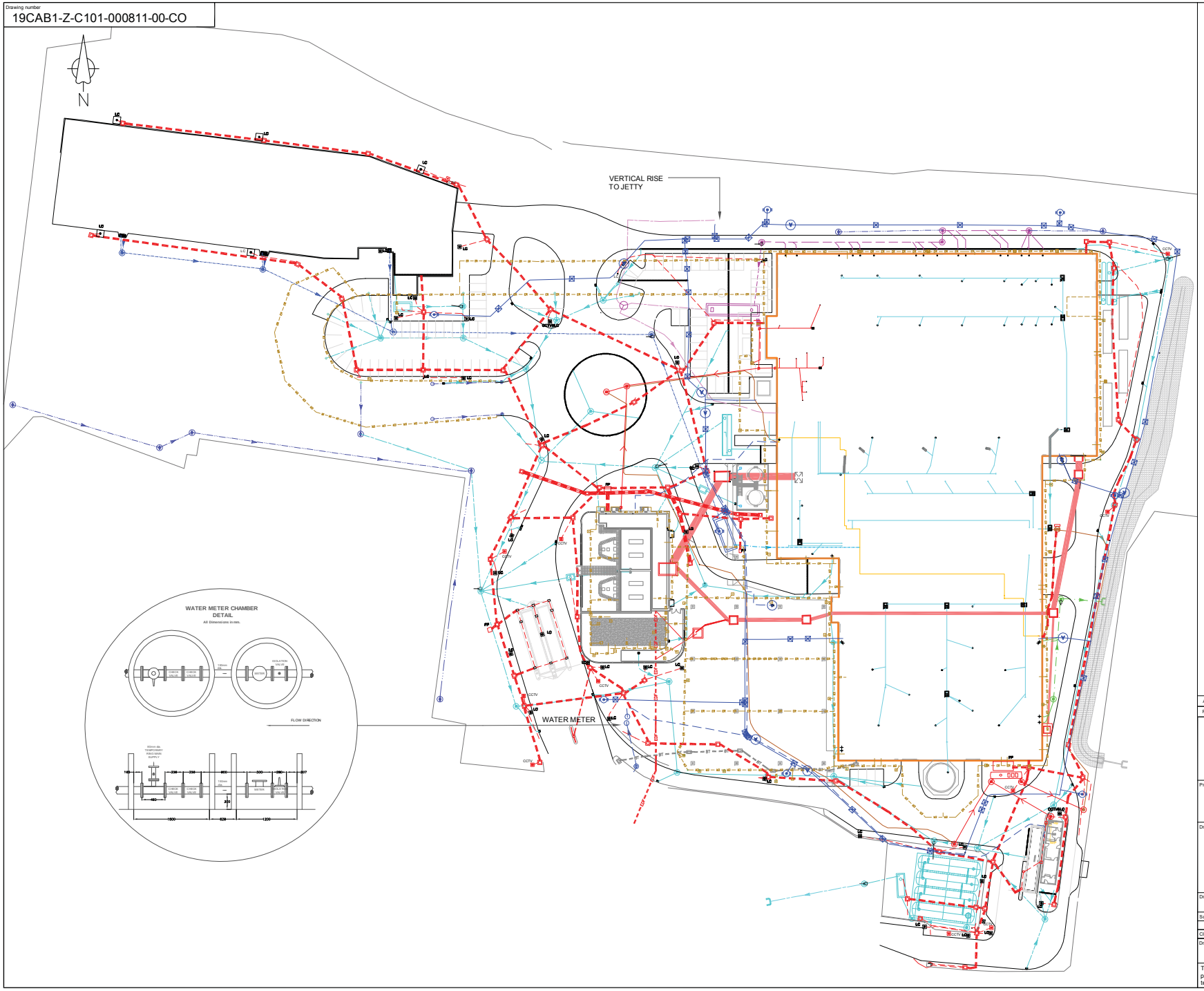
8.6 The flood level and freeboard allowance outlined should be discussed and approved with the Environment Agency.

Electronic Copy

APPENDIX A

Riverside Resource Recovery Facility As-Built Services
Doc Ref 2.4 Illustrative Site Layout Plan
Doc Ref 2.6 Illustrative Access/Parking/Landscaping Plan

Drawing number
19CAB1-Z-C101-000811-00-CO



LEGEND

EXTERNAL DRAINAGE

- Penstock valve
- Surface water network pipe and manhole
- Slag water network pipe and manhole
- Slag water rising main
- Thames roof water network pipe and manhole
- Thames roof water rising main
- Wet land roof water network pipe and manhole
- Filter water drain and catchpit manhole
- Linear drainage
- Road gully
- Ramp gully
- Foul sewer network pipe and manhole
- Foul pumped main

INTERNAL DRAINAGE

- Foul above ground network and riser
- Surface Water Drainage & Manhole
- Pipework cast into concrete foundation
- Internal Gully
- Pipe Upstand

FIREMAIN & POTABLE WATER

- Firemain
- Valve
- Hydrant
- Electro-fusion Joint
- Potable Water

CABLEWAYS AND DRAWPITS

- Drawpit (DP) and cable ducts
- Drawpit and 11kV cable ducts
- BT cable ducts
- EDF cable ducts
- 11kv Drawpit and cable ducts
- 50 - 160mm dia small power cable ducts
- Earthing tape
- Earthing Rod Location
- LC Lighting Column
- CCTV CCTV Column

NOTES:

This Drawing is for reference only.
For further details and as-built information please refer to the following as-built drawings:-

19CAB1-Z-C101-000788-AB-CO - Ducting
19CAC1-S-702.02b-501-AB-CO - Drainage
19CAC1-S-702.02b-502-AB-CO - Drainage
19CAC1-S-702.02b-503-AB-CO - Drainage
19CAC1-S-702.02b-504-AB-CO - Drainage
19CAC1-S-702.02b-505-AB-CO - Drainage

AS BUILT

Rev	Rev. Date	Purpose of revision	Drawn	Checked	Approved
AB	13-12-11	AS BUILT INFORMATION ADDED.	DJ	NG	AM

COSTAIN
Head Office
Costain House
Vanwall Business Park
Maidenhead
SL6 4UB

Project
RIVERSIDE
RESOURCE RECOVERY
FACILTY

Drawing title
COMBINED SERVICES
AS BUILT

Drawing status: AS-BUILT

Scale	1:500@ A1	DO NOT SCALE

Client no.

Drawing Number: 19CAB1-Z-C101-000811-00-CO
Rev: AB

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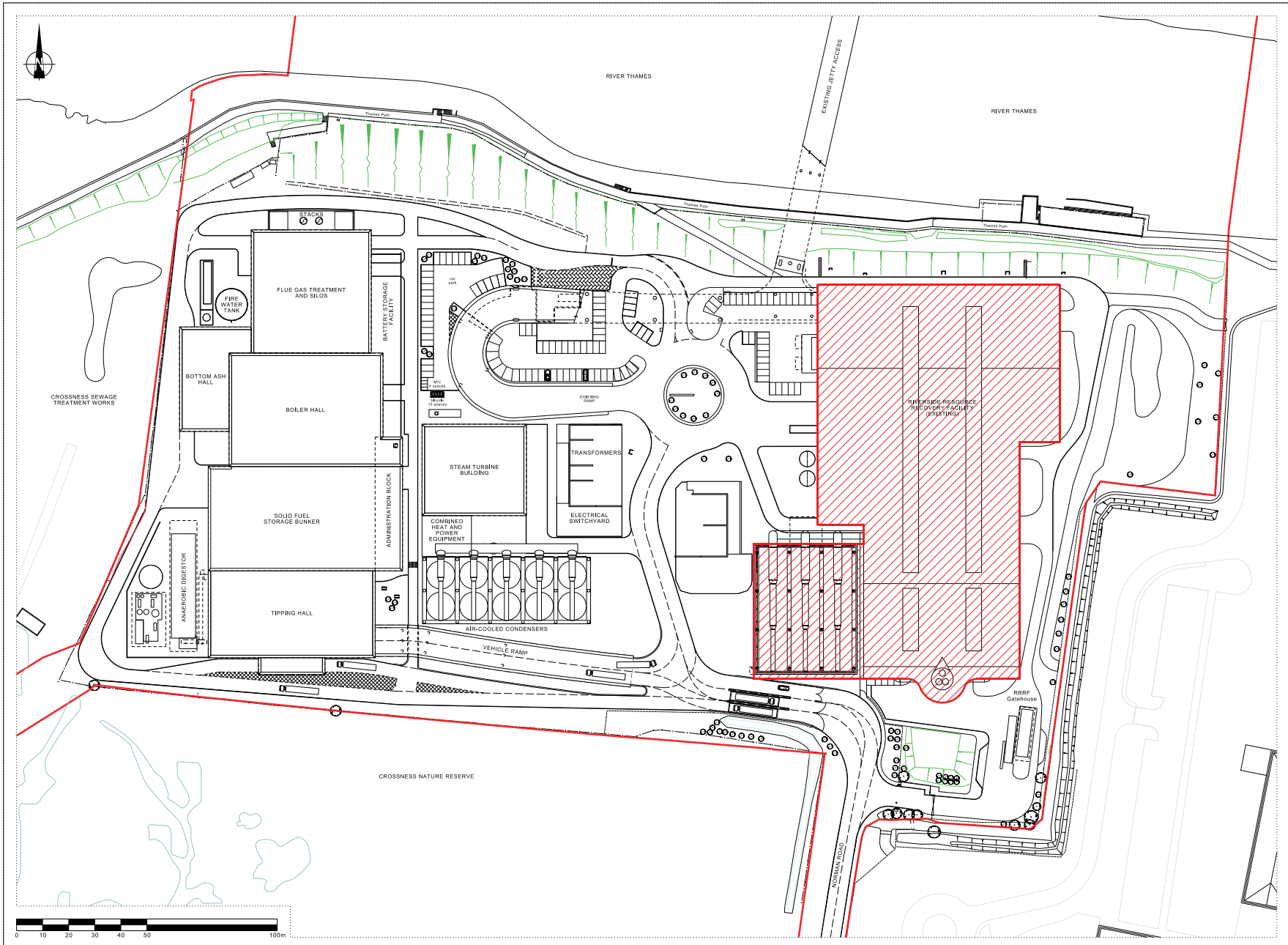

KEY:

ORDER LIMITS

AREA NOT INCLUDED IN DEVELOPMENT CONSENT ORDER

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RIVERSIDE ENERGY PARK

NORMAN ROAD BELVEDERE LONDON

DOC REF 2.4 ILLUSTRATIVE SITE LAYOUT PLAN

THE RIVERSIDE ENERGY PARK SITE LONDON

REGULATION 5(2)(o)

Date	22.10.18
A1 Scale	1:750
Drawn by	AG
Checked by	PC
Drawing Number	DOC REF 2.4

KEY:

- ORDER LIMITS
- AREA NOT INCLUDED IN DEVELOPMENT CONSENT ORDER
- MAIN VEHICLE CIRCULATION ROUTE
- JETTY VEHICLE ROUTE
- ANAEROBIC DIGESTION OUTPUT COLLECTION VEHICLE ROUTE
- BOTTOM ASH COLLECTION ROUTE
- ANCILLARY VEHICLE CIRCULATION ROUTE
- STAFF/VISITOR ROUTE

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RIVERSIDE ENERGY PARK

NORMAN ROAD BELVEDERE LONDON

DOC REF 2.6 ILLUSTRATIVE ACCESS/PARKING/LANDSCAPING PLAN

THE RIVERSIDE ENERGY PARK SITE LONDON

REGULATION 5(2)(o)

Date	22.10.18
A1 Scale	1:750
Drawn by	AG
Checked by	PC
Drawing Number	DOC REF 2.6

Electronic Copy

APPENDIX B

Environment Agency Product 4
Environment Agency Product 8
Environment Agency Correspondence

Product 4 (Detailed Flood Risk) for: Land adjacent to Riverside Resource Recovery Ltd [TQ4946780680]

Requested by: Stuart Harwood, Peter Brett Associates LLP
Reference: KSL 87642 AB (previous request KSL 74869 UE)
Date: 4 June 2018

Contents

- Flood Map for Planning (Rivers and Sea)
- Flood Map Extract
- Thames Estuary 2100 (TE2100)
- Thames Tidal Downriver Breach Inundation Modelling 2018
- Thames Tidal Downriver Breach Inundation Modelling Map
- Site Node Locations Map
- Defence Details
- Recorded Flood Events Data
- Recorded Flood Events Outlines Map
- Additional Information

The information provided is based on the best data available as of the date of this letter.

You may feel it is appropriate to contact our office at regular intervals, to check whether any amendments/ improvements to the data for this location have been made. Should you re-contact us after a period of time, please quote the above reference in order to help us deal with your query.

Please refer to the Open Government Licence which explains the permitted use of this information.

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Email: kslenquiries@environment-agency.gov.uk
Website: https://www.gov.uk/government/organisations/environment-agency

Flood Map for Planning (Rivers and Sea)

The Flood Map:

Our Flood Map shows the natural floodplain for areas at risk from river and tidal flooding. The floodplain is specifically mapped ignoring the presence and effect of defences. Although flood defences reduce the risk of flooding they cannot completely remove that risk as they may be over topped or breached during a flood event.

The Flood Map indicates areas with a 1% (0.5% in tidal areas), Annual Exceedance Probability (AEP) - the probability of a flood of a particular magnitude, or greater, occurring in any given year, and a 0.1% AEP of flooding from rivers and/or the sea in any given year. In addition, the map also shows the location of some flood defences and the areas that benefit from them.

The Flood Map is intended to act as a guide to indicate the potential risk of flooding. When producing it we use the best data available to us at the time and also take into account historic flooding and local knowledge. The Flood Map is updated on a quarterly basis to account for any amendments required. These amendments are then displayed on the internet at https://www.gov.uk/check-flood-risk

At this Site:

The Flood Map shows that this site lies within the outline of Flood Zone 3. This zone comprises land assessed as having a 0.5% (1 in 200) or greater annual probability of tidal flooding.

Enclosed is an extract of our Flood Map which shows this information for your area.

Method of production

The Flood Map at this location has been derived using detailed modelling of the tidal River Thames through the North Kent Coastal Modelling study completed in 2013 by JBA Consulting.

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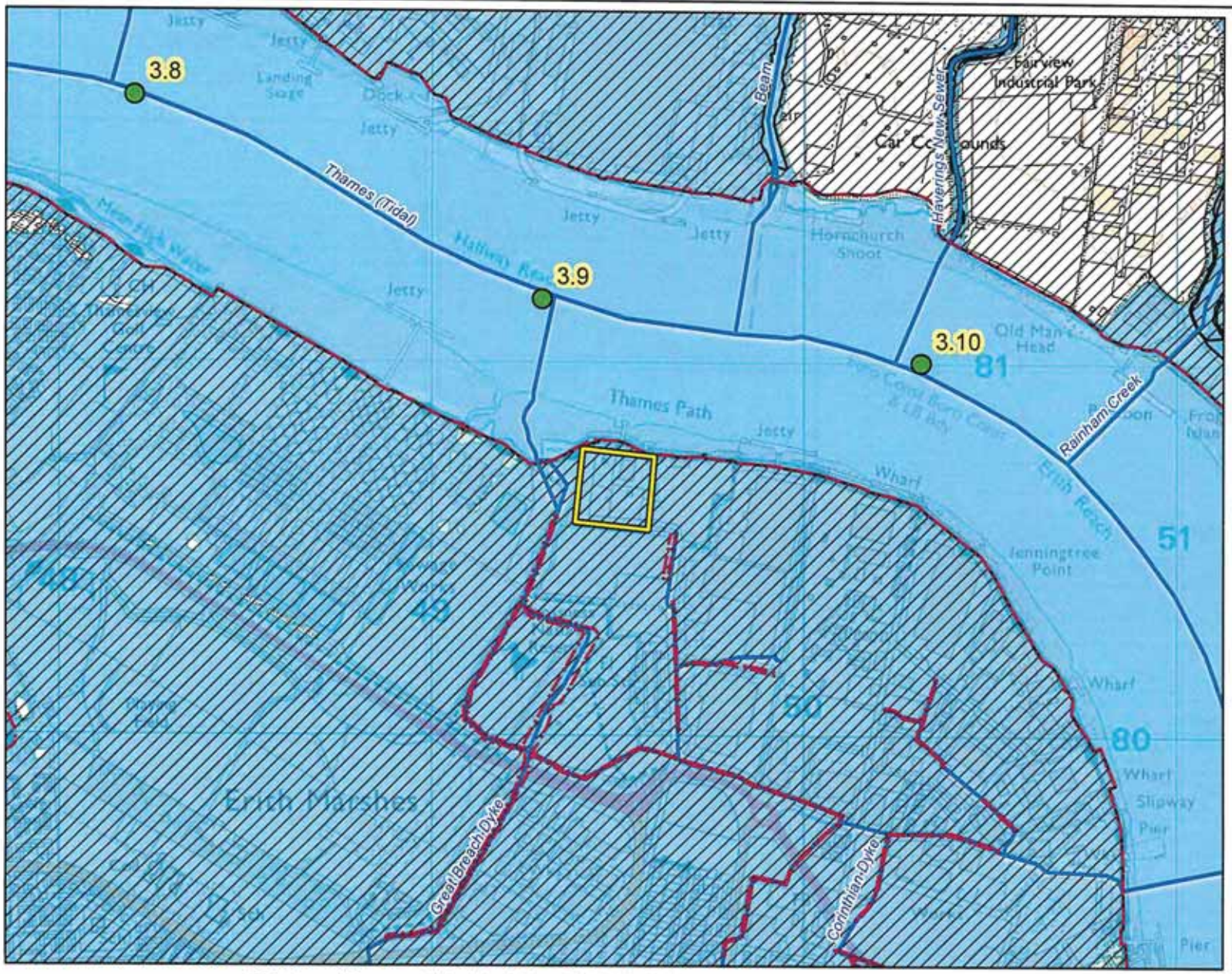
Detailed FRA/FCA Map centred on TQ4946780680 created 4 June 2018 [Ref: KSL 87642 AB]



Environment Agency

Scale 1: 15,000

Legend

- Site Location
- TE2100 Model Nodes
- Flood Map - Defences
- Main Rivers
- Flood Map - Flood Storage Areas
- Areas Benefiting from Flood Defences
- Flood Map - Flood Zone 3
- Flood Map - Flood Zone 2

Flood Map for Planning (assuming no defences)

Flood Zone 3 shows the area that could be affected by flooding:
- from the sea with a 0.5% or greater chance of occurring each year
- or from a river with a 1% or greater chance of occurring each year.

Flood Zone 2 shows the extent of an extreme flood from rivers or the sea with up to a 0.1% chance of occurring each year.

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Thames Estuary 2100 (TE2100)

You have requested in-channel flood levels for the tidal river Thames. These have been taken from the Thames Estuary 2100 study completed by HR Wallingford in 2008. The modelled node closest to your site is **3.9**; the locations of nearby nodes are also shown on the enclosed map.

Details about the TE2100 plan

The TE2100 plan is now live and within it are a set of levels on which the flood risk management strategy is based. The plan is the overarching flood management strategy for the Thames Estuary and therefore any development planning should be based on the same underlying data.

Details about the TE2100 in-channel levels

The TE2100 in-channel levels take into account operation of the Thames Barrier when considering future levels. The Thames Barrier requires regular maintenance and with additional closures the opportunity for maintenance will be reduced. When this happens, river levels – for which the Barrier would normally shut for the 2008 epoch – will have to be allowed through to ensure that the barrier is not shut too often. For this reason, levels upriver of the barrier will increase and the tidal walls will need to be heightened to match.

For further information about the Thames Barrier please visit our website at:

https://www.gov.uk/the-thames-barrier

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TE2100 2008 levels:

Levels downriver of the Thames Barrier are 0.1% AEP (1 in 1000) and levels upriver are the highest levels permitted by the Thames Barrier, described as the Maximum Likely Water Levels (MLWLs). The defence levels (left defence, right defence) are the minimum levels to which the defences should be built.

Location	Node	Easting	Northing	Extreme water level (m)	Left defence (m)	Right defence (m)	Allow for future defence raising to a level of...	
							Left Bank (m)	Right Bank (m)
	3.7	547183	181618	6.01	7.30	7.10	8.20	8.20
	3.8	548204	181714	6.01	7.30	7.10	8.20	8.20
Beam River	3.9	549299	181171	6.00	7.20	7.10	8.20	8.20
	3.10	550318	181003	5.98	7.10	7.10	8.10	8.10
	3.11	551166	180048	5.97	7.05	7.10	8.10	8.10

TE2100 climate change levels:

Location	Node	Easting	Northing	1000-year design water levels					
				2000	2040	2070	2100	2120	2170
	3.7	547183	181618	6.01	6.22	6.42	6.75	6.95	7.46
	3.8	548204	181714	6.01	6.22	6.41	6.74	6.94	7.44
Beam River	3.9	549299	181171	6.00	6.21	6.40	6.72	6.92	7.42
	3.10	550318	181003	5.98	6.19	6.37	6.70	6.90	7.40
	3.11	551166	180048	5.97	6.18	6.37	6.70	6.90	7.39

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Thames Tidal Downriver Breach Inundation Modelling - 2018

The table below displays site-specific modelled flood levels at your site. These have been taken from the Downrvier Breach Inundation Modelling Study 2018 completed by Atkins Ltd. in May 2018.

We have developed a modelling approach where all downriver breach locations along the Thames are equitably modelled, to ensure a consistent approach across London. This modelling simulates continuous tidal breaches along the entire extent of the Thames between the Thames Barrier and east of Gravesend on the south bank and east of Tilbury on the north bank. For hard and composite defences breaches are set at 20 m wide; for soft defences, breaches are 50 m wide. In both cases, the defence breach scour distance was assumed to extend into the floodplain by the same distance as the breach width.

Based on the 2008 TE2100 in-channel levels, the 0.5% (1 in 200 year) and 0.1% (1 in 1000 year) annual probability of exceedance tidal events were modelled for all breach locations downriver of the Thames Barrier. These were modelled for the 2014 year epoch (current year), as well as 2100 epoch which include allowances for climate change.

This model has been designed for catchment wide flood risk mapping. It should be noted that it was not created to produce flood levels for specific development sites within London.

	National Grid Reference		Modelled levels in mAODN for 0.5% AEP		Modelled levels in mAODN for 0.1% AEP	
Node	Easting	Northing	2014	2115	2014	2115
1	549411	180767	4.82	5.08	4.93	5.14
2	549458	180761	3.58	3.72	3.64	3.77
3	549511	180755	2.30	2.49	2.34	2.63
4	549593	180744	4.30	4.56	4.40	4.63
5	549407	180725	2.92	3.01	2.96	3.04
6	549485	180713	2.28	2.49	2.32	2.63
7	549568	180710	2.51	2.58	2.55	2.63
8	549401	180679	2.37	2.49	2.41	2.63
9	549464	180667	2.03	2.49	2.08	2.63
10	549529	180669	2.45	2.62	2.52	2.67
11	549590	180672	2.37	2.53	2.43	2.63

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	National Grid Reference		Modelled levels in mAODN for 0.5% AEP		Modelled levels in mAODN for 0.1% AEP	
Node	Easting	Northing	2014	2115	2014	2115
12	549396	180631	1.92	2.49	1.97	2.63
13	549457	180626	1.97	2.49	2.02	2.63
14	549535	180608	1.97	2.49	2.01	2.63
15	549584	180612	1.99	2.49	2.02	2.63
16	549390	180580	1.87	2.49	1.97	2.63
17	549449	180573	1.87	2.49	1.97	2.63
18	549508	180565	1.87	2.49	1.97	2.63
19	549579	180556	1.87	2.49	1.97	2.63

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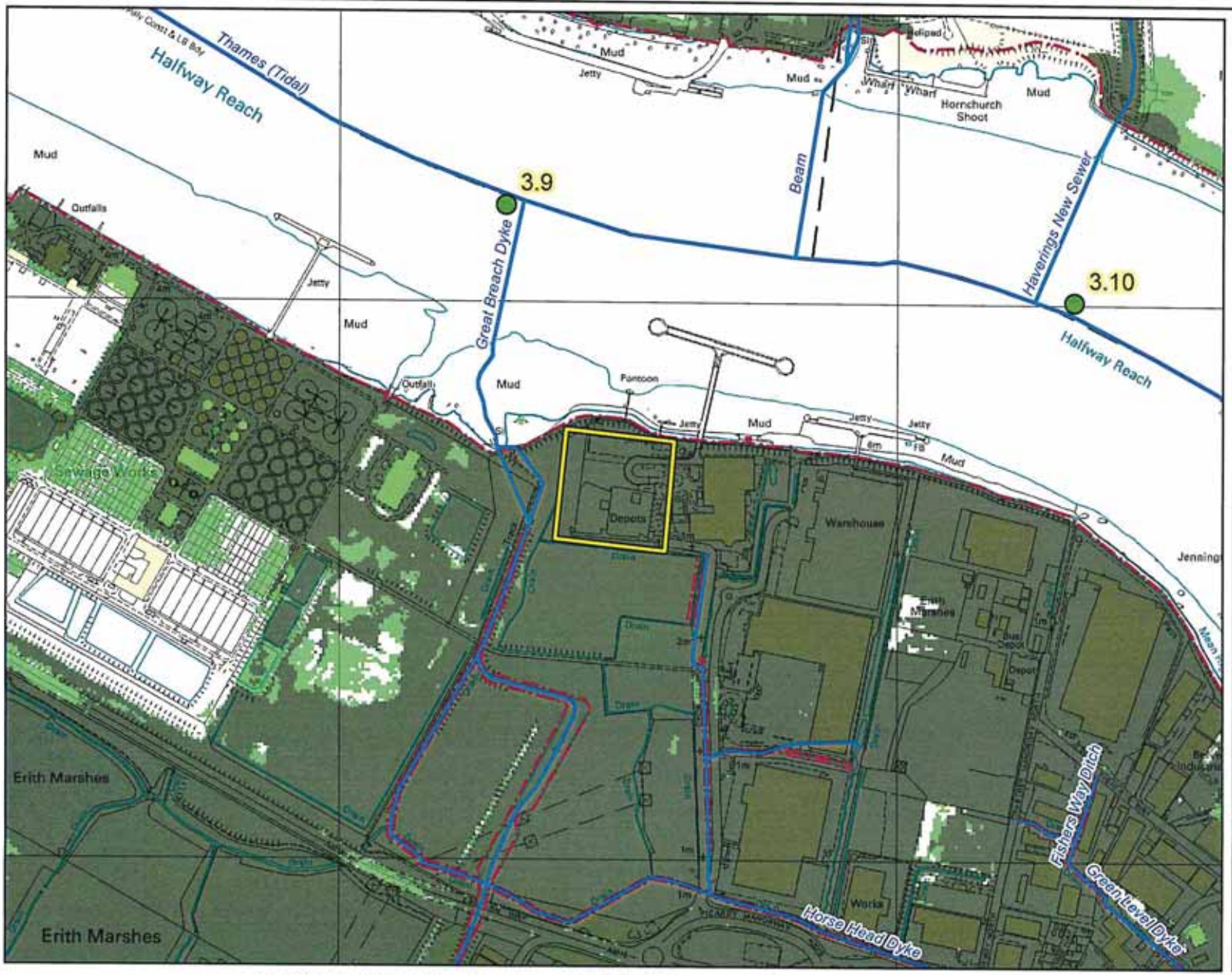
Downriver Breach Modelling Map centred on TQ4946780680 created 4 June 2018 [Ref: KSL 87642 AB]



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Scale 1: 10,000

Legend

- Site Location
- TE2100 Model Nodes
- Main Rivers
- Flood Map - Defences

Downriver 0.5% AEP Outlines

Epoch

- 2014 (Current year)
- 2115

Thames Tidal Downriver Breach Inundation Modelling 2018

A modelled representation of all tidal breach locations along the Thames from the Thames Barrier to Gravesend, based on low floodplain topography. For hard and composite defences breaches are set at 20 m wide; for soft defences, breaches are 50 m wide. In both cases, the defence breach scour distance was assumed to extend into the floodplain by the same distance as the breach width. The modelling is based on the 2008 TE2100 in-channel levels, with an allowance for climate change for epoch 2115.

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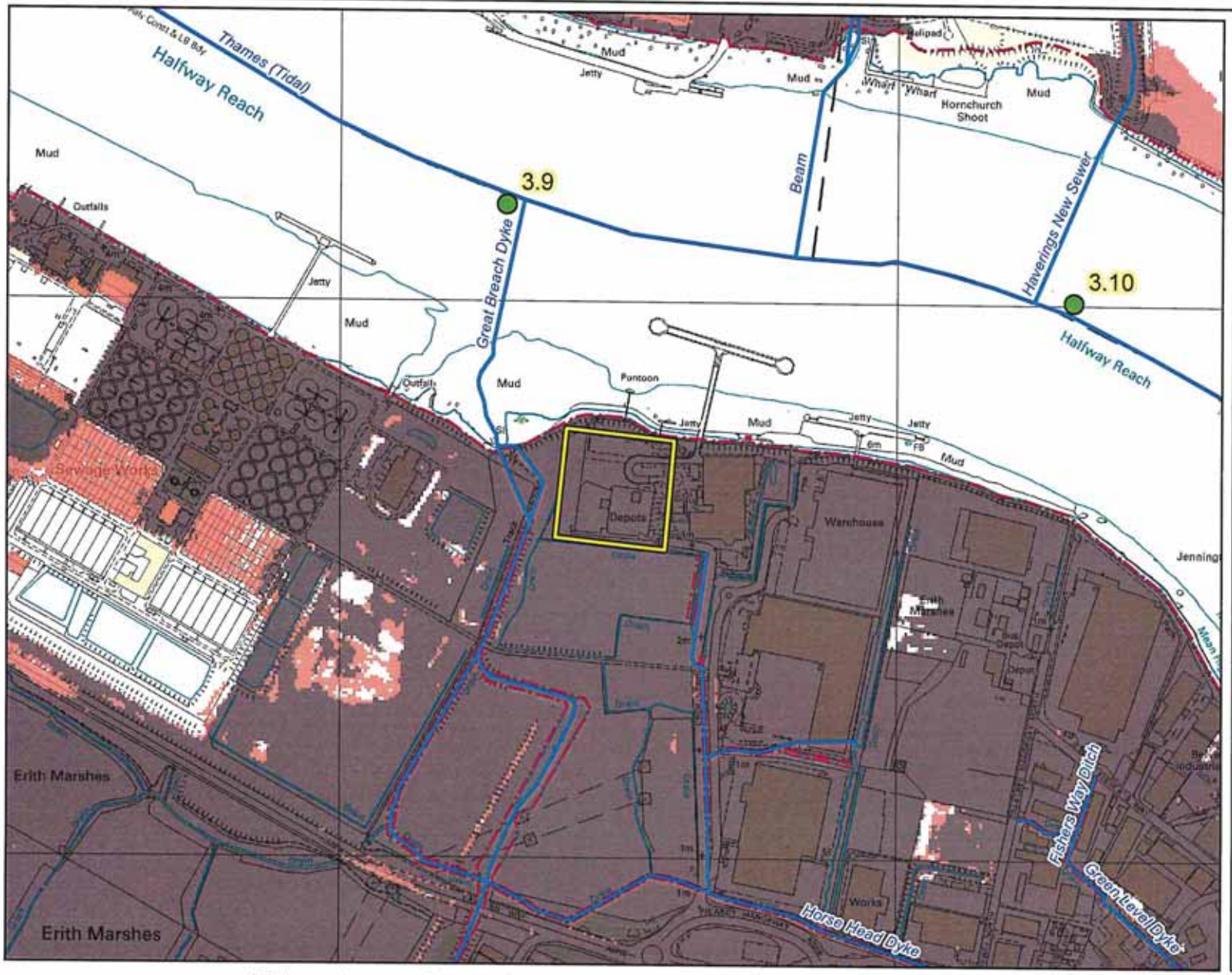
Downriver Breach Modelling Map centred on TQ4946780680 created 4 June 2018 [Ref: KSL 87642 AB]



Environment Agency

Scale 1: 10,000

Legend

- Site Location
- TE2100 Model Nodes
- Main Rivers
- Flood Map - Defences

Downriver 0.1% AEP Outlines

Epoch

- 2014 (Current year)
- 2115

Thames Tidal Downriver Breach Inundation Modelling 2018

A modelled representation of all tidal breach locations along the Thames from the Thames Barrier to Gravesend, based on low floodplain topography. For hard and composite defences breaches are set at 20 m wide; for soft defences, breaches are 50 m wide. In both cases, the defence breach scour distance was assumed to extend into the floodplain by the same distance as the breach width.
The modelling is based on the 2008 TE2100 in-channel levels, with an allowance for climate change for epoch 2115.

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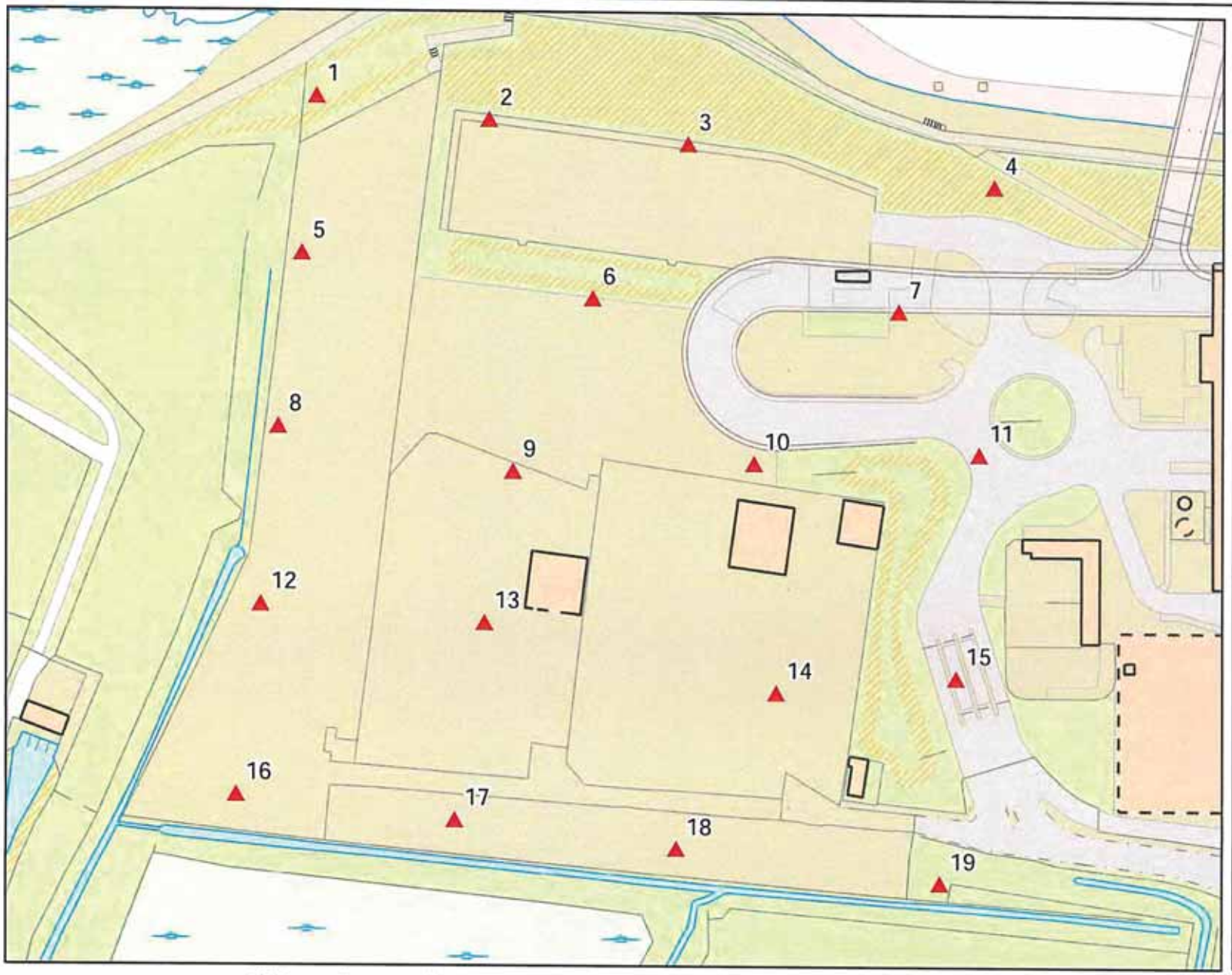
Node Location Map centred on TQ4946780680 created 4 June 2018 [Ref: KSL 87642 AB]



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Scale 1: 1,500

Legend

▲ Node Point Locations

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Defence Details

The design standard of protection of the flood defences in this area of the Thames is 0.1% AEP; they are designed to defend London up to a 1 in 1000 year **tidal** flood event. The defences are all raised, man-made and privately owned. It is the riparian owners' responsibility to ensure that they are maintained to a crest level of **7.10m AODN** (the Statutory Flood Defence Level in this reach of the Thames). We inspect them twice a year to ensure that they remain fit for purpose. The current condition grade for defences in the area is 2 (good), on a scale of 1 (very good) to 5 (very poor). For more information on your rights and responsibilities as a riparian owner, please see our document 'Living on the edge' found on our website at:

https://www.gov.uk/government/publications/riverside-ownership-rights-and-responsibilities

There are no planned improvements in this area. Please see the 'Thames Estuary 2100' document on our website for the short, medium and long term Flood Risk Management strategy for London:

https://www.gov.uk/government/publications/thames-estuary-2100-te2100

Areas Benefiting from Flood Defences

This site is within an area benefiting from flood defences, as shown on the enclosed extract of our Flood Map. Areas benefiting from flood defences are defined as those areas which benefit from formal flood defences specifically in the event of flooding from rivers with a 1% (1 in 100) chance in any given year, or flooding from the sea with a 0.5% (1 in 200) chance in any given year.

If the defences were not there, these areas would be flooded. An area of land may benefit from the presence of a flood defence even if the defence has overtopped, if the presence of the defence means that the flood water does not extend as far as it would if the defence were not there.

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Recorded Flood Events Data

We hold records of historic flood events from rivers and the sea. Information on the floods that may have affected the area local to your site is provided below and in the enclosed map (if relevant).

Flood Event Data

1953 – The site was subject to tidal flooding, due to a storm surge in the North Sea, on the night of the 31st January into the morning of 1st February. An approximate level in the Thames at the time was 5.10m AODN.

Due to the fact that our records are not comprehensive, we would advise that you make further enquiries locally with specific reference to flooding at this location. You should consider contacting the relevant Local Planning Authority and/or water/sewerage undertaker for the area.

We map flooding to land, not individual properties. Our historic flood event record outlines are an indication of the geographical extent of an observed flood event. Our historic flood event outlines do not give any indication of flood levels for individual properties. They also do not imply that any property within the outline has flooded internally.

Please be aware that flooding can come from different sources. Examples of these are:

- from rivers or the sea;
- surface water (i.e. rainwater flowing over or accumulating on the ground before it is able to enter rivers or the drainage system);
- overflowing or backing up of sewer or drainage systems which have been overwhelmed,
- groundwater rising up from underground aquifers

Currently the Environment Agency can only supply flood risk data relating to the chance of flooding from rivers or the sea. However you should be aware that in recent years, there has been an increase in flood damage caused by surface water flooding and drainage systems that have been overwhelmed.

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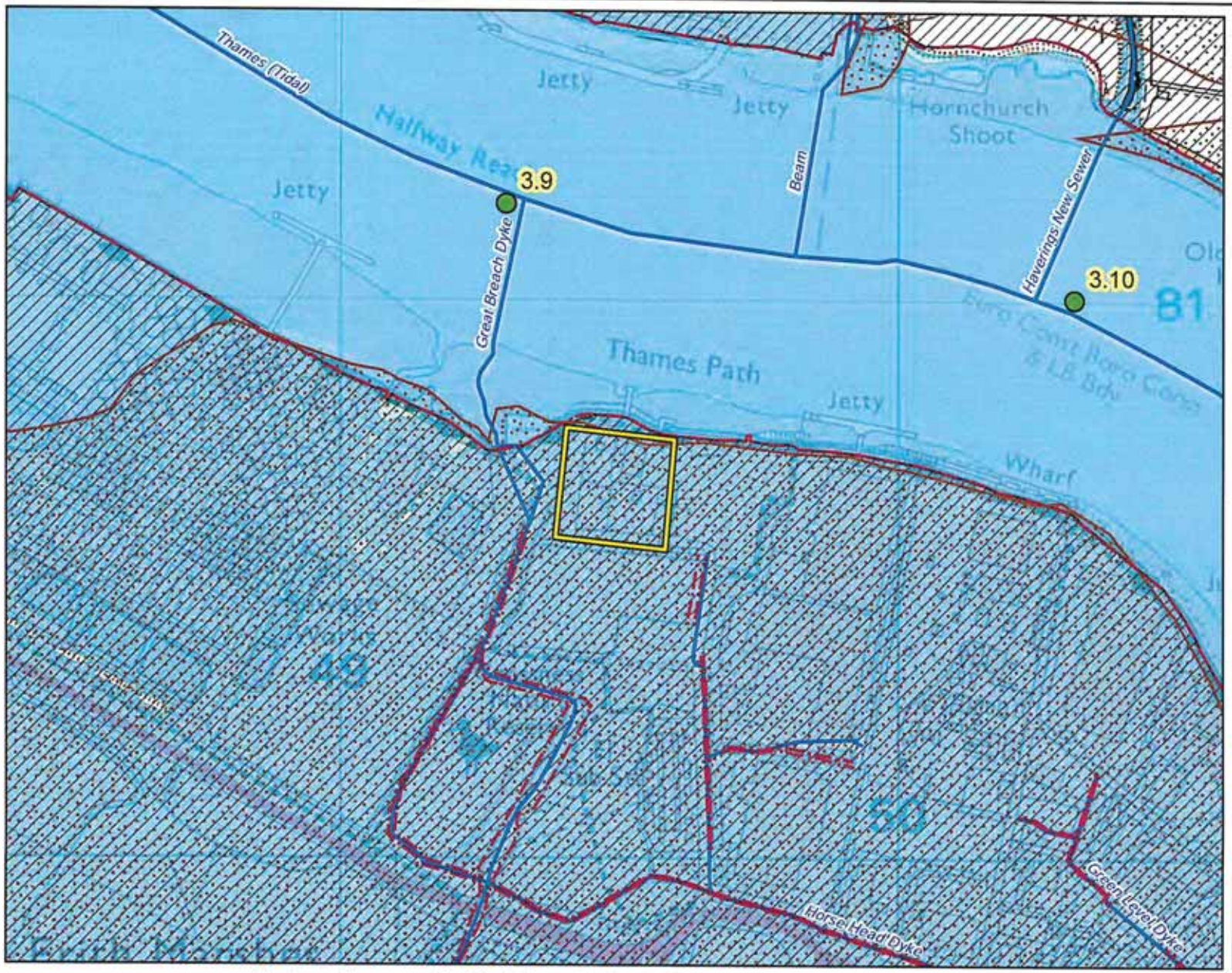
Historic Flood Map centred on TQ4946780680 created 4 June 2018 [Ref: KSL 87642 AB]



Environment Agency

Scale 1: 10,000

Legend

- Site Location
- TE2100 Model Nodes
- Flood Map - Defences
- Main Rivers
- Jan 1953 Flood Outline
- Flood Map - Flood Storage Areas
- Areas Benefiting from Flood Defences
- Flood Map - Flood Zone 3
- Flood Map - Flood Zone 2

Flood Map for Planning
(assuming no defences)

Flood Zone 3 shows the area that could be affected by flooding:
- from the sea with a 0.5% or greater chance of occurring each year
- or from a river with a 1% or greater chance of occurring each year.

Flood Zone 2 shows the extent of an extreme flood from rivers or the sea with up to a 0.1% chance of occurring each year.

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Contact Us: National Customer Contact Centre, PO Box 544, Rotherham, S60 1BY. Tel: 03708 506 506 (Mon-Fri 8-6). Email: enquiries@environment-agency.gov.uk

Additional Information

Information Warning - OS background mapping

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Planning advice and guidance

The Environment Agency are keen to work with partners to enable development which is resilient to flooding for its lifetime and provides wider benefits to communities. If you have requested this information to help inform a development proposal, then we recommend engaging with us as early as possible by using the pre-application form available from our website:
https://www.gov.uk/government/publications/pre-planning-application-enquiry-form-preliminary-opinion

Complete the form in the link and email back to kslplanning@environment-agency.gov.uk

We recognise the value of early engagement in development planning decisions. This allows complex issues to be discussed, innovative solutions to be developed that both enables new development and protects existing communities. Such engagement can often avoid delays in the planning process following planning application submission, by reaching agreements up-front. We offer a charged pre-application advice service for applicants who wish to discuss a development proposal.
We can also provide a preliminary opinion for free which will identify environmental constraints related to our responsibilities including flooding, waste, land contamination, water quality, biodiversity, navigation, pollution, water resources, foul drainage or Environmental Impact Assessment.

Orchard House, Endeavour Park, London Road, Addington, West Malling, Kent, ME19 5SH.
Customer services line: 020 8474 6848
Email: kslenquiries@environment-agency.gov.uk
Website: https://www.gov.uk/government/organisations/environment-agency

Flood Risk Assessments guidance

Flood risk standing advice for applicants

In preparing your planning application submission, you should refer to the Environment Agency's Flood Risk Standing Advice and the Planning Practice Guidance for information about what flood risk assessment is needed for new development in the different Flood Zones. This information can be accessed via:

https://www.gov.uk/flood-risk-assessment-standing-advice

http://planningguidance.planningportal.gov.uk/

https://www.gov.uk/guidance/flood-risk-assessment-for-planning-applications

https://www.gov.uk/guidance/flood-risk-and-coastal-change

You should also consult the Strategic Flood Risk Assessment and flood risk local plan policies produced by your local planning authority.

You should note that:

1. Information supplied by the Environment Agency may be used to assist in producing a Flood Risk Assessment where one is required, but does not constitute such an assessment on its own.
2. This information covers flood risk from main rivers and the sea, and you will need to consider other potential sources of flooding, such as groundwater or overland runoff. You should discuss surface water management with your Lead Local Flood Authority.
3. Where a planning application requires a FRA and this is not submitted or deficient, the Environment Agency may well raise an objection due to insufficient information

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Surface Water

We have provided two national Surface Water maps, under our Strategic Overview for flooding, to your Lead Local Flood Authority who are responsible for local flood risk (i.e. surface runoff, ground water and ordinary watercourse), which alongside their existing local information will help them in determining what best represents surface water flood risk in your area.

Your Lead Local Flood Authority have reviewed these and determined what it believes best represents surface water flood risk. You should therefore contact this authority so they can provide you with the most up to date information about surface water flood risk in your area.

You may also wish to consider contacting the appropriate relevant Local Planning Authority and/or water/sewerage undertaker for the area. They may be able to provide some knowledge on the risk of flooding from other sources. We are working with these organisations to improve knowledge and understanding of surface water flooding.

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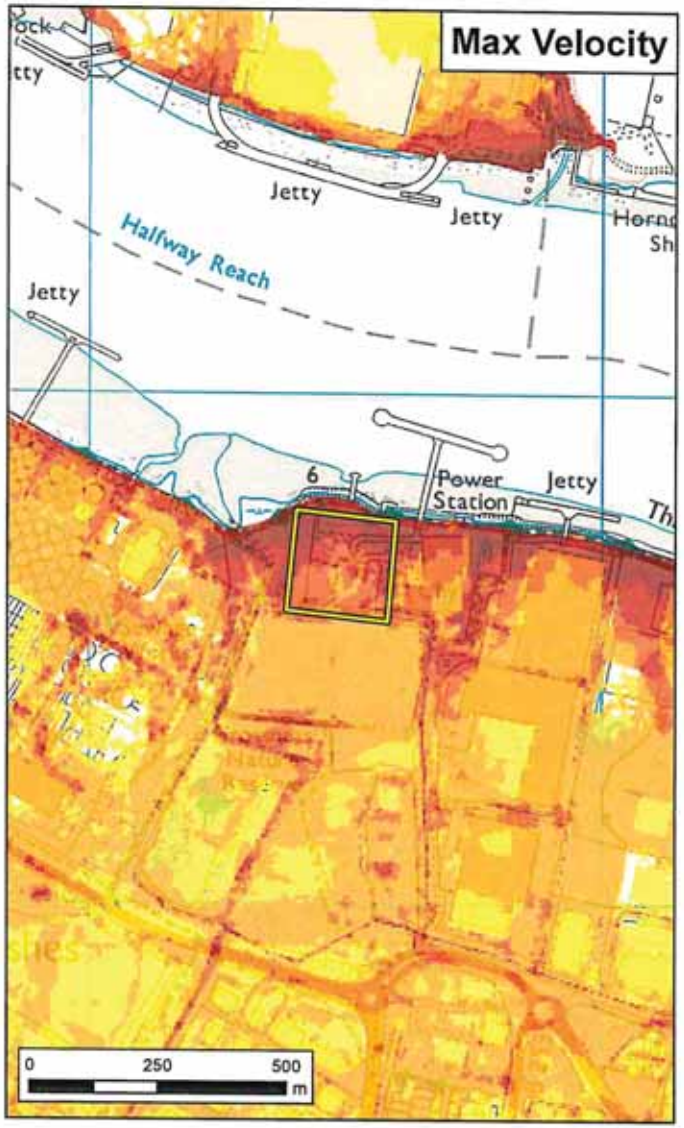

Max Hazard

- Less than 0.75 (Low Hazard)
- Between 0.75 and 1.25 (Danger for Some)
- Between 1.25 and 2.00 (Danger for Most)
- Greater than 2.00 (Danger for All)

Max Depth (m)

- 0 - 0.25
- 0.25 - 1.00
- 1.00 - 1.50
- 1.50 - 2.00
- > 2.00

Max Velocity (m/s)

- 0 - 0.3
- 0.3 - 1.0
- 1.0 - 1.5
- 1.5 - 2.5
- > 2.5

Date Printed	04/06/2018	Scenario year	2115	Scenario Annual Chance	0.5% (1 in 200)

This map shows the combined flood hazard to people (called a hazard rating) if our flood defences are breached at any given single location, for a range of scenarios. The hazard rating depends on the depth and velocity of floodwater, and maximum values of these are also mapped.

The map is based on computer modelling of simulated breaches covering the entire extent between the Thames Barrier and Gravesend. Each breach has been modelled individually and the results combined to create this map. Multiple breaches, other combinations of breaches, different sized tidal surges or flood flows may all give different results.

The map only considers the consequences of a breach, it does not make any assumption about the likelihood of a breach occurring. The likelihood of a breach occurring will depend on a number of different factors, including the construction and condition of the defences in the area. A breach is less likely where defences are of a good standard, but a risk of breaching remains.

Please contact the Environment Agency for further information on emergency planning associated with flood risk in this area.

General Enquiries No: 03708 506 506, Weekday Daytime calls cost 5p plus up to 6p per minute from BT Weekend Unlimited. Mobile and other providers' charges may vary

Environment Agency

Thames Tidal Downriver Breach Hazard Mapping

Map Centred on TQ4946780680
KSL 87642 AB

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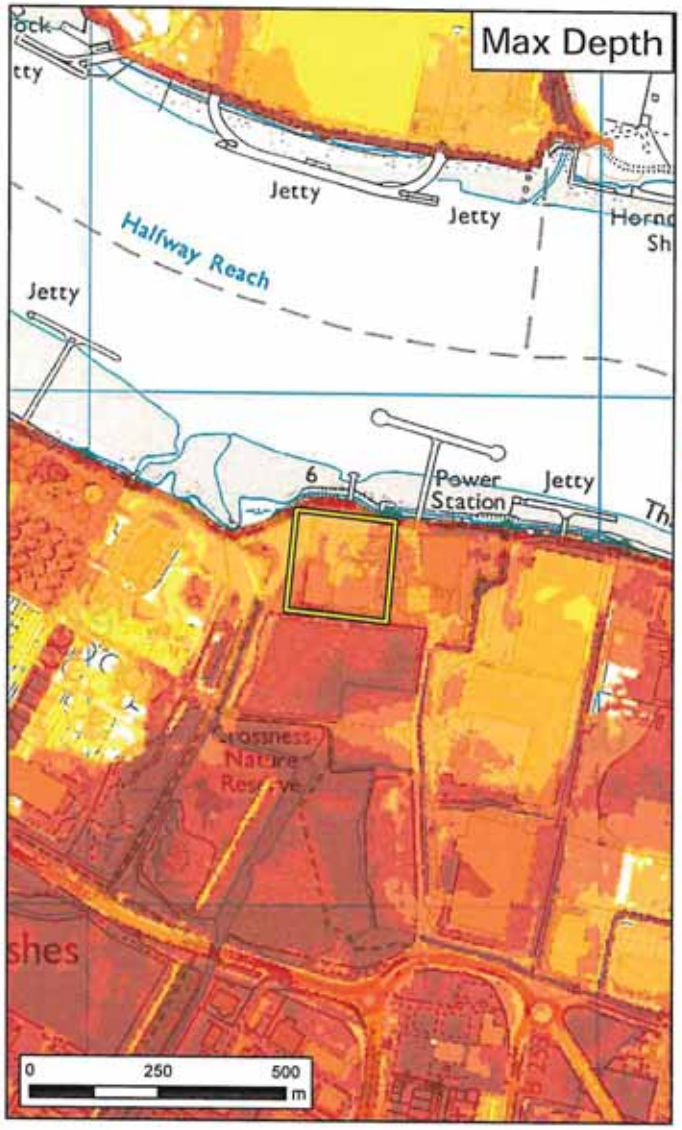

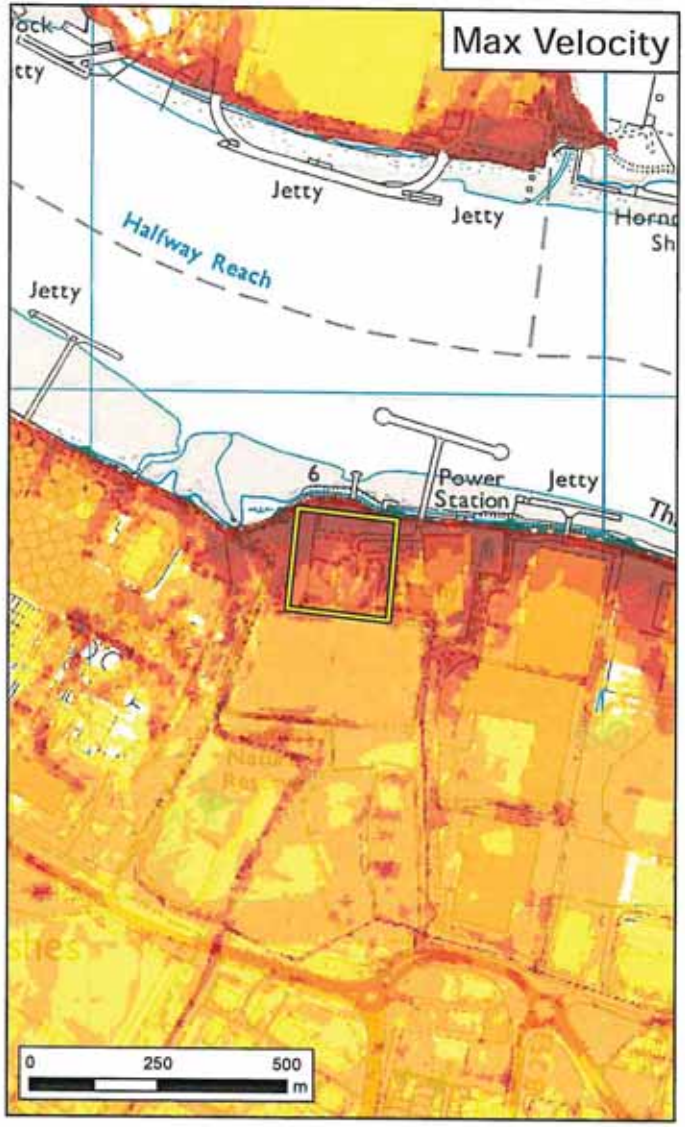

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Max Velocity (m/s)

- 0 - 0.3
- 0.3 - 1.0
- 1.0 - 1.5
- 1.5 - 2.5
- > 2.5

Date Printed	04/06/2018	Scenario year	2115	Scenario Annual Chance	0.1% (1 in 1000)

This map shows the combined flood hazard to people (called a hazard rating) if our flood defences are breached at any given single location, for a range of scenarios. The hazard rating depends on the depth and velocity of floodwater, and maximum values of these are also mapped.

The map is based on computer modelling of simulated breaches covering the entire extent between the Thames Barrier and Gravesend. Each breach has been modelled individually and the results combined to create this map. Multiple breaches, other combinations of breaches, different sized tidal surges or flood flows may all give different results.

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Environment Agency

Thames Tidal Downriver Breach Hazard Mapping

Map Centred on TQ4946780680
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From:	Martyn, Joe
To:	Riverside Energy Park
Subject:	EA response EN010093-000004 Scoping Opinion - Riverside Energy Park, Belvedere.
Date:	27 December 2017 09:37:57
Attachments:	SL 117720-01 (JM) Scoping Opinion Opinion Riverside Energy Park, Belvedere, EN010093-000004 .pdf

Dear Sir/madam

Please find attached our response. This was originally sent on the 22 of December. However I have just noticed it was in my draft box and so will not have reached you. I hope you can still considered our comments.

Kind regards

Joe Martyn
Planning Specialist - South London

Environment Agency | South East | Kent and South London | London

☏ **020 3025 5546** ✉ kslplanning@environment-agency.gov.uk

Environment Agency | 3rd Floor, Seacole Building, 2 Marsham Street, London SW1P 4DF

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Environment Agency

The Planning Inspectorate
Major Casework Directorate
Temple Quay House (2 The Square)
Temple Quay
Bristol
Avon
BS1 6PN

Our ref: SL/2017/117720/01-L01
Your ref: EN010093-000004

Date: 21 December 2017

Dear Sir/Madam

Scoping Opinion - An integrated energy park of up to 96 megawatts generating capacity (comprising waste energy recovery, waste anaerobic digestion, battery storage and solar generation) and associated electrical connection.

Riverside Energy Park, Belvedere.

We have review the Environmental Impact Scoping report by Peter Brett Associates Project Name: Riverside Energy Park, Belvedere. Project Ref: 42166, Report Title: EIA Scoping Report, Doc Ref: FINAL, Date: 24th November 2017 and wish to provide comments on the following:

- Flood Risk
- Thames Tidal Flood Defences
- Groundwater Protection
- Ecology
- Environmental Permits
- Waste Planning
- Water quality and the Water Framework Directive (WFD)

Flood Risk

The proposed development is defined by Table 2 of the Planning Practice Guidance (PPG) as Less Vulnerable/Essential Infrastructure. The site is within Flood Zone 3, defined by Table 1 of the PPG as land having a 1 in 200 or greater annual probability of sea flooding. The site is protected by the Thames Tidal defences, with a standard of protection of a 1 in 1000 annual probability of flooding. However, the site is situated within an area that would be flooded if there were to be a breach in the defences. We would expect any new development at this location to have finished floor levels set no lower than the breach flood event at this site.

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Thames Tidal Flood Defences
The Riverside Energy Park Site and an area of the Potential Temporary Construction Work Areas appear to be adjacent to the flood defences. The condition grade of the flood defence is currently ‘fair’ with some sections ‘poor’, as such a flood defence condition survey will be necessary to identify remedial works required to improve the condition of the flood defence.

We would expect that any development at this site to be set back from the defences to allow for any required maintenance, emergency access and to allow for the defences to be raised in the future. A continuous fit for purpose flood defence line must be maintained at the minimum statutory level throughout the construction works and for the lifetime of the development.

It will need to be demonstrated that the flood defence can be raised in line with Thames Estuary 2100 Plan levels in the future without undue cost. Further on the Thames Estuary 2100 Plan can be found at https://www.gov.uk/government/publications/thames-estuary-2100-te2100.

Due to the level of flood risk that the site faces and the proximity to the Tidal Flood Defences, we would expect flood risk to be scoped in to the Environmental Impact Assessment to ensure that the risks are assessed adequately.

The applicant should be aware that any works in/over/underneath a main river may require a Flood Risk Activity Permit (FRAP). Additionally, any works within 16m of a Tidal Flood Defence may also require a FRAP. The applicant can find out more information regarding FRAPs, including Exclusions and Exemptions, on our website.

Groundwater Protection
Section 7.11 (Ground Conditions) summarises the site's history and proposes a Phase 1 Ground Condition Assessment (GCA) to inform any possible site investigation / remedial actions that may be required. The GCA will be undertaken in accordance with CLR11. This approach is considered acceptable.

Ecology
Section 8.7 Lighting proposes to scope lighting out of the EIA. For lighting to be scoped out of the EIA the development will have to clearly demonstrate that there is no change from the existing lighting on site, particularly in relation to the adjacent nature reserve and the River Thames, which is subject to considerable amounts of change and possible in-combination affects from other developments.

Therefore lighting will have to be included for marine and terrestrial habitats in order to demonstrate that it is identical in terms of impact to the existing conditions.
This approach applies to all development aspects that could impact on the adjacent nature reserve and River Thames.

The development may have to leave sufficient space for future raising of the Thames

defences, depending on their current condition. If additional wall raising will be required to meet the TE2100 standard the development must be set back to allow embankment raising to take place. This is so that no encroachment takes place and the tidal Thames habitats can be protected and enhanced where feasible to do so.

The development must consider how it can deliver a net gain for ecology both terrestrial, to achieve further mitigation for its proximity to the adjacent nature reserve, but also on the River Thames. The use of Estuary Edges guidance can help with this process.

Environmental Permit

An Environmental Permit will be required for the proposed activities at Riverside Energy Park (REP) under the Environmental Permitting (England and Wales) Regulations 2016. Since this proposal is likely to be of high public interest we strongly recommended that the applicant considers joint discussion and/or parallel tracking of the application alongside the planning permission.

Air Quality

The proposed activities fall within an area designated as an Air Quality Manager Area for NO_2 and PM_{10}. These pollutants, particularly NO_2, are produced by waste incineration processes and therefore this proposal will need to be considered in more detail. The proposed operations will need appropriate risk assessment and mitigation measures in place to control these emissions and reduce the risk of exceeding air quality standards. Dispersion modelling of the emissions and impacts will be needed, and further pollution prevention and control methods and appropriate height and location of major emission points will need to be considered. These may affect the layout and/or location of the development, so are likely to be key considerations for planning permission. Our assessment process and criteria can be found as follows:
https://www.gov.uk/guidance/risk-assessments-for-your-environmental-permit

Paragraph 7.3.18 states that the proposed stack height will be chosen in accordance with Best Available Techniques. Please note that we have recently produced guidance on options for assessing whether a proposed stack height represents best available techniques (BAT) and can be made available from the Environment Agency on request.

Combined heat and power (CHP)

Paragraph 2.1.14 states that the REP would be CHP enabled with necessary infrastructure within the REP site (heat exchangers, pumps and pressurisation system) included. This is in line with our requirements for new energy from waste plants which we need to be CHP-ready if they do not include CHP from the outset. The applicant will need to comply with the Environment Agency's CHP-Ready guidance.

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However, the applicant should also note that they will need to comply with additional requirements imposed by Article 14 of the Energy Efficiency Directive. This legislation requires all new combustion plant (including power stations and energy from waste plants) which has a total net thermal input of more than 20 megawatts to carry out a cost benefit analysis for operating as a high-efficiency co-generation plant or supplying a district heating or cooling network with waste heat. Guidance on how to comply with these requirements can be made available from the Environment Agency on request.

Proximity to nature conservation sites at risk from emissions to air

The proposed energy from waste plant is within 2km of Sites of Special Scientific Interest (SSSI) the closest one being the Inner Thames Marshes. We will need to give more detailed consideration to the proposal if the critical levels for pollutants such as ammonia, nitrogen oxides or sulphur dioxide, or critical loads for acidification or eutrophication are exceeded or close to the threshold. These operations may require consideration of additional pollution prevention and control methods as well as the height and location of major emission points. These may affect the layout of the development so are likely to be material considerations for planning permission. Our assessment process and criteria can be found as follows: https://www.gov.uk/guidance/air-emissions-risk-assessment-for-your-environmental-permit

Please note that some larger emitters (greater than 50 megawatt), such as this proposal, may be required to screen to 15km for European sites and to 10km or 15km for SSSIs. Relevant screening distances should be discussed with the Environment Agency at pre-application.

Waste Planning and transport

The EIA should identify the need for the scheme in terms of the nature of the wastes that will be treated and the catchment area that the materials will be drawn from. It will need to consider the waste hierarchy under the waste framework directive. It should considered if the materials being sourced are actually residual waste.

The EIA should consider if the existing network for waste transfer stations have capacity to take the extra materials that will be generated. If not will the works needed to increase capacity should be included in the assessment.

Anaerobic digestion plant - In section 2.1.12 it mentions that the digestate could be incinerated or used in agriculture. The digestate should be used for the latter in order to move this particular waste stream up the waste hierarchy, and to capture this materials full resource potential. The transport assessment could include transport of the AD digestate to agriculture.

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The EIA should consider the impact of the additional transport at the existing transfer station network be factored into the Air Quality assessment.

For the construction phase a comprehensive site waste management plan should be adopted.

Water quality and the Water Framework Directive (WFD)

The EIA has identified that a WFD assessment will be required .

Whilst we appreciate the temporary nature of the construction works, and that following cessation of construction there will be further decommissioning of the temporary structures and reinstatement of the intertidal and subtidal habitats, both the construction and the decommissioning & reinstatement works have potential (albeit temporary) to impact upon water quality, principally by raising sediment into suspension, whereupon it may interact with the water column, and cause chemical and/or physicochemical physical changes to the water column.

The degree, extent and duration of the effects are important in determining WFD compliance. The EIA should consider the Water Framework Directive and its daughter directives, including the Environmental Quality Standards Directive (EQSD) both have Environmental Quality Standards (EQS's) for Annual Average (AA) and Maximum Allowable Concentration (MAC).

Sediments in the vicinity of the proposed works will require chemical sampling, including for polycyclic aromatic hydrocarbons (PAH's) as directed by the MMO, in order to provide a basis for estimation of contaminant loadings for use in the impact assessment stage of the WFD assessment. It is very likely that sediment will be found to contain significant levels of contamination, based on our experience of sediment chemistry results from other dredges in the waterbody, such that water quality will not "scope out" when using the EA's "Clearing the Waters for All" guidance to WFD assessment. Thus a full "impact assessment" will be required, and the applicant will need to discuss with the marine team the level of evidence and arguments and assumptions that may be required by us to consider the applicants impact assessment for water quality to be acceptable.

Reasonable estimation of the volume of (contaminated) sediment likely to be disturbed will be required.

The rate of disturbance is also a relevant consideration–if the activity happens over a protracted period- the "peak loads" of contaminants transferred to the water column may be smaller than if one assumed an "instantaneous" load transfer of the whole dredged volume for example.

Considerations of the type of methodology used to dredge (dispersive vs removal)

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and the timing of dredging will be pertinent to assessment of water quality risks. There are timing restrictions to dispersive dredging generally applied; dredging by dispersive methods, whilst often cheaper when viable, has greater potential to result in transfer of contaminants from sediment to water, and is generally resisted by us during the months of June-August inclusive in this reach of the Thames. Removal dredging, by comparison, results in much less sediment “lost” back into the water column, so has lower risks for water quality.

The requirements of the project timetable may influence the choice of an appropriate method to mitigate risks, and the rate of dredging can be varied to reduce risks also, should the initial assessment indicate water quality risks are too high.

The proximity of both Crossness and Beckton sewage treatment works (STW) outfalls would tend to suggest the sediments will have a relatively high organic content and may be anoxic fairly close to the surface. We hold historical benthic invertebrate subtidal grab and intertidal core data for the Crossness area (which was sampled regularly as a routine site of the Thames Estuary Biological Program [TEBP a.k.a. Thames Benthic Program] until spring 2008 when this local initiative was discontinued in favour of a more spatially randomised grab sampling methodology brought in to service the WFD program. These data are available on Open Data at .gov.uk (this can be found using the term BIOSYS, which is our biological database archive.)

With respect to
[7.3.3] A human health risk assessment, to assess the risk to human health from potential emissions of persistent organic pollutants, will also be undertaken.
[7.3.13]ϒ Increased deposition of metals to soil**; and**
ϒ Increased NOx concentrations, nitrogen, sulphur, hydrogen fluoride, ammonia and acid deposition on sensitive ecological receptors.

We would wish to see some consideration of the effects of emissions on TRAC waterbodies. The drop out of persistent organic pollutants to the water and sediment environments of the waterbody, deposition of metals, sulphur, hydrogen fluoride, ammonia and acid deposition should all be placed in WFD context, since emissions will be long-term and may result in small far field effects at distances which could extend not only to the adjacent Thames Middle waterbody, but also other adjoining transitional waterbodies Thames Upper and Thames Lower for example. Shellfish fisheries in Thames Lower could conceivably receive additional chemical burdens, though the bacteriological drivers for designated shellfish waters monitoring under WFD are unlikely to be affected. Any EQSD/ WFD chemicals present in the emission that might enter the waterbodies need to be considered up to the point that their contribution can be demonstrated to be too low to affect WFD compliance over the life of the development. Persistent organic pollutants may well accumulate in the river sediments if they deposit in turbid, sediment-laden estuary water (due to their partitioning characteristics) and there are already concerns for high levels of PAH’s in Thames sediments (Thames Middle failed for benzo g,h,i-perylene in 2009 RBMP

classification). As EQS's for PAH's are already hard to meet, activities which significantly elevate their concentrations in water or sediments potentially could be a reason for a waterbody to fail to meet its objectives in the future. The lifetime of the development spans several RBMP cycles, when RBMP objectives might be revised to be more stringent, and this may include adoption of tighter EQS standards for some chemicals, and new standards for chemicals not yet regulated.

[7.6.2] Proposed river works for construction may also include some localised dredging of the river bed.

Dredging and marine construction both require a marine licences. We are a statutory consultee to both the Port of London Authority and the Marine Management Organisation (licenses will be required from both; dual licensing is currently the norm at present) and will consult on both. WFD assessments are required from the applicant for activities requiring a marine licence, and the marine team will determine whether the water quality elements of such assessments are of acceptably low risk to justify any claim to comply with WFD.

[7.9.22] The Environment Agency's "Clearing the Waters for All" process will be used for the WFD Assessment

We agree with this protocol; advice at the "impact assessment" stage should be sought from the marine team at the earliest possible opportunity, since no formal guidance can be written that is both waterbody and activity specific- location context **is** important. We are, however, able to offer insights into how impact assessment could be structured and what constitutes acceptable levels of evidence and argument, and we can agree what assumptions may be reasonably made in making arguments. Water quality predictions are extremely complex and gaps in data can cause problems for applicants.

[7.9.28] Data availability could provide a limitation to the assessment…..

The level of impact assessment should generally reflect the potential risks perceived. Small dredge and construction works in- river will seldom require full-scale modelling of sediment plumes and a fully numerical treatment to estimate final concentrations. Capital dredge works application will be required to provide sediment chemistry data to underpin sediment quality claims, and volume of material disturbed will be a key variable which will require quantification. For a dredge this is a relatively straightforward calculation (as dredge box dimensions and depth are known- volume is a calculated product), for construction impacts we are prepared to enter into a dialogue over quantities of sediment involved to determine what might be a reasonable figure we can agree upon, in order to supply this in any consideration of whether "sufficient dilution" will be achieved to remain WFD compliant. The MMO will require sediment analysis for dredge applications, but the need for sediment analysis for other construction activities in water rather depends on the amount of sediment that might be mobilised; projects which mobilise more than approximately 300 cu m of sediment *might* require sediment chemistry data to be provided to us, within a WFD assessment, to underpin dilution arguments, whereas smaller volumes will not

require such a high burden of proof to demonstrate likely WFD compliance.

We agree that scoping out of shellfish and bathing waters from water quality assessment is appropriate. Shellfish waters in the Thames estuary are located seaward (east) of Thames Middle waterbody, in the Thames Lower and the Swale waterbodies. The triggers for shellfish water failures are microbiological, and there would be no pathway for transfer of faecal bacteria to water via the airborne emission route.

The sediments locally in the vicinity of the development might have higher levels of faecal bacteria taking into account the proximity to outfalls of sewage treatment works(STW's), though only if the STW was not performing to its usual effluent standards. Whilst the triggers for shellfish water non-compliance, following revision of the Shellfish Waters Regulations, are now purely bacteriological, the chemical element compliance limits which were formerly included within the shellfish regulations were harmonised with and incorporated into the main body of the WFD, and now apply to the water column of waterbodies generally. Any chemical transfers to shellfish waters should be considered under the water quality assessment section of a WFD assessment.

The high organic loadings on sediments in this area may increase the risk of high chemical or biological oxygen demand on the water column when disturbing sediments locally, which has relevance for achieving WFD chemical and physico-chemical standards (dissolved oxygen for example).

I hope our comments are helpful, if you have any questions please contact me.

Yours faithfully

Mr Joe Martyn
Planning Specialist

Direct dial 020 3025 5546
Direct e-mail kslplanning@environment-agency.gov.uk

Flood map for planning

Your reference	Location	Created
172067a	**549478/180635**	**9 Jan 2018 3:14**

Your selected location is in flood zone 3 – an area with a high probability of flooding that benefits from flood defences.

This means:

- you may need to complete a flood risk assessment for development in this area
- you should ask the Environment Agency about the level of flood protection at your location and request a Flood Defence Breach Hazard Map (You can email the Environment Agency at: enquiries@environment-agency.gov.uk)
- you should follow the Environment Agency's standing advice for carrying out a flood risk assessment (find out more at www.gov.uk/guidance/flood-risk-assessment-standing-advice)

Notes

The flood map for planning shows river and sea flooding data only. It doesn’t include other sources of flooding. It is for use in development planning and flood risk assessments.

This information relates to the selected location and is not specific to any property within it. The map is updated regularly and is correct at the time of printing.

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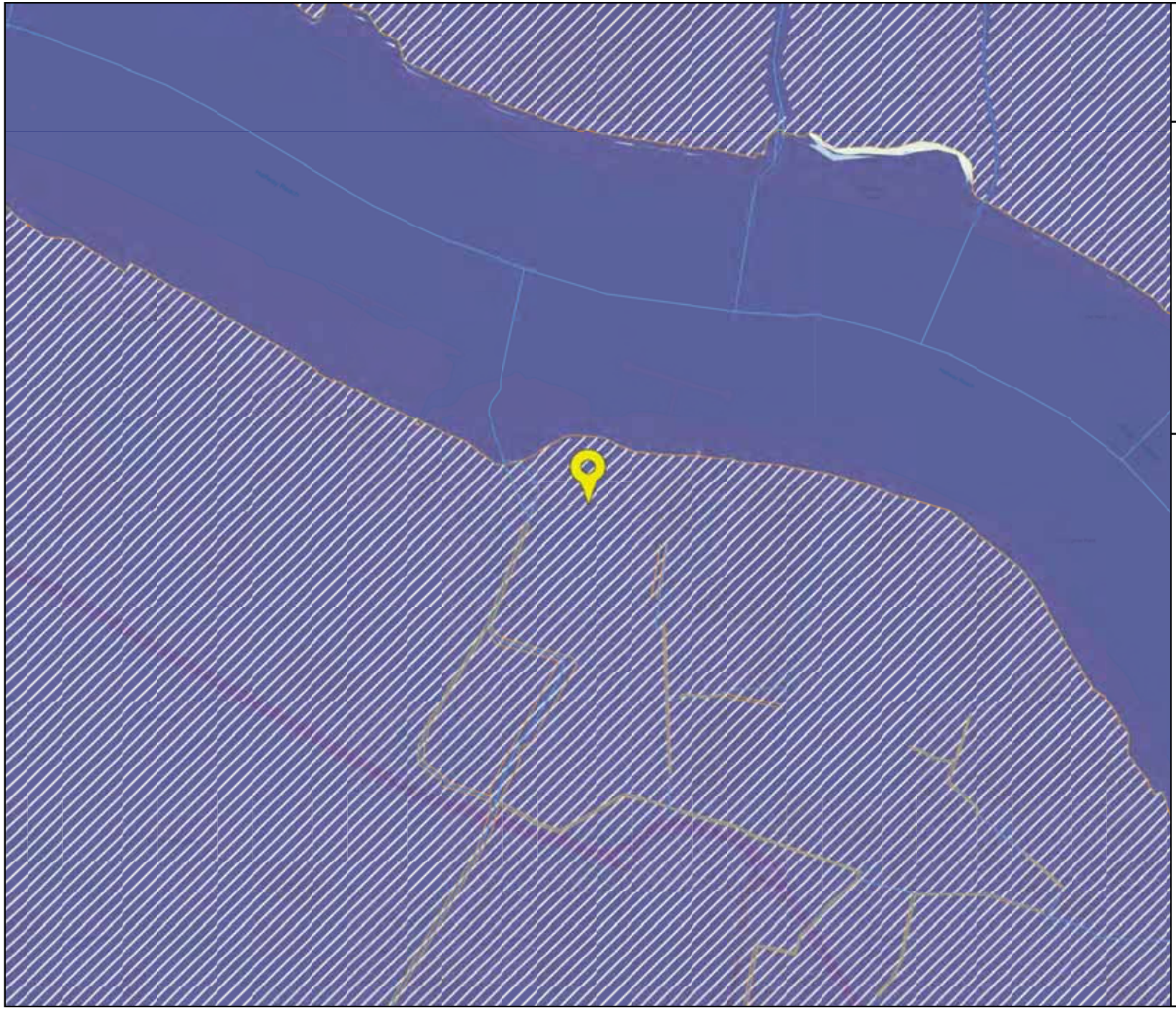

Environment Agency

Flood map for planning

Your reference
172067a

Location
549478/180635

Scale
1:12500

Created
9 Jan 2018 3:14

- Development location
- Flood zone 3
- Flood zone 3: areas benefitting from flood defences
- Flood zone 2
- Flood zone 1
- Flood defence
- Main river
- Flood storage area

0 200 400 600m

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APPENDIX C

Extracts from Bexley Local Flood Risk Management Strategy

KEYPLAN Scale 1:500,000

LEGEND

Fluvial and Coastal Flood Zones

- Areas Benefiting from Flood Defences
- Flood Zone 3
- Flood Zone 2

LONDON BOROUGH OF BEXLEY

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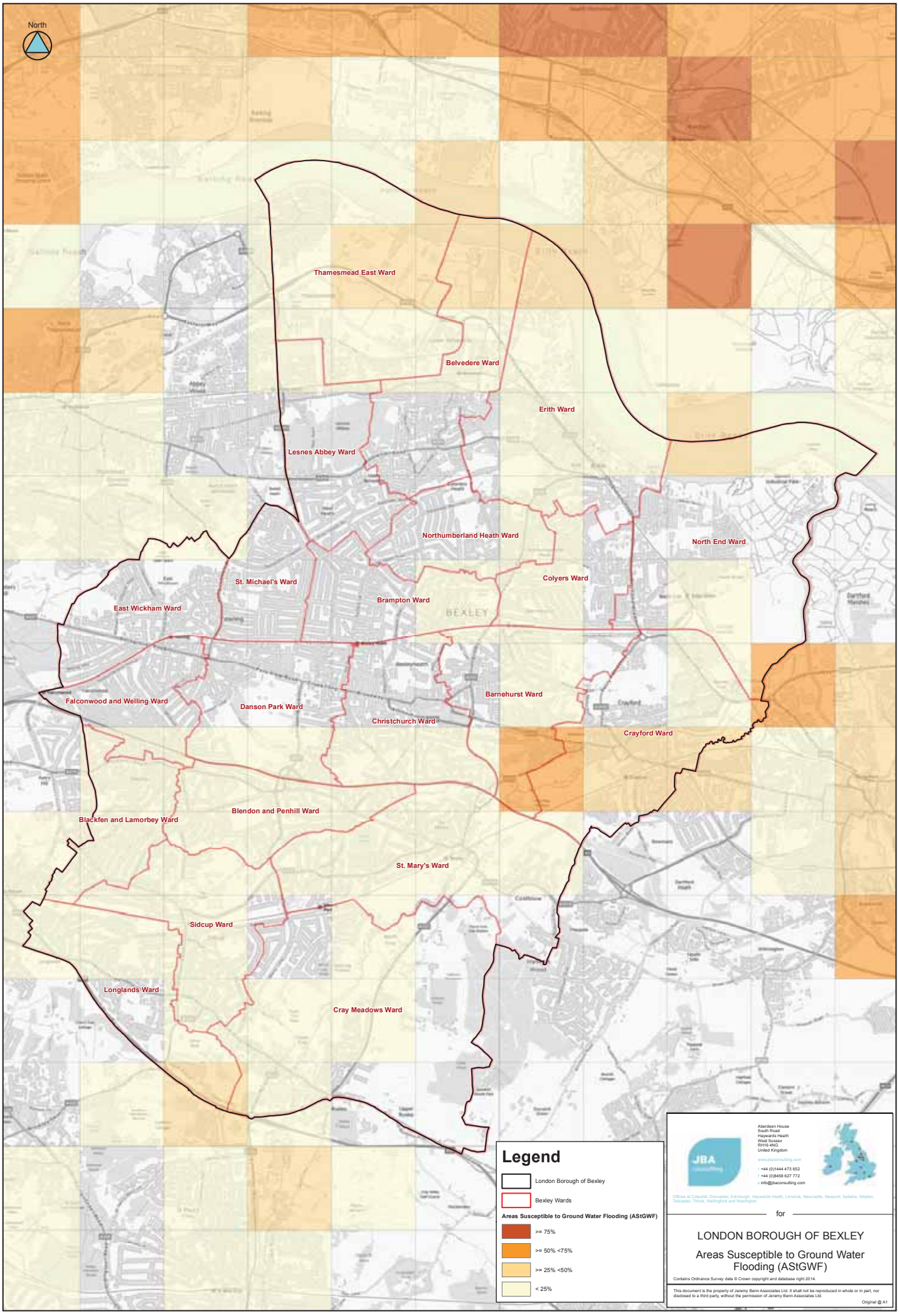
Scale 1:45,000

0 2 4 km


North
Thamesmead East Ward
Belvedere Ward
Erith Ward
Lesnes Abbey Ward
Northumberland Heath Ward
North End Ward
St. Michael's Ward
Colyers Ward
East Wickham Ward
Brampton Ward
BEXLEY
Falconwood and Welling Ward
Danson Park Ward
Barnehurst Ward
Christchurch Ward
Crayford Ward
Blendon and Penhill Ward
Blackfen and Lamorbey Ward
St. Mary's Ward
Sidcup Ward
Longlands Ward
Cray Meadows Ward
Legend
London Borough of Bexley
Bexley Wards
Areas Susceptible to Ground Water Flooding (AStGWF)
>= 75%
>= 50% <75%
>= 25% <50%
< 25%
JBA consulting
Aberdeen House
South Road
Haywards Heath
West Sussex
RH16 4NG
United Kingdom
www.jbaconsulting.com
t +44 (0)1444 473 652
f +44 (0)8458 627 772
e info@jbaconsulting.com
Offices at Coleshill, Doncaster, Edinburgh, Haywards Heath, Limerick, Newcastle, Newport, Saltaire, Skipton, Tadcaster, Thirsk, Wallingford and Warrington
for
LONDON BOROUGH OF BEXLEY
Areas Susceptible to Ground Water Flooding (AStGWF)
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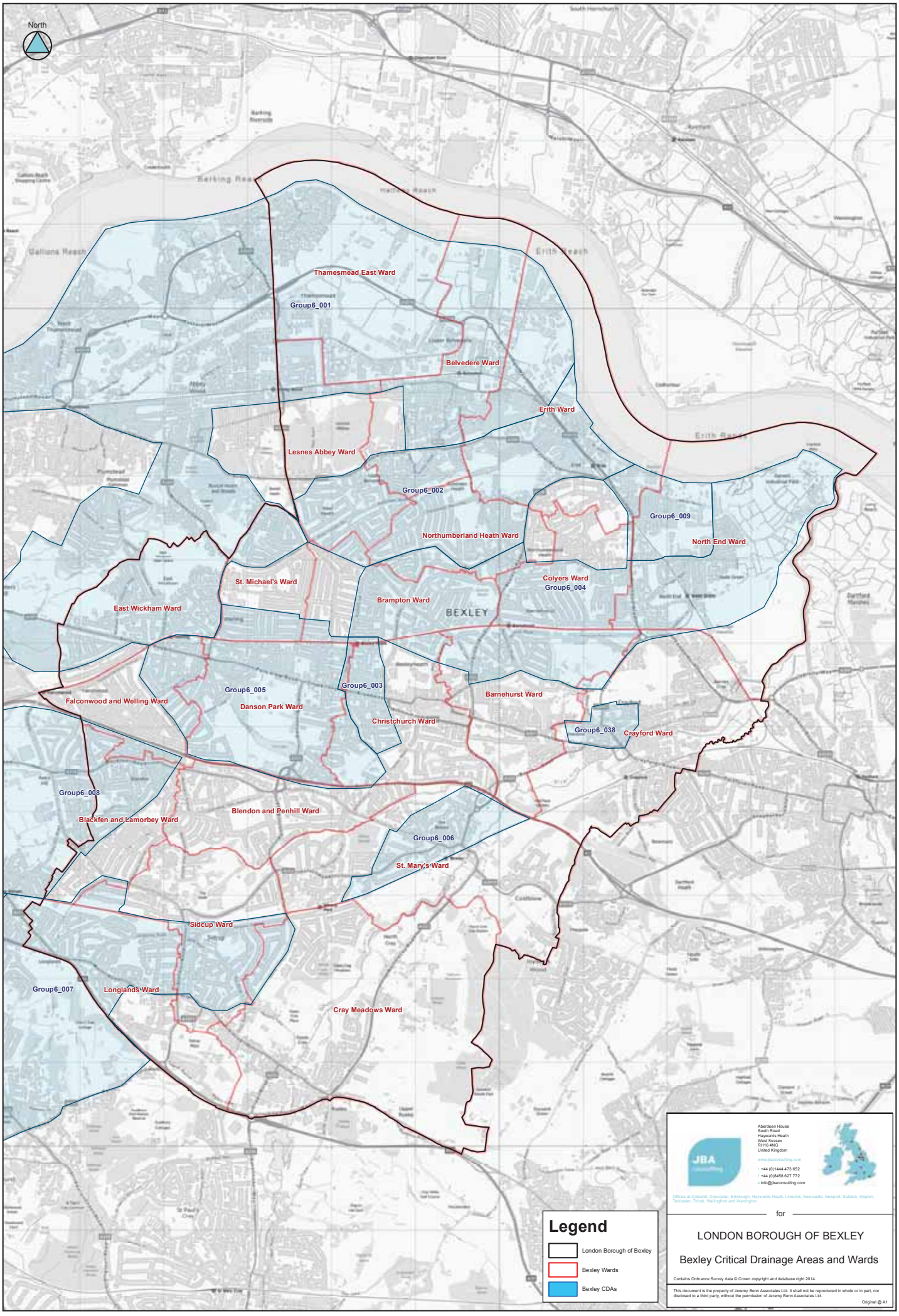
North
Thamesmead East Ward
Group6_001
Belvedere Ward
Erith Ward
Lesnes Abbey Ward
Group6_002
Group6_009
Northumberland Heath Ward
North End Ward
St. Michael's Ward
Colyers Ward
Group6_004
East Wickham Ward
Brampton Ward
BEXLEY
Group6_005
Group6_003
Barnehurst Ward
Falconwood and Welling Ward
Danson Park Ward
Christchurch Ward
Group6_038
Crayford Ward
Group6_008
Blackfen and Lamorbey Ward
Blendon and Penhill Ward
Group6_006
St. Mary's Ward
Sidcup Ward
Group6_007
Longlands Ward
Cray Meadows Ward
Legend
London Borough of Bexley
Bexley Wards
Bexley CDAs
Aberdeen House
South Road
Haywards Heath
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e info@jbaconsulting.com
Offices at Coleshill, Doncaster, Edinburgh, Haywards Heath, Limerick, Newcastle, Newport, Saltaire, Skipton, Tadcaster, Thirsk, Wallingford and Warrington
for
LONDON BOROUGH OF BEXLEY
Bexley Critical Drainage Areas and Wards
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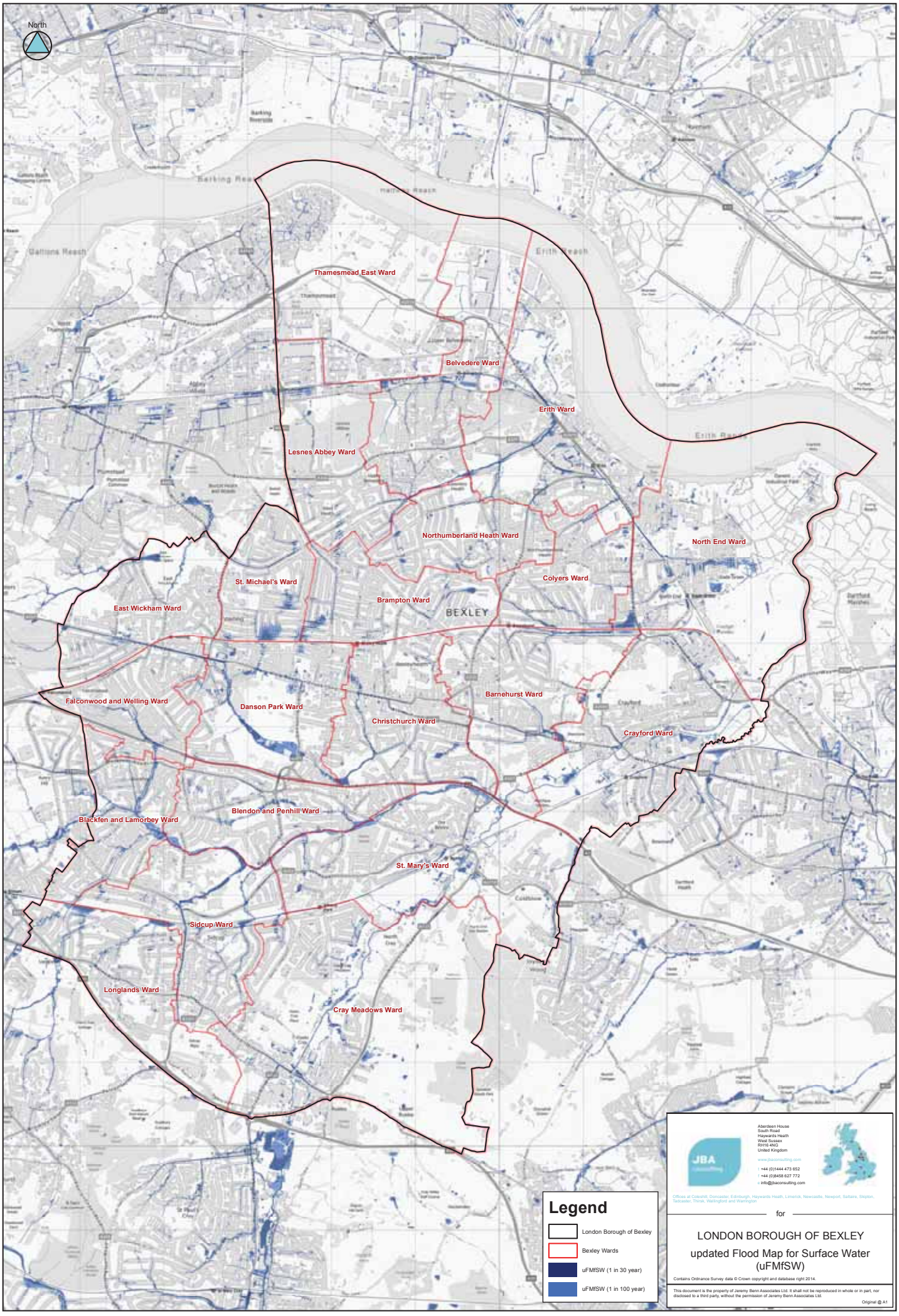

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for

LONDON BOROUGH OF BEXLEY

updated Flood Map for Surface Water (uFMfSW)

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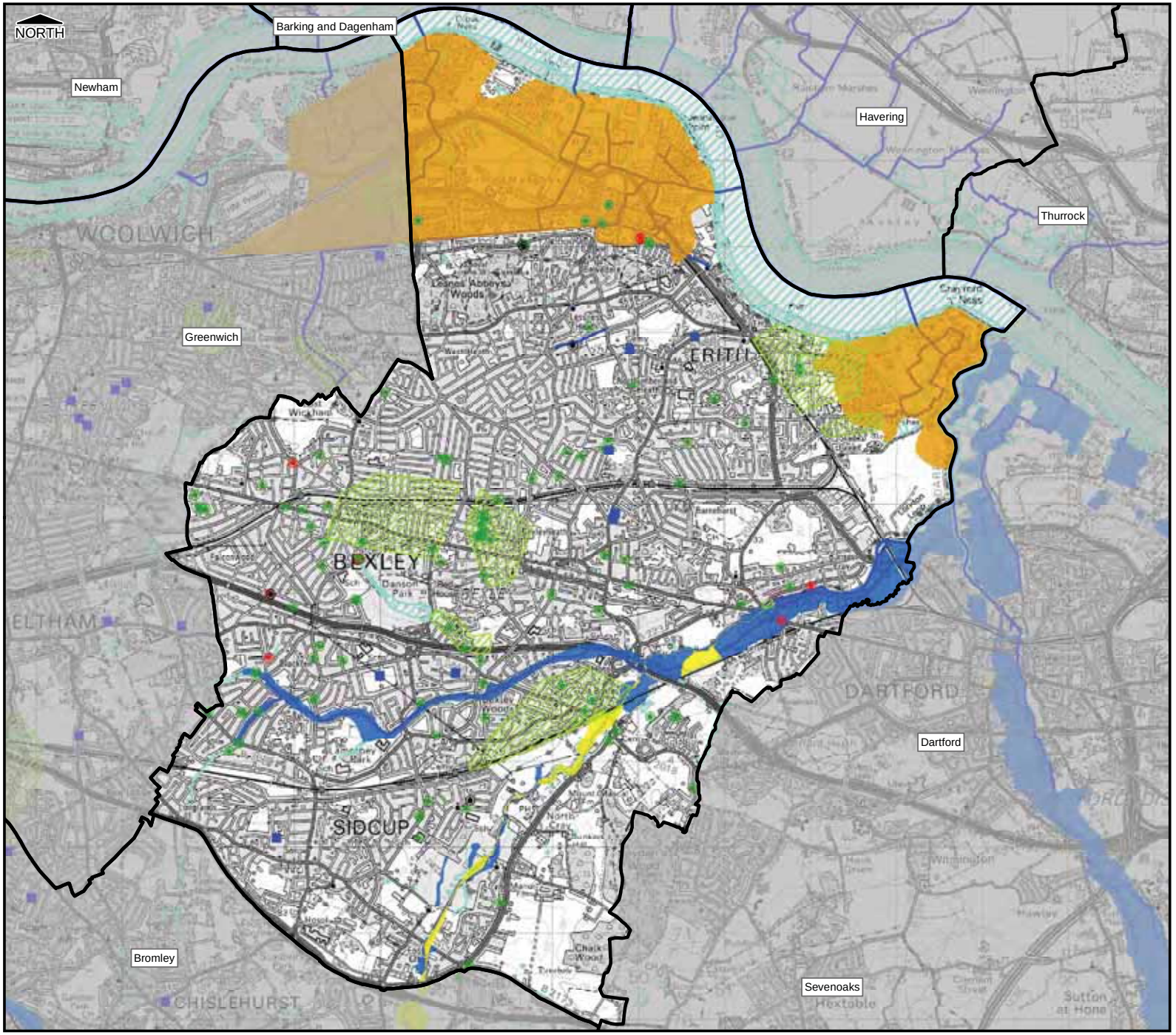
APPENDIX D

Extracts from Bexley Preliminary Flood Risk Assessment



THIS DRAWING MAY BE USED ONLY FOR THE PURPOSE INTENDED

Legend

- P — Sewer Flooding Incident
- P — Surface Water Flooding Incident
- P — Unknown Flooding Incident
- " — Ground Water Flood Incident (EA Records)
- Surface Water Flood Extent
- Coastal Flood Extent
- Fluvial Flood Extent
- Other Flood Extent
- Main River
- Permanent Water Bodies
- LB Bexley Administrative Boundary

Notes

1. Sewer, Surface Water and unknown incident data taken from Bexley SFRA (Entec 2010)

London Borough of Bexley

LONDON BOROUGH OF BEXLEY

Preliminary Flood Risk Assessment

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Scale at A3	Date	Drawn by	Approved by
1:46,000	13/04/2011	H.Winter	I.Felstead

Summary Map of Past Floods

Consultants

Halcrow

Halcrow Group Limited
Elms House
43 Brook Green
Hammersmith
London
W6 7EF

Drain London Programme Board Members

Environment Agency · Thames Water · LONDON COUNCILS · GREATER LONDON AUTHORITY

MAP 4.1

V0.3

22/06/2011

15 of 38

Filepath: W:\Geospatial\Projects\WDLSW\Documents\PFRA\Group_6\Mapping\Bexley\DLGP6_Bexley_PFRA_PastFloods.mxd

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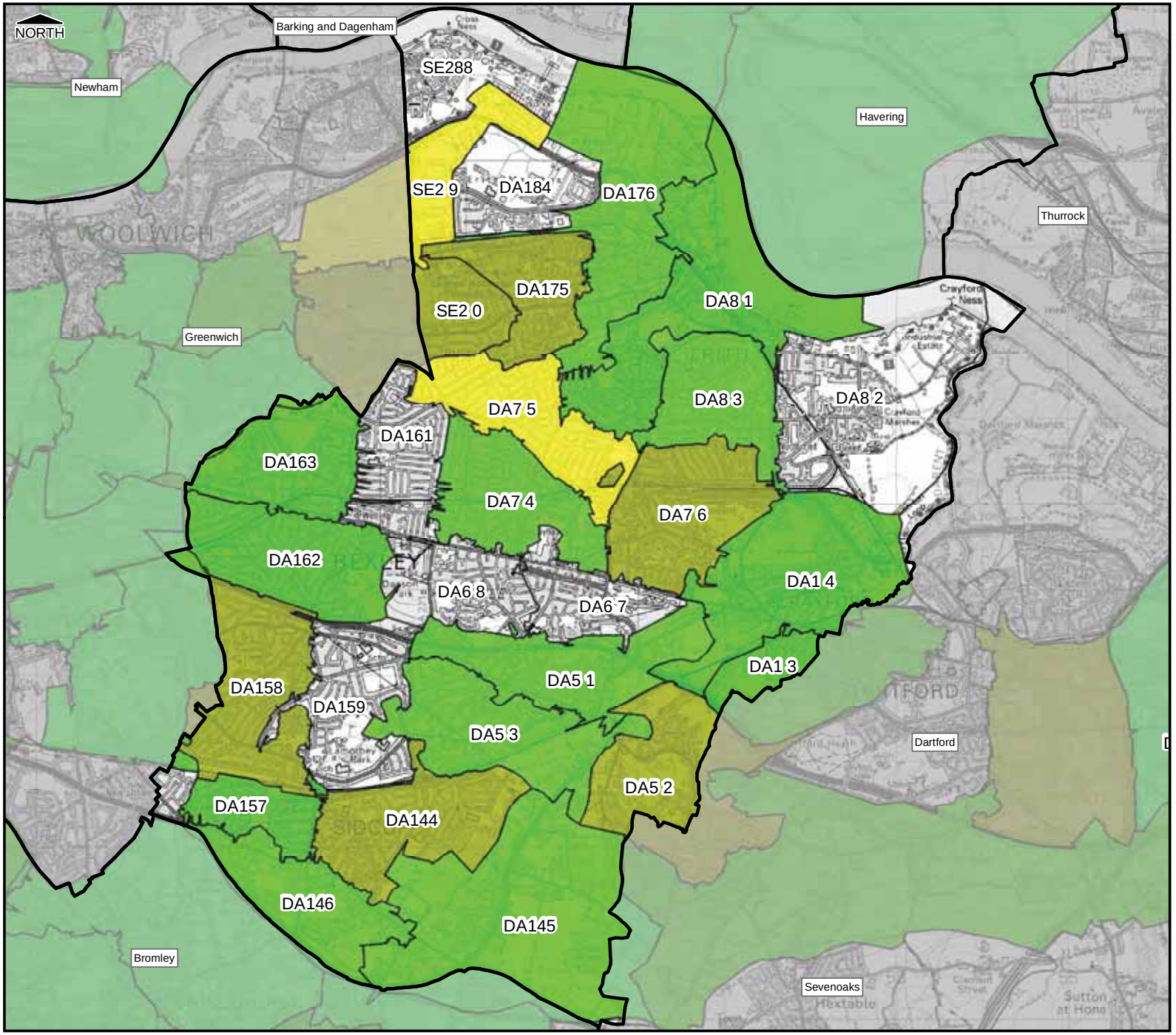

THIS DRAWING MAY BE USED ONLY FOR THE PURPOSE INTENDED

Legend

Thames Water DG5 Records

No. of Sewer Flood Records

- None
- 1 - 5
- 6 - 10
- 11 - 20
- 21 - 50
- 51 - 100
- 101+
- LB Bexley Administrative Boundary

Notes

1. Sewer flood records relate to internal and external flooding of properties
2. Data supplied by Thames Water Ltd and is correct as at June 2010

London Borough of Bexley

LONDON BOROUGH OF BEXLEY

Preliminary Flood Risk Assessment

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Scale at A3	Date	Drawn by	Approved by
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Summary Map of Past Floods - Recorded Incidents of Sewer Flooding (Thames Water DG5 Data)

Consultants

Halcrow

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43 Brook Green
Hammersmith
London
W6 7EF

Drain London Programme Board Members

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MAP 4.1a

V0.3

22/06/2011

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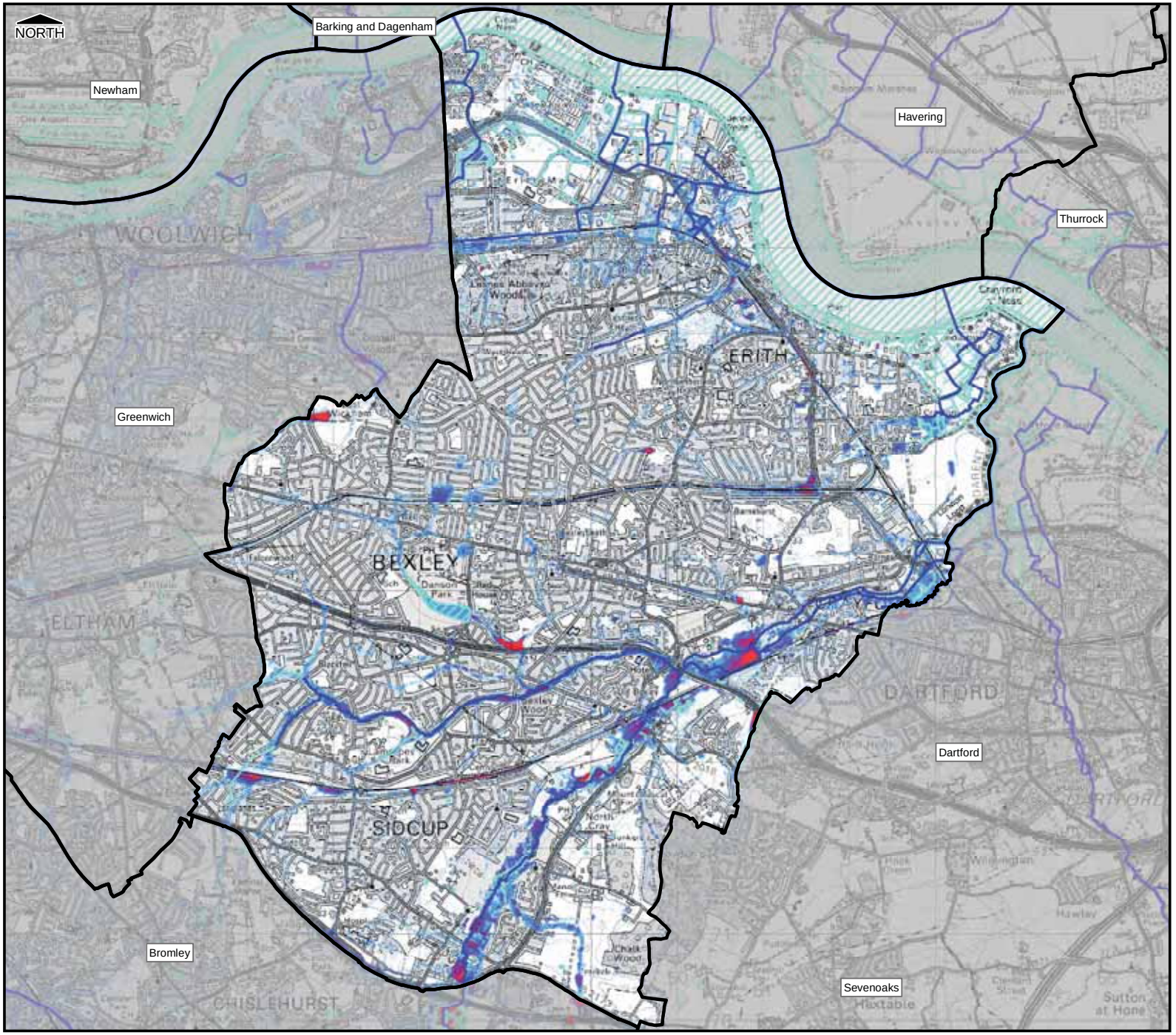

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Legend

Flood Depth

- <0.1m
- 0.1m to 0.25m
- 0.25m to 0.5m
- 0.5m to 1.0m
- 1.0m to 1.5m
- >1.5m
- Main River
- Permanent Water Bodies
- LB Bexley Administrative Boundary

Notes

1. This map provides a strategic overview of surface water flood risk and may be subject to further analysis in the future.
2. This map only shows the predicted likelihood of surface water flooding (this includes flooding from sewers, drains, small watercourses and ditches that occurs in heavy rainfall) for defined areas, and due to the coarse nature of the source data used, are not detailed enough to account for precise addresses.
3. Users of this map should refer to Section 3.2 of the Surface Water Management Plan for a complete description of limitations and accuracy of the flood / hazard extents shown.

London Borough of Bexley

LONDON BOROUGH OF BEXLEY

Preliminary Flood Risk Assessment

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Scale at A3	Date	Drawn by	Approved by
1:46,000	13/04/2011	H.Winter	I.Felstead

Surface Water Depth (m)
1 in 200 chance of rainfall event occurring in any given year (0.5% AEP)

Consultants

Halcrow

Halcrow Group Limited
Elms House
43 Brook Green
Hammersmith
London
W6 7EF

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MAP 5.1

V0.3

22/06/2011

23 of 38

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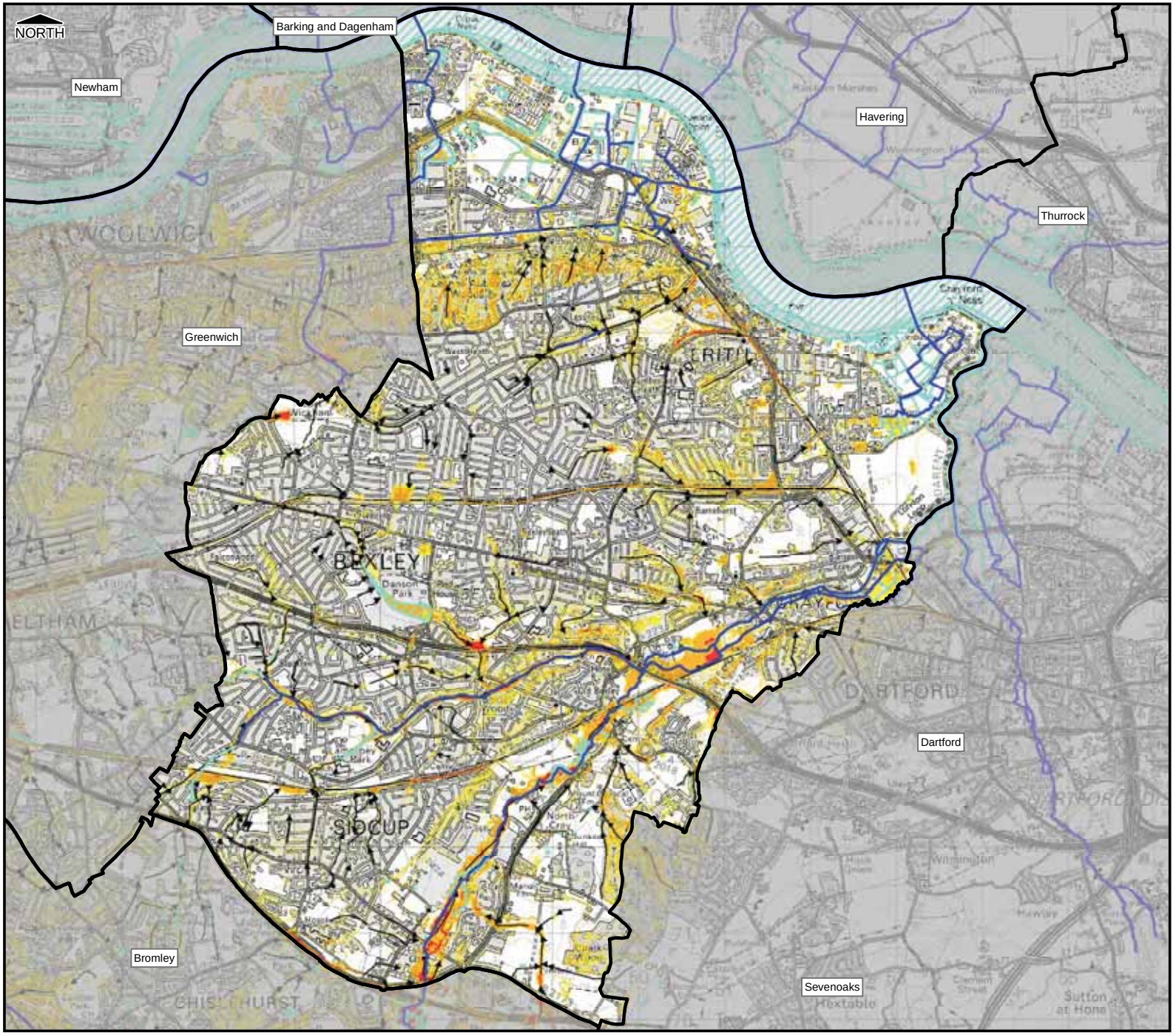

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Legend

Flood Hazard

- <0.75 - Caution
- 0.75 - 1.25 Moderate
- 1.25 - 2.0 Significant
- >2.0 Extreme
- Main River
- Permanent Water Bodies
- LB Bexley Administrative Boundary
- Direction of Flow

Notes

1. This map provides a strategic overview of surface water flood risk and may be subject to further analysis in the future.
2. This map only shows the predicted likelihood of surface water flooding (this includes flooding from sewers, drains, small watercourses and ditches that occurs in heavy rainfall) for defined areas, and due to the coarse nature of the source data used, are not detailed enough to account for precise addresses.
3. Users of this map should refer to Section 3.2 of the Surface Water Management Plan for a complete description of limitations and accuracy of the flood / hazard extents shown.
4. Flood Hazard has been defined based upon the joint EA and Defra R&D Technical Report FD2320 (January 2006).
5. Degree of flood hazard can be interpreted as follows:
- Caution: Flood zone with shallow flowing water or deep standing water
- Moderate: Flood Zone with deep or fast flowing water. Dangerous for children, the elderly and the infirm
- Significant: Flood zone with deep fast flowing water. Dangerous for most people
- Extreme: Flood zone with deep fast flowing water. Dangerous for all (including emergency services)

London Borough of Bexley

LONDON BOROUGH OF BEXLEY

Preliminary Flood Risk Assessment

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Scale at A3	Date	Drawn by	Approved by
1:46,000	13/04/2011	H.Winter	I.Felstead

Surface Water Flood Hazard Rating
1 in 200 chance of rainfall event occurring in any given year (0.5% AEP)

Consultants

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London
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MAP 5.2

V0.3

22/06/2011

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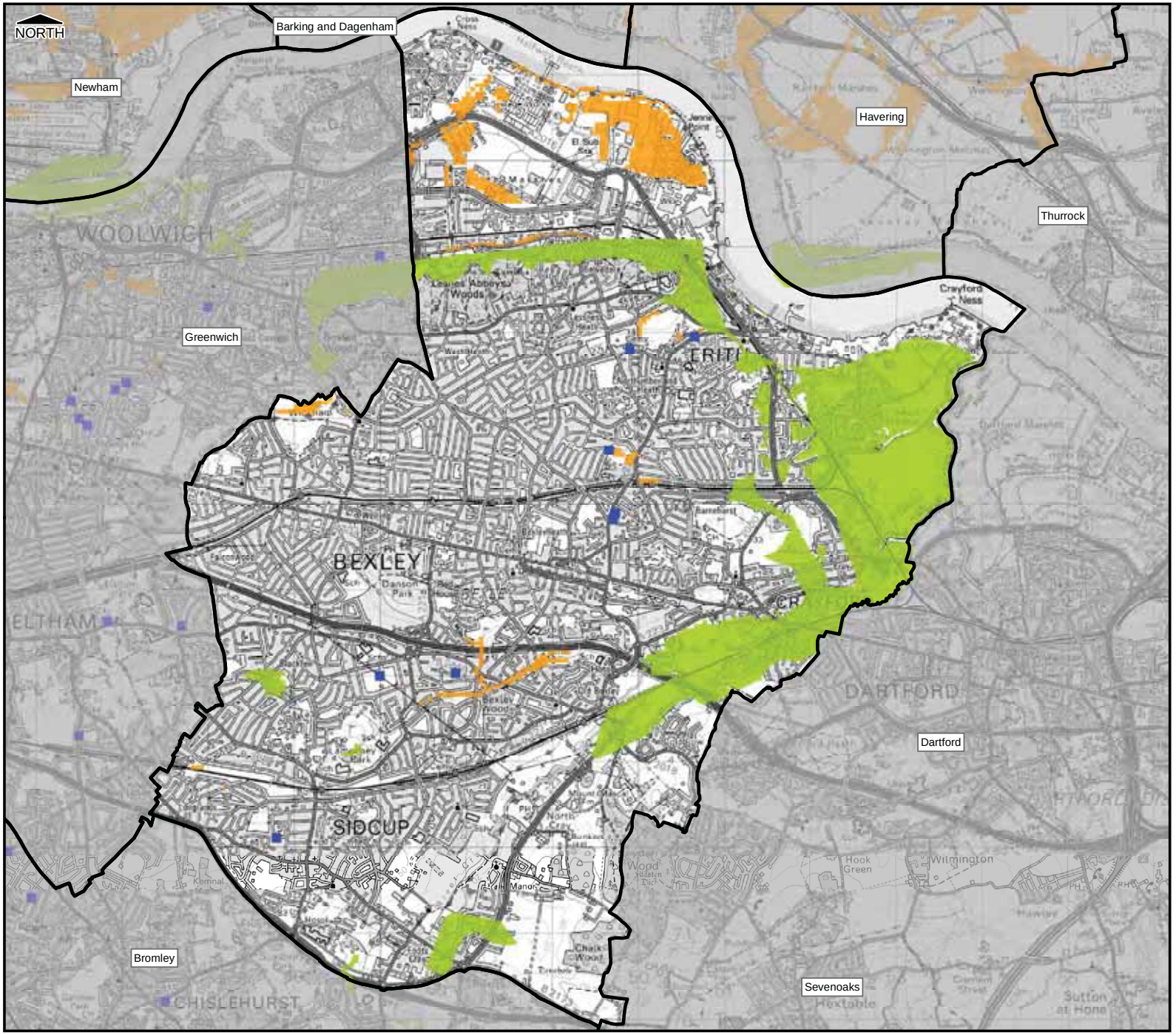

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Legend

Increased Potential for Elevated Groundwater

- Consolidated Aquifers
- Permeable Superficial Deposits
- Ground Water Flood Incident (EA Records)
- LB Bexley Administrative Boundary

Notes

1. The increased Potential for Elevated Groundwater map shows those areas within the London Boroughs where there is an increased potential for groundwater to rise sufficiently to interact with the ground surface or be within 2m of the ground surface. Such groundwater rise could lead to the following consequences:
- flooding of basements of buildings below ground level;
- flooding of buried services or other assets below ground level;
- inundation of farmland, roads, commercial, residential and amenity areas;
- flooding of ground floors of buildings above ground level; and
- overflowing of sewers and drains
2. Incident records shown are generally unconfirmed and may include issues such as water main bursts or non-groundwater related problems.
3. Areas not shown to have increased potential for elevatedgroundwater should be considered to have a low potential for elevated groundwater
- Lack of information does not imply 'no potential' of elevated groundwater in that area.
4. Includes groundwater flood mapping provided by JBA Consulting, Copyright Jeremy Benn Associates Limited 2008-2011, partially derived from data supplied by the Environment Agency.

London Borough of Bexley

LONDON BOROUGH OF BEXLEY

Preliminary Flood Risk Assessment

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Scale at A3	Date	Drawn by	Approved by
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Increased Potential for Elevated Groundwater Map

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MAP 5.3

V0.3

22/06/2011

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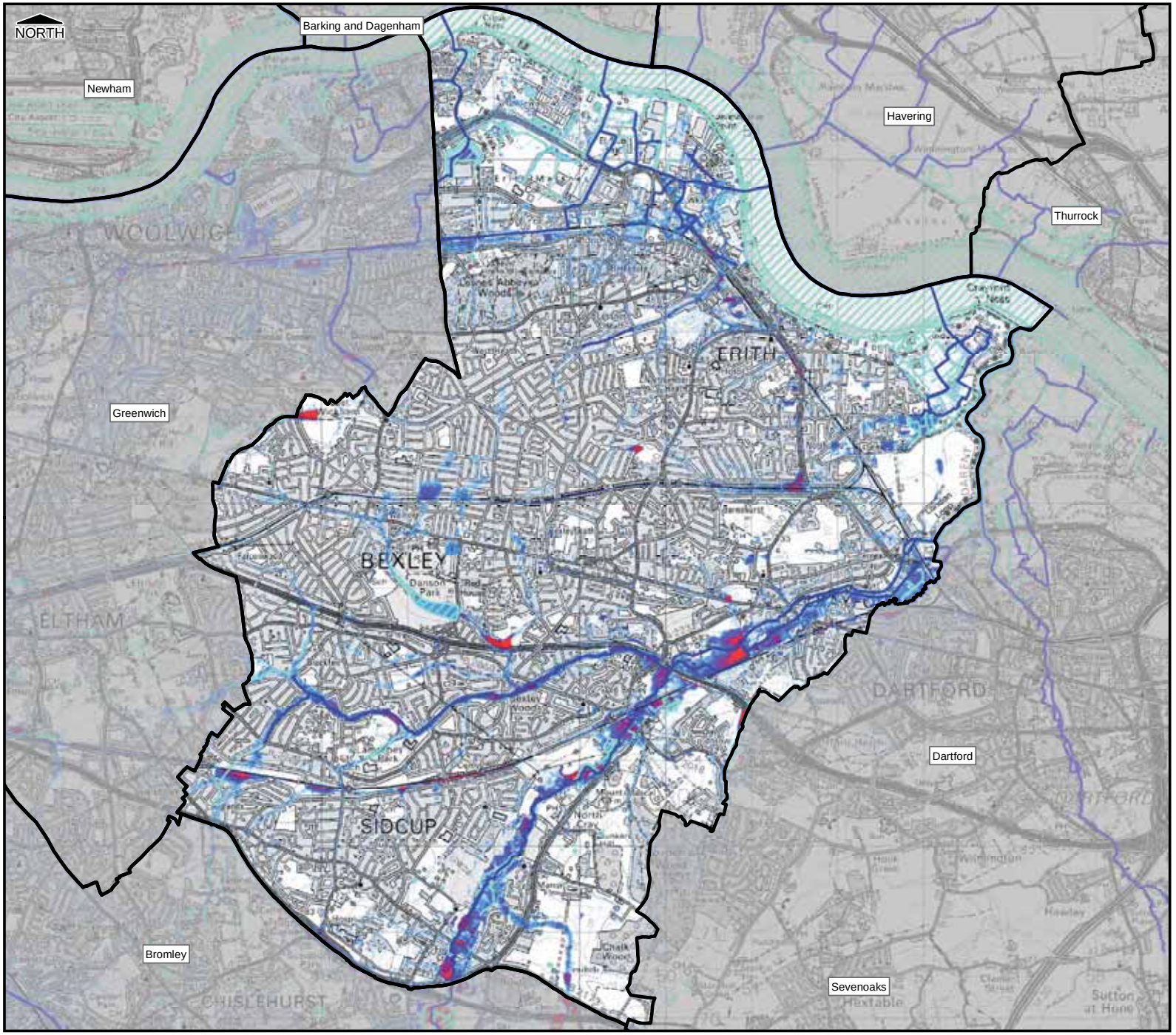

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Legend

Flood Depth

- <0.1m
- 0.1m to 0.25m
- 0.25m to 0.5m
- 0.5m to 1.0m
- 1.0m to 1.5m
- >1.5m
- Main River
- Permanent Water Bodies
- LB Bexley Administrative Boundary

Notes

1. This map provides a strategic overview of surface water flood risk and may be subject to further analysis in the future.
2. This map only shows the predicted likelihood of surface water flooding (this includes flooding from sewers, drains, small watercourses and ditches that occurs in heavy rainfall) for defined areas, and due to the coarse nature of the source data used, are not detailed enough to account for precise addresses.
3. Users of this map should refer to Section 3.2 of the Surface Water Management Plan for a complete description of limitations and accuracy of the flood / hazard extents shown.

London Borough of Bexley

LONDON BOROUGH OF BEXLEY

Preliminary Flood Risk Assessment

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Scale at A3	Date	Drawn by	Approved by
1:46,000	13/04/2011	H.Winter	I.Felstead

Surface Water Depth (m)
1 in 100 chance of rainfall event occurring in any given year (1% AEP) plus climate change

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Hammersmith
London
W6 7EF

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MAP 5.4

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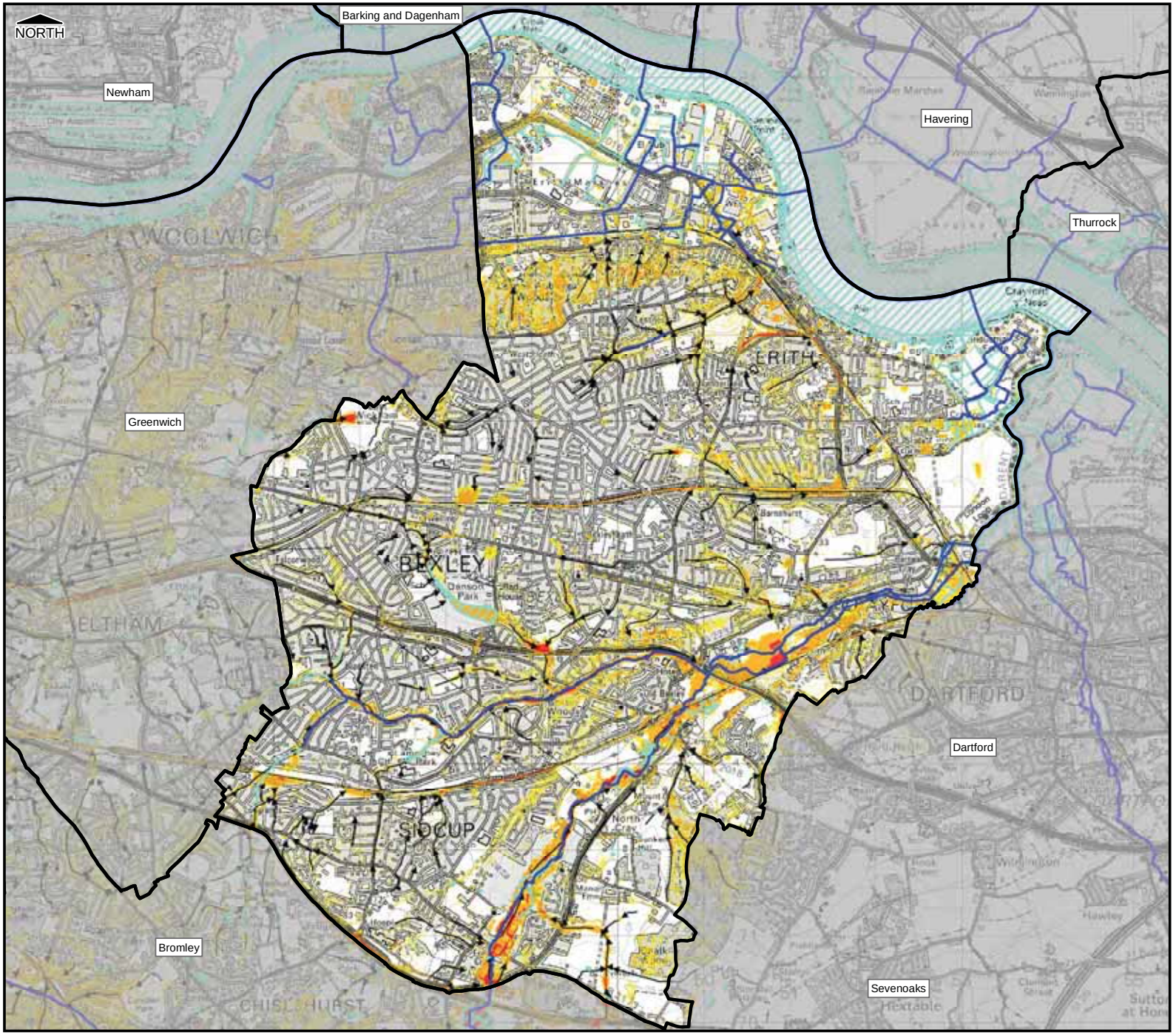

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Legend

Flood Hazard

- <0.75 - Caution
- 0.75 - 1.25 Moderate
- 1.25 - 2.0 Significant
- >2.0 Extreme
- Main River → Flow Direction
- Permanent Water Bodies
- LB Bexley Administrative Boundary

Notes

1. This map provides a strategic overview of surface water flood risk and may be subject to further analysis in the future.
2. This map only shows the predicted likelihood of surface water flooding (this includes flooding from sewers, drains, small watercourses and ditches that occurs in heavy rainfall) for defined areas, and due to the coarse nature of the source data used, are not detailed enough to account for precise addresses.
3. Users of this map should refer to Section 3.2 of the Surface Water Management Plan for a complete description of limitations and accuracy of the flood / hazard extents shown.
4. Flood Hazard has been defined based upon the joint EA and Defra R&D Technical Report FD2320 (January 2006).
5. Degree of flood hazard can be interpreted as follows:
- Caution: Flood zone with shallow flowing water or deep standing water
- Moderate: Flood Zone with deep or fast flowing water. Dangerous for children, the elderly and the infirm
- Significant: Flood zone with deep fast flowing water. Dangerous for most people
- Extreme: Flood zone with deep fast flowing water. Dangerous for all (including emergency services)

London Borough of Bexley

LONDON BOROUGH OF BEXLEY

Preliminary Flood Risk Assessment

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Scale at A3	Date	Drawn by	Approved by
1:46,000	13/04/2011	H.Winter	I.Felstead

Surface Water Flood Hazard Rating
1 in 100 year chance of rainfall occurring in any given year (1% AEP) plus climate change

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London
W6 7EF

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MAP 5.5

V0.3

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APPENDIX E

Extracts from Bexley Strategic Flood Risk Assessment

Key:

- Bexley borough
- Flood Zone 2 (issued September 2008)
- Flood Zone 3 (issued September 2008)

0 520 1,040 1,560 2,080 Meters

Scale: 1:40000 @ A3

H:\Projects\HM-255\23000-Projects\23736 - Bexley SFRA\Data\GIS\ESRIMXDs\23736-A02.mxd

Bexley SFRA

Figure 6

Environment Agency Flood Zones 2 and 3

November 2008
23736-A06.mxd squij

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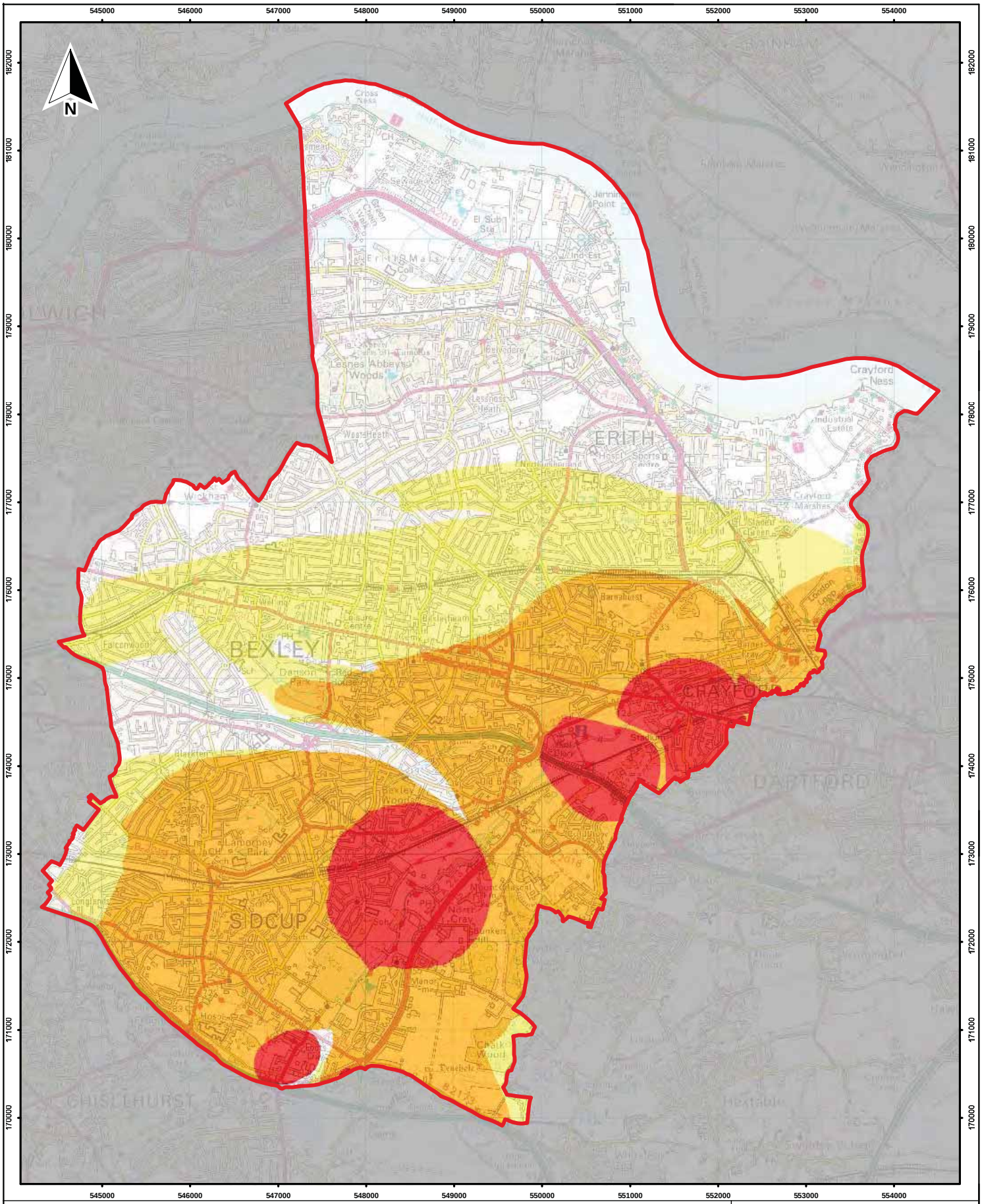

Key:

Bexley borough

Groundwater Source Protection Zones

- SPZ 1
- SPZ 2
- SPZ 3
- SPZ 4

SPZs supplied by EA September 2008

0 500 1,000 1,500 2,000 Meters

Scale: 1:30000 @ A3

H:\Projects\HM-255\23000-Projects\23736 - Bexley SFRA\Data\GIS\ESRIMXDs\23736-A05.mxd

Bexley SFRA

Figure 10

Groundwater Source Protection Zones

November 2008
23736-A10.mxd squij

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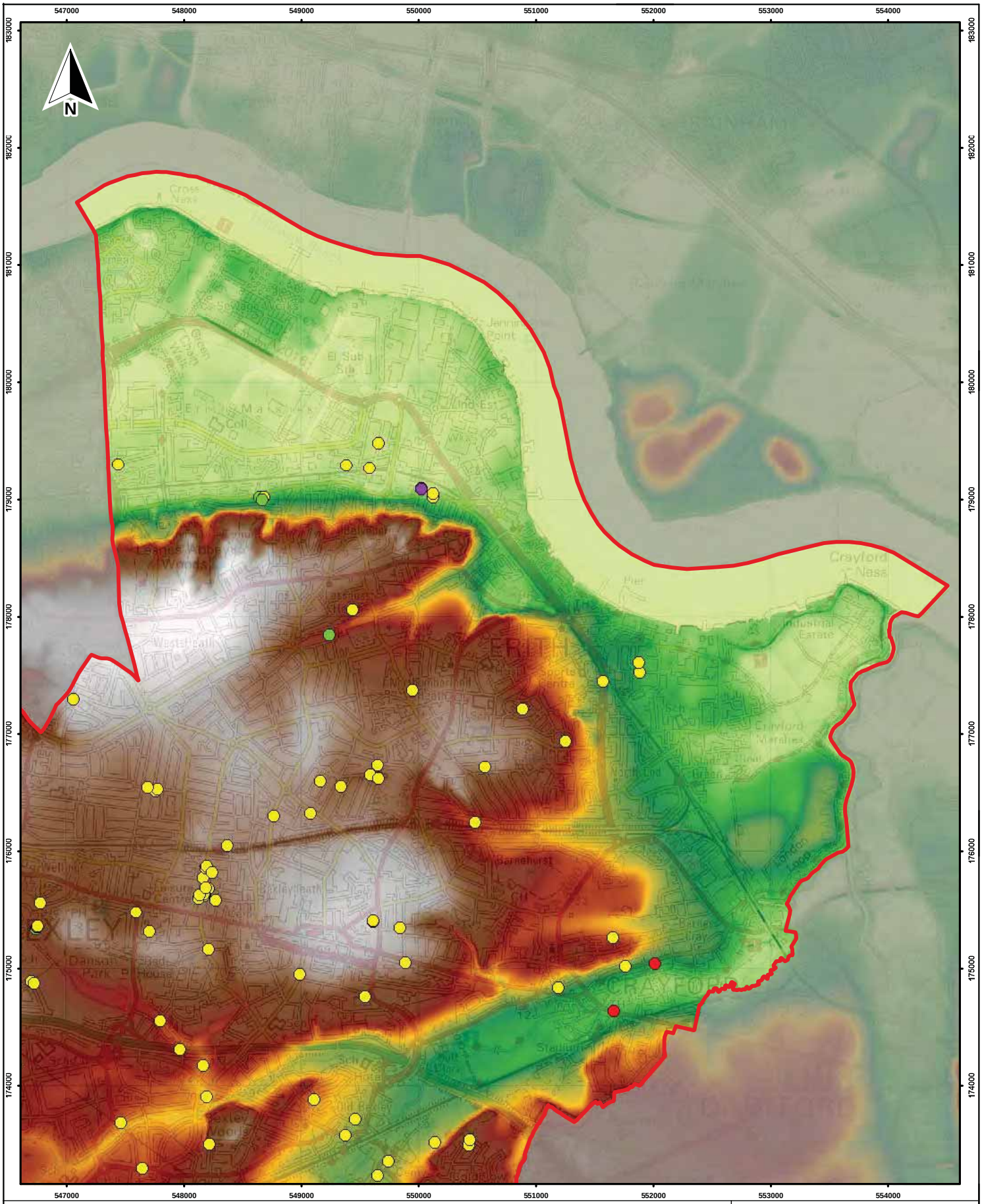

Key:

Bexley borough

Drainage Locations
Source

- Foul water
- Surcharge from sewers
- Surface water
- Unknown

Data Source = London Borough of Bexley

Ground Elevation (m) - Based on SAR data

High : 140

Low : < 0

0 390 780 1,170 1,560 Meters

Scale: 1:30000 @ A3

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Bexley SFRA

Figure 17

Historic Drainage Events (Source) (North)

November 2008
23736-A17.mxd squij

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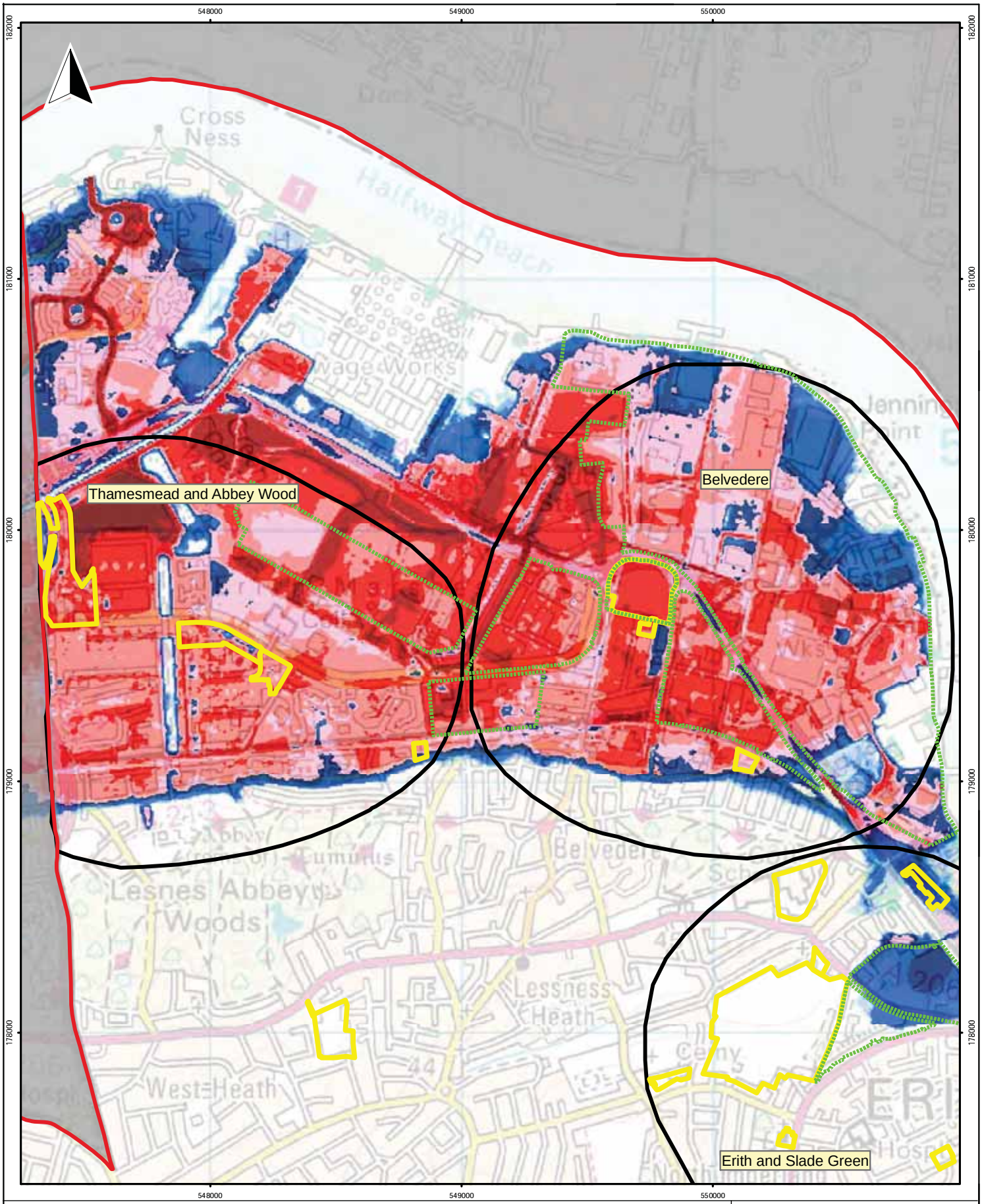

Key:

- London Borough of Bexley Boundary
- LDF Growth Areas
- SHLAA Sites
- Employment Sites

Maximum Flood Depth (m)

0 - 0.25	2.01 - 2.5
0.25 - 0.5	2.51 - 3
0.50 - 0.75	3.01 - 3.5
0.75 - 1	3.51 - 4
1.00 - 1.5	4.01 - 5
1.51 - 2	5.01 - 6

0 180 360 540 720 Meters

Scale: 1:14000 @ A3

H:\Projects\HM-255\23000-Projects\23736 - Bexley SFRA\Data\GIS\ESRI\Level2_projects

Bexley SFRA

Figure B3

Thamesmead & Abbey Wood and Belvedere - Maximum Predicted Flood Depths From all Breaches in the 1 in 200 Year Tidal Event Plus CC

July 2010
23736-A032.mxd RAMPJ

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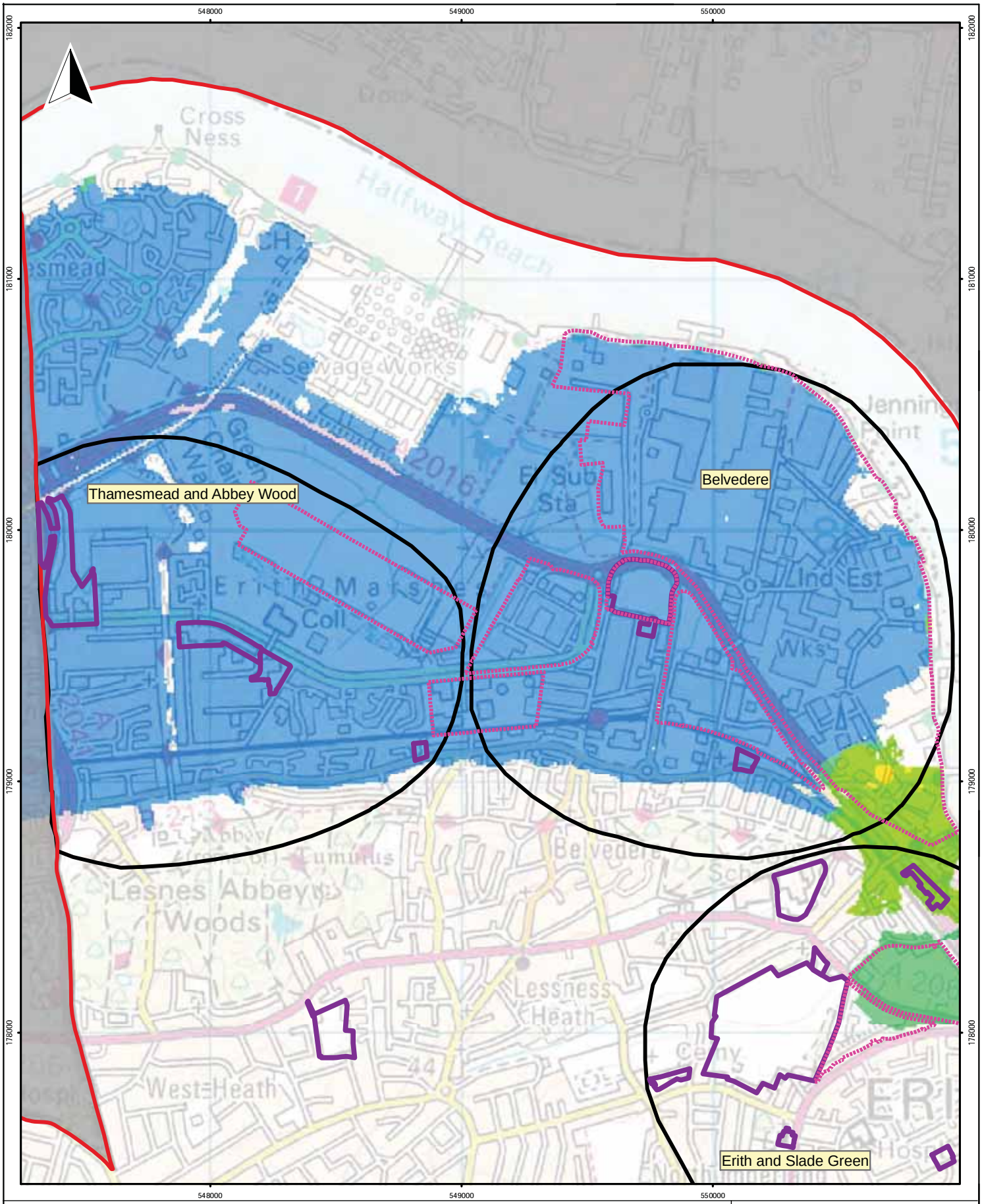

Key:

- London Borough of Bexley Boundary
- LDF Growth Areas
- SHLAA Sites
- Employment Sites

Maximum Water Surface Elevation
From all Breaches (1 in 200yr +CC)
mAOD

0.01 - 3.70	5.31 - 5.79
3.71 - 4.10	5.80 - 6.21
4.11 - 4.40	6.22 - 6.75
4.41 - 4.89	
4.90 - 5.30	

0 180 360 540 720 Meters

Scale: 1:14000 @ A3

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Bexley SFRA

Figure B5

Thamesmead & Abbey Wood and Belvedere - Maximum Predicted Flood Water Level From all Breaches in the 1 in 200 Year Tidal Event Plus CC

July 2010
23736-A034.mxd RAMPJ

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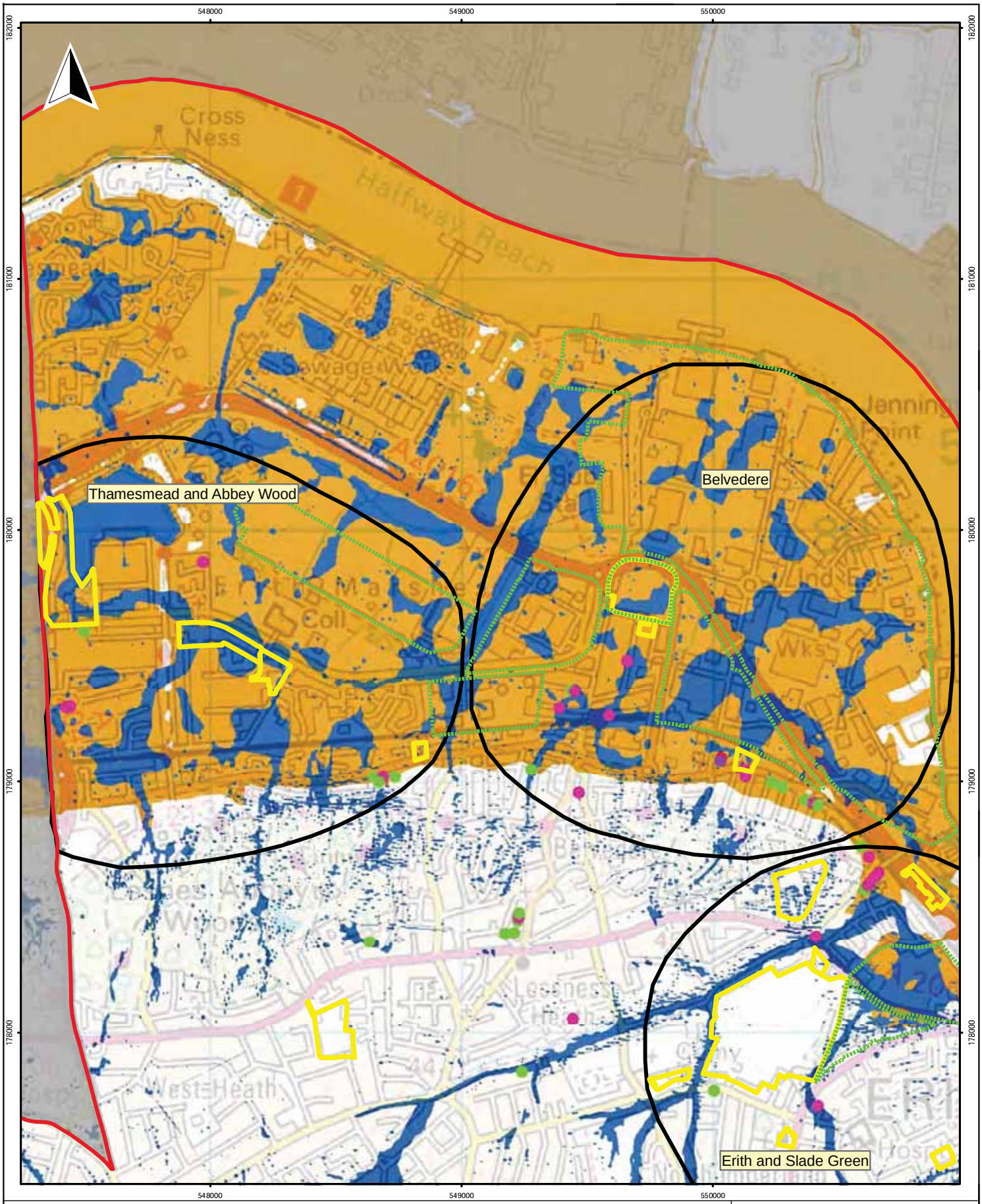

Key:

- London Borough of Bexley Boundary
- LDF Growth Areas
- SHLAA Sites
- Employment Sites

Surface Water Flooding Locations Classified by Source

- Foul water
- Surcharge from sewers
- Surface water
- Unknown

(Data Source = London Borough of Bexley)

- Environment Agency Flood Zone 3 (September 2008)
- Potential Surface Water Flow Routes and Ponding Areas (1 in 100 year +CC rainfall event)

0 180 360 540 720 Meters

Scale: 1:14000 @ A3

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Bexley SFRA

Figure B7

Thamesmead & Abbey Wood and Belvedere - Incidents of Surface Water Flooding and Modelled areas of Potential Surface Water Flow Routes and Ponding Areas

July 2010
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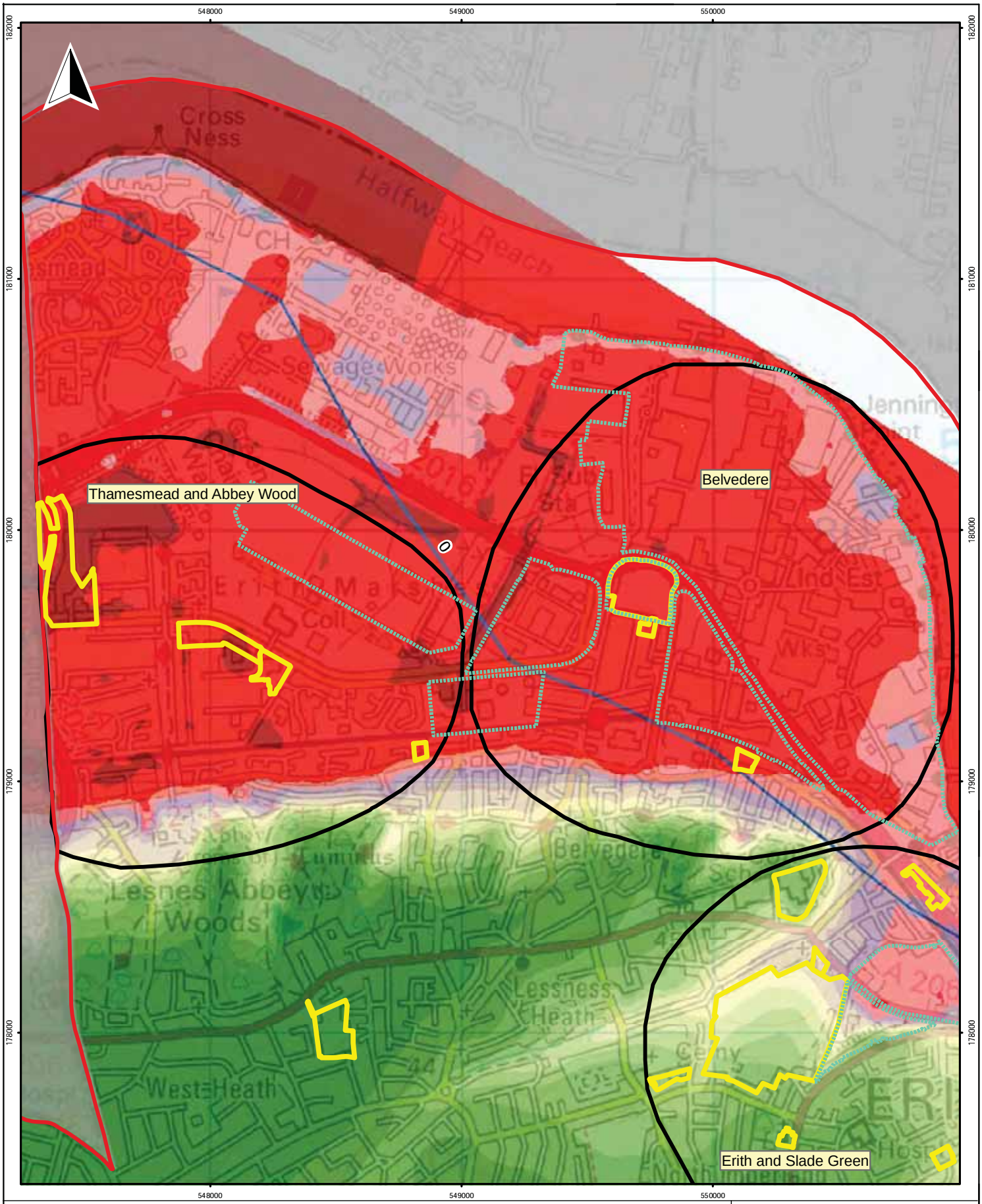

Key:

- London Borough of Bexley Boundary
- LDF Growth Areas
- SHLAA Sites
- Employment Sites

Groundwater Head (m below ground)

- -3 - 0
- 0 - 2.5
- 2.51 - 5
- 5.01 - 7.5
- 7.51 - 10
- 10.01 - 15
- 15.01 - 20
- 20.01 - 25
- 25.01 - 30
- 30.01 - 35
- 35.01 - 40
- 40.01 - 45
- 45.01 - 50
- 50.01 - 55

Depth to groundwater head was based on ground elevations provided by 5m SAR topographic data

Groundwater Contours (m) below ground Supplied by EA

0 180 360 540 720 Meters

Scale: 1:14000 @ A3

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Bexley SFRA

Figure B8
Thamesmead & Abbey Wood and Belvedere - Depth to Groundwater Head (m below ground level)

July 2010
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APPENDIX F

Extracts from Riverside Dana Centre Flood Assessment

Product 4 (Detailed Flood Risk) for: The Riverside Data Centre, DA17 6JY
Requested by: Konstantinos Kordalis
Reference: KSL151008 KR72
Date: 13 October 2015

Contents

- Flood Map for Planning (Rivers and Sea)
- Flood Map Extract
- Thames Estuary 2100 (TE2100)
- Thames Tidal Breach Modelling
- Thames Tidal Breach Modelling Map
- Site Node Locations Map
- Defence Details
- Recorded Flood Events Data
- Recorded Flood Events Outlines Map
- Additional Information
- Environment Agency Standard Notice

The information provided is based on the best data available as of the date of this letter.

You may feel it is appropriate to contact our office at regular intervals, to check whether any amendments/ improvements to the data for this location have been made. Should you re-contact us after a period of time, please quote the above reference in order to help us deal with your query.

This information is provided subject to the enclosed notice which you should read.

Orchard House, Endeavour Park, London Road, Addington, West Malling, Kent, ME19 5SH.
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Email: kslenquiries@environment-agency.gov.uk
Website: https://www.gov.uk/government/organisations/environment-agency

Flood Map for Planning (Rivers and Sea)

The Flood Map:

Our Flood Map shows the natural floodplain for areas at risk from river and tidal flooding. The floodplain is specifically mapped ignoring the presence and effect of defences. Although flood defences reduce the risk of flooding they cannot completely remove that risk as they may be over topped or breached during a flood event.

The Flood Map indicates areas with a 1% (0.5% in tidal areas), Annual Exceedance Probability (AEP) - the probability of a flood of a particular magnitude, or greater, occurring in any given year, and a 0.1% AEP of flooding from rivers and/or the sea in any given year. In addition, the map also shows the location of some flood defences and the areas that benefit from them.

The Flood Map is intended to act as a guide to indicate the potential risk of flooding. When producing it we use the best data available to us at the time and also take into account historic flooding and local knowledge. The Flood Map is updated on a quarterly basis to account for any amendments required. These amendments are then displayed on the internet at

https://www.gov.uk/government/organisations/environment-agency.

At this Site:

The Flood Map shows that this site lies within the outline of Flood Zone 3. This zone comprises land assessed as having a 0.5% (1 in 200) or greater annual probability of tidal flooding.

Enclosed is an extract of our Flood Map which shows this information for your area.

Method of production

The Flood Map at this location has been derived using detailed modelling of the tidal River Thames through the Thames Tidal Defences Study completed in 2006 by Halcrow Ltd.

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Thames Estuary 2100 (TE2100)

You have requested in-channel flood levels for the tidal river Thames. These have been taken from the Thames Estuary 2100 study completed by HR Wallingford in 2008. The modelled node closest to your site is **3.9**; the locations of nearby nodes are also shown on the enclosed map.

Details about the TE2100 plan

The TE2100 plan is now live and within it are a set of levels on which the flood risk management strategy is based. The plan is the overarching flood management strategy for the Thames Estuary and therefore any development planning should be based on the same underlying data.

Details about the TE2100 in-channel levels

The TE2100 in-channel levels take into account operation of the Thames Barrier when considering future levels. The Thames Barrier requires regular maintenance and with additional closures the opportunity for maintenance will be reduced. When this happens, river levels – for which the Barrier would normally shut for the 2008 epoch – will have to be allowed through to ensure that the barrier is not shut too often. For this reason, levels upriver of the barrier will increase and the tidal walls will need to be heightened to match.

For further information about the Thames Barrier please visit our website at:

https://www.gov.uk/the-thames-barrier

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TE2100 2008 levels:

Levels downriver of the Thames Barrier are 0.1% AEP (1 in 1000) and levels upriver are the highest levels permitted by the Thames Barrier, described as the Maximum Likely Water Levels (MLWLs). The defence levels (left defence, right defence) are the minimum levels to which the defences should be built.

Location	Node	Easting	Northing	Extreme water level (m)	Left defence (m)	Right defence (m)	Allow for future defence raising to a level of...	
							Left Bank (m)	Right Bank (m)
	3.7	547183	181618	6.01	7.30	7.10	8.20	8.20
	3.8	548204	181714	6.01	7.30	7.10	8.20	8.20
Beam River	3.9	549299	181171	6.00	7.20	7.10	8.20	8.20
	3.10	550318	181003	5.98	7.10	7.10	8.10	8.10
	3.11	551166	180048	5.97	7.05	7.10	8.10	8.10

TE2100 climate change levels:

Location	Node	Easting	Northing	1000-year design water levels					
				2000	2040	2070	2100	2120	2170
	3.7	547183	181618	6.01	6.22	6.42	6.75	6.95	7.46
	3.8	548204	181714	6.01	6.22	6.41	6.74	6.94	7.44
Beam River	3.9	549299	181171	6.00	6.21	6.40	6.72	6.92	7.42
	3.10	550318	181003	5.98	6.19	6.37	6.70	6.90	7.40
	3.11	551166	180048	5.97	6.18	6.37	6.70	6.90	7.39

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Thames Tidal Breach Modelling

The table below displays site-specific modelled flood levels at your site. These have been taken from the Thames Tidal Breach Modelling Study 2015 completed by CH2M HILL in March 2015. The exact location of the given site-specific levels and the extent of the breach are shown on the enclosed map.

This modelling simulates tidal breaches along the Thames from Teddington to the Mar Dyke and River Darent. A series of 113 tidal models were developed for the Environment Agency at pre-determined breach locations. These were chosen using a risk-based approach by examining critical locations based on low floodplain topography. For hard and composite defences breaches are set at 20 m wide; for soft defences, breaches are 50 m wide. In both cases, the defence breach scour distance was assumed to extend into the floodplain by the same distance as the breach width.

Based on the 2008 TE2100 in-channel levels, the 0.5% (1 in 200 year) and 0.1% (1 in 1000 year) annual probability of exceedance tidal events were modelled for all breach locations downriver of the Thames Barrier. These were modelled for the 2014 year epoch, as well as a 2065 and 2100 epoch which include allowances for climate change.

For breaches upriver of the Thames Barrier, there is no return period for modelled levels as the levels are controlled by barrier closures. The levels used are referred to as Maximum Likely Water Levels (MLWLs). Therefore 2014, 2065 and 2100 epochs were modelled on that basis.

The modelled levels shown assume that the Thames defences have been breached at location ‘Thm05’ (NGR TQ5027580613).

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			Thm05					
	National Grid Reference		Modelled levels in mAODN for 0.5% AEP			Modelled levels in mAODN for 0.1% AEP		
Node	Easting	Northing	2014	2065	2100	2014	2065	2100
1	549583	180573	2.01	2.20	2.37	2.08	2.33	2.53
2	549669	180550	2.01	2.20	2.37	2.08	2.33	2.53
3	549651	180431	2.01	2.20	2.37	2.08	2.33	2.53
4	549642	180339	2.01	2.20	2.37	2.08	2.33	2.53
5	549644	180250	2.02	2.20	2.37	2.08	2.33	2.53
6	549648	180110	2.02	2.21	2.37	2.08	2.34	2.53
7	549618	179894	2.02	2.21	2.37	2.08	2.33	2.53
8	549384	179872	2.01	2.20	2.37	2.08	2.33	2.53

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Defence Details

The design standard of protection of the flood defences in this area of the Thames is 0.1% AEP; they are designed to defend London up to a 1 in 1000 year **tidal** flood event. The defences are all raised, man-made and privately owned. It is the riparian owners' responsibility to ensure that they are maintained to a crest level of 7.1 m AODN (the Statutory Flood Defence Level in this reach of the Thames). We inspect them twice a year to ensure that they remain fit for purpose. The current condition grade for defences in the area is 2 (good), on a scale of 1 (very good) to 5 (very poor). For more information on your rights and responsibilities as a riparian owner, please see our document 'Living on the edge' found on our website at:

https://www.gov.uk/government/publications/riverside-ownership-rights-and-responsibilities

There are no planned improvements in this area. Please see the 'Thames Estuary 2100' document on our website for the short, medium and long term Flood Risk Management strategy for London:

https://www.gov.uk/government/publications/flooding-thames-estuary-2100-te2100-plan

Areas Benefiting from Flood Defences

This site is within an area benefiting from flood defences, as shown on the enclosed extract of our Flood Map. Areas benefiting from flood defences are defined as those areas which benefit from formal flood defences specifically in the event of flooding from rivers with a 1% (1 in 100) chance in any given year, or flooding from the sea with a 0.5% (1 in 200) chance in any given year.

If the defences were not there, these areas would be flooded. An area of land may benefit from the presence of a flood defence even if the defence has overtopped, if the presence of the defence means that the flood water does not extend as far as it would if the defence were not there.

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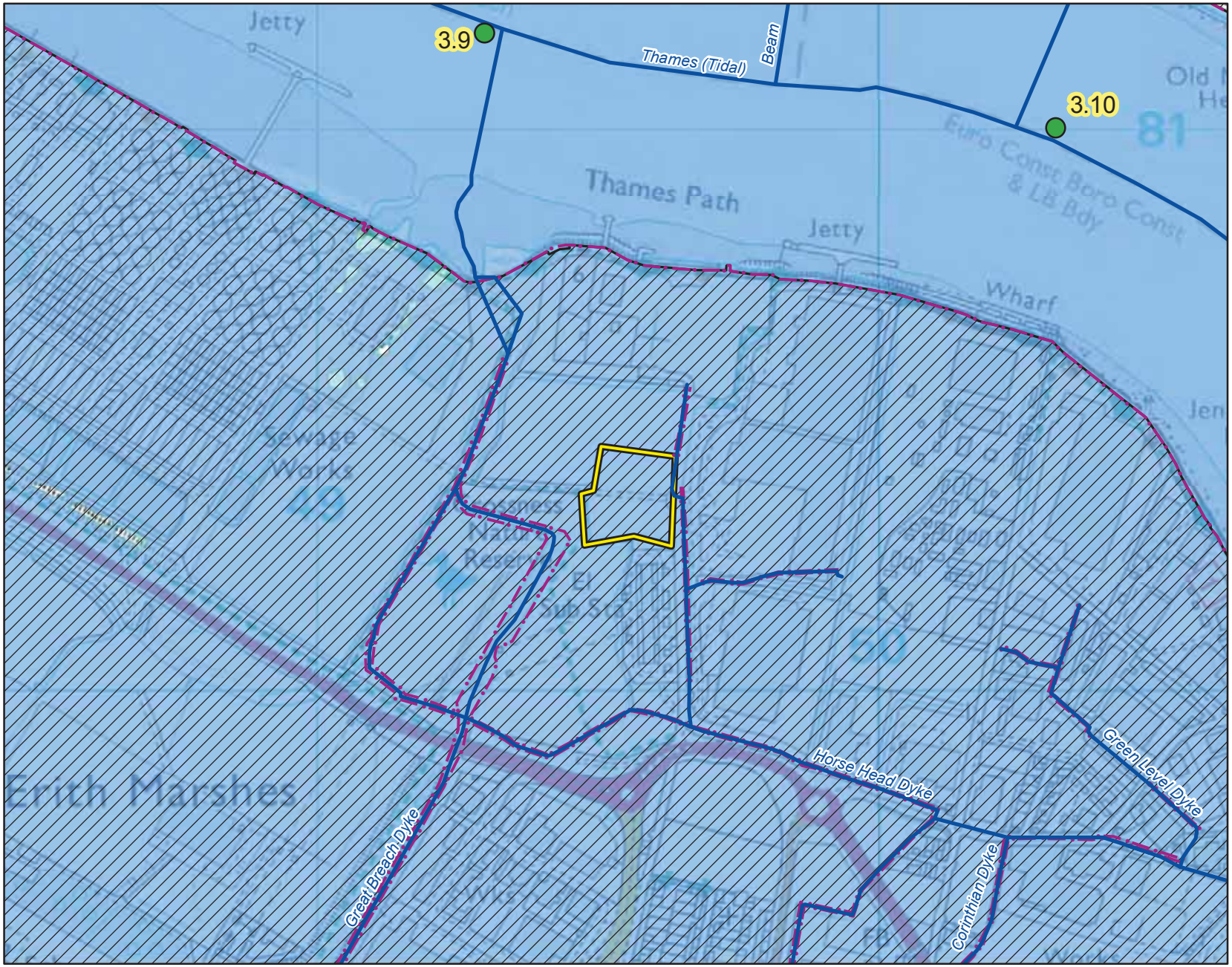
Detailed FRA/FCA Map centred on DA17 6JY created 13 October 2015 [Ref: KSL151008 KR72]



Environment Agency

Scale 1: 10,000

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Legend

- TE2100 Model Nodes
- Main Rivers
- Flood Map - Defences
- Site Location
- Flood Map - Flood Storage Areas
- Areas Benefiting from Flood Defences
- Flood Map - Flood Zone 3
- Flood Map - Flood Zone 2

Flood Map for Planning (assuming no defences)

Flood Zone 3 shows the area that could be affected by flooding:
– from the sea with a 0.5% or greater chance of occurring each year
– or from a river with a 1% or greater chance of occurring each year.

Flood Zone 2 shows the extent of an extreme flood from rivers or the sea with up to a 0.1% chance of occurring each year.

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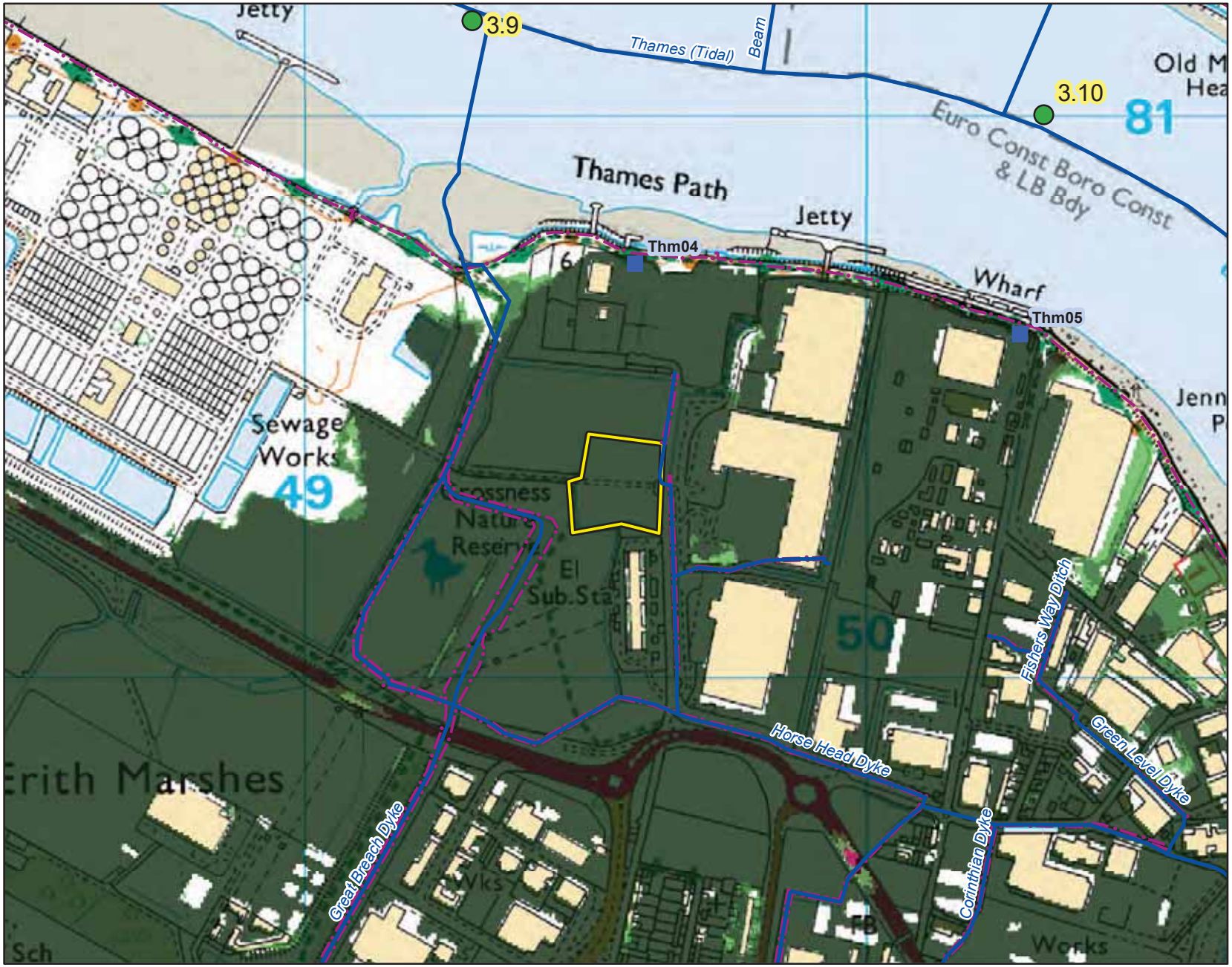
Breach Modelling Map centred on DA17 6JY created 13 October 2015 [Ref: KSL151008 KR72]



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Scale 1: 10,000

Legend

- TE2100 Model Nodes
- Breach Locations
- Main Rivers
- Flood Map - Defences
- Site Location

Downriver 0.5% AEP Outlines

- 2014
- 2065
- 2100

Thames Tidal Breach Modelling 2015

A modelled representation of tidal breaches along the Thames from Teddington to the Mar Dyke and River Darent, based on low floodplain topography. For hard and composite defences breaches are set at 20 m wide; for soft defences, breaches are 50 m wide. In both cases, the defence breach scour distance was assumed to extend into the floodplain by the same distance as the breach width.
The modelling is based on the 2008 TE2100 in-channel levels, with an allowance for climate change for epochs 2065 and 2100.

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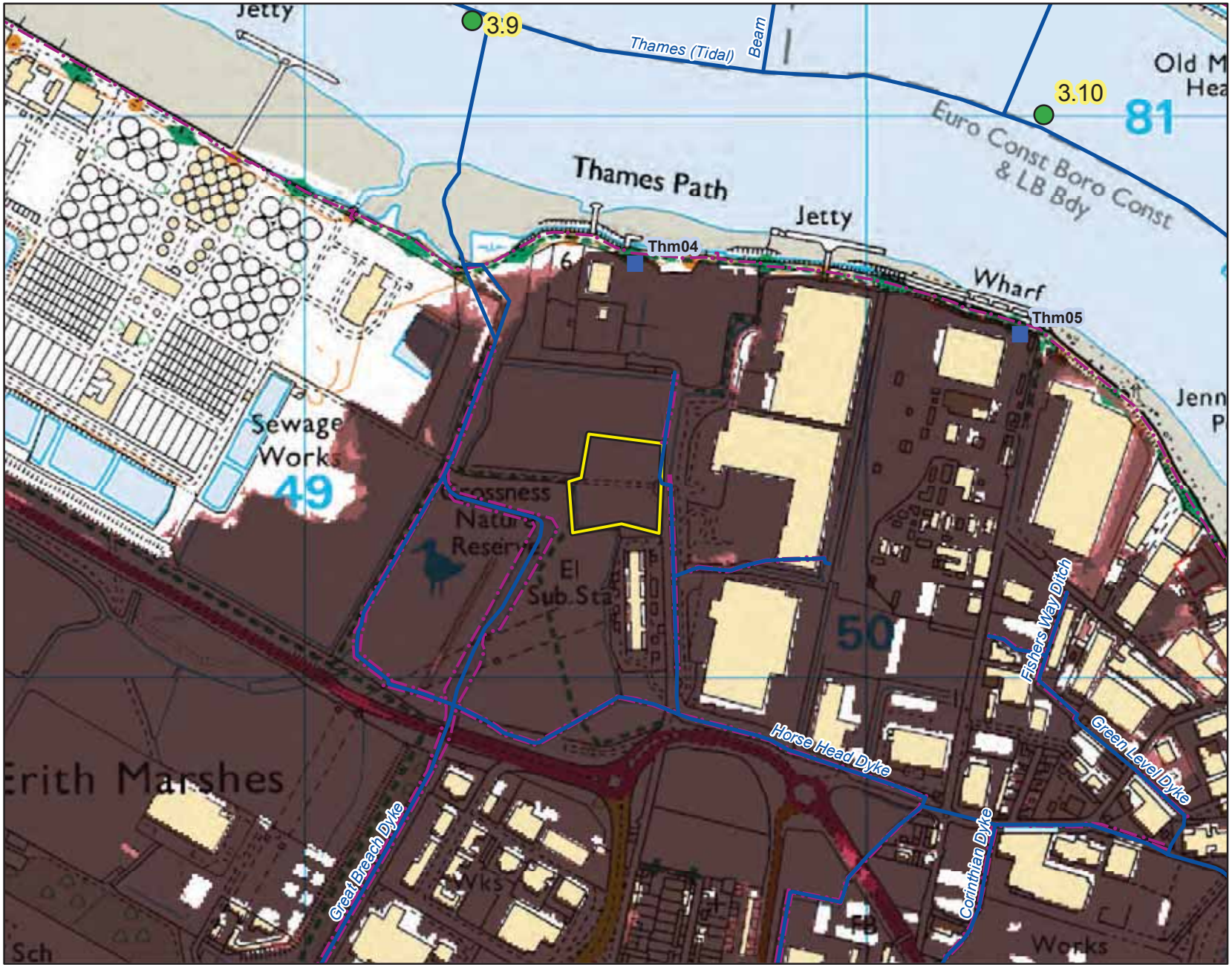
Breach Modelling Map centred on DA17 6JY created 13 October 2015 [Ref: KSL151008 KR72]



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Scale 1: 10,000

Legend

- TE2100 Model Nodes
- Breach Locations
- Main Rivers
- Flood Map - Defences
- Site Location

Downriver 0.1% AEP Outlines

- 2014
- 2065
- 2100

Thames Tidal Breach Modelling 2015

A modelled representation of tidal breaches along the Thames from Teddington to the Mar Dyke and River Darent, based on low floodplain topography. For hard and composite defences breaches are set at 20 m wide; for soft defences, breaches are 50 m wide. In both cases, the defence breach scour distance was assumed to extend into the floodplain by the same distance as the breach width.
The modelling is based on the 2008 TE2100 in-channel levels, with an allowance for climate change for epochs 2065 and 2100.

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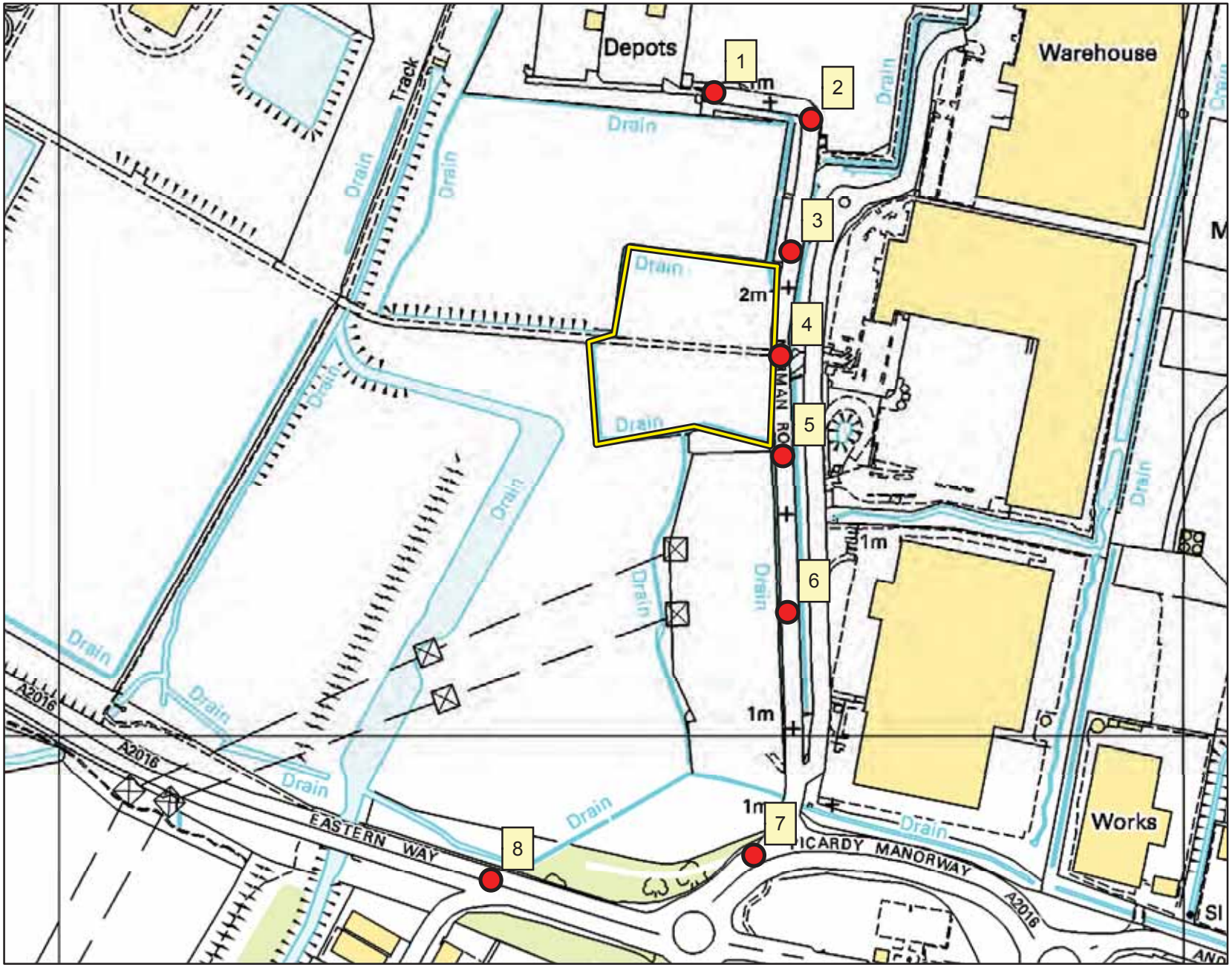
Node Location Map centred on DA17 6JY created 13 October 2015 [Ref: KSL151008 KR72]



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Legend

2D Nodes

Site Location

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