Thurrock Flexible Generation Plant

Environmental Statement Volume 6
Appendix 15.1: Flood Risk Assessment

Date: November2020

Environmental Impact Assessment

Environmental Statement

Volume 6

Appendix 15.1

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This report is also downloadable from the Thurrock Flexible Generation Plant website at: http://www.thurrockpower.co.uk

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Summary

This document provides a development-specific Flood Risk Assessment (FRA) in accordance with the requirements of the National Planning Policy Framework (NPPF) and Planning Practice Guidance (PPG ID7) for the proposed Thurrock Flexible Generation Plant.

Qualifications

This document has been prepared by Jonathan Morley, an Associate Director, who has 14 years' experience of environmental impact assessment.

It has been checked by Ola Holmstrom who is a Chartered Engineer, with over 20 years' professional experience in consultancy in the UK.

1. Introduction

1.1 Background

1.1.1 A site-specific Flood Risk Assessment (FRA) has been prepared for the Thurrock Flexible Generation Plant (proposed development), specifically the main development site which is referred to as Zone A encompassing the proposed gas engine, battery storage and substation facilities, and Zone G associated with the causeway.

1.1.2 A review of the flood risk posed to the above-ground installation for gas connection to Feeder 18 (within Zone D3) has also been undertaken to aid in informing flood resilience requirements. It has been determined that the size and scale of development in Zone D3 would have negligible impact on the local hydrological regimes, as the majority of the development would be buried pipe with a small water-tight gas terminal projected above ground. In addition, appropriate flood resilience and/or resistance measures will be incorporated into the design to ensure critical infrastructure can remain operational.

1.1.3 The FRA has been produced in accordance with the Overarching National Policy Statement (NPS) for Energy EN-1, the National Planning Policy Framework (NPPF) and Planning Practice Guidance (PPG) ID7 and relevant local planning policies, a summary of each is presented in Section 3. The policies cover the requirements in respect to Nationally Significant Infrastructure Projects.

1.1.4 The FRA supports the Development Consent Order (DCO) application for the proposed development in accordance with the Infrastructure Planning (Applications: Prescribed Forms and Procedure) Regulations 2009 (as amended). It also forms an appendix to Thurrock Flexible Generation Plant Environmental Statement Volume 3, Chapter 15: Hydrology and Flood Risk.

1.1.5 Developments that are designed without regard to flood risk may endanger lives, damage property, cause disruption to the wider community, damage the environment, be difficult to insure and require additional expense on remedial works.

1.1.6 Current guidance on development and flood risk (PPG: ID7 Flood risk and coastal change) identifies several key aims for a development to ensure that it is sustainable in flood risk terms. These aims are as follows:

- The development should not be at a significant risk of flooding and should not be susceptible to damage due to flooding;
- The development should not be exposed to flood risk such that the health, safety and welfare of the users of the development, or the population elsewhere, is threatened;
- Normal operation of the development should not be susceptible to disruption as a result of flooding;
- Safe access to and from the development should be possible during flood events;
- The development should not increase flood risk elsewhere;
- The development should not prevent safe maintenance of watercourses or maintenance and operation of flood defences;
- The development should not be associated with an onerous or difficult operation and maintenance regime to manage flood risk. The responsibility for any operation and maintenance required should be clearly defined;
- Future users of the development should be made aware of any flood risk issues relating to the development;
- The development design should be such that future users will not have difficulty obtaining insurance or mortgage finance, or in selling all or part of the development, as a result of flood risk issues;
- The development should not lead to degradation of the environment; and
- The development should meet all of the above criteria for its entire lifetime, including consideration of the potential effects of climate change.

1.1.7 The FRA is undertaken with due consideration of these sustainability aims.

1.1.8 The key objectives of the FRA are:

- To assess the flood risk to the proposed development and to demonstrate the feasibility of appropriately designing the development such that any residual flood risk to the development and users would be acceptable;
- To assess the potential impact of the proposed development on flood risk elsewhere and to demonstrate the feasibility of appropriately designing the development, such that the development would not increase flood risk elsewhere; and
- To satisfy the requirements of the NPS, the NPPF and PPG and DCO application guidance insofar as they require FRAs to be submitted in support of DCO applications.

1.2 Methodology

1.2.1 The proposed study area of the FRA follows the Thurrock Flexible Generation Plant hydrology and flood risk study area as defined in Volume 3, Chapter 15: Hydrology and Flood Risk. It includes a 1 km buffer around proposed development.

1.2.2 The buffers applied are considered appropriate for data collection taking into account the nature of proposed development and likely zone of influence on hydrological receptors.

1.2.3 In order to achieve the objectives outlined within 1.1.8, a staged approach was adopted in undertaking the FRA in accordance with NPS (EN-1), the NPPF and PPG. Initially, screening studies have been undertaken utilising publicly available information, records and data to identify whether there are any potential sources of flooding within Zone A and elsewhere in the proposed development hydrology and flood risk study area, which may warrant further consideration. Identified potential flooding issues are then assessed further within a specific flood risk section. The aims of the assessment are:

- to review all available information and provide a qualitative analysis of the flood risk to the proposed development; and
- to identify any impact of the proposed development on flood risk elsewhere.

1.3 Report structure

1.3.1 This report has the following structure:

- Section 1.4 identifies the sources of information that have been consulted in preparation of the FRA;
- Section 2 sets out relevant legislation, guidance and planning policy including requirements of the NPPF and PPG;
- Section 3 provides information pertinent to the site setting; and
- Section 4 provides the development specific FRA for the proposed permanent surface structures.

1.3.2 A hydrological review of the proposed development and a description of the flood risk management measures incorporated into the design of the proposed development are also presented below.

1.4 Information Sources

1.4.1 The information used in the preparation of report is set out in Table 1.1.

Table 1.1: Information sources consulted during the preparation of the report.

Source	Data	Information consulted/provided
Site setting and hydrology	Ordnance Survey (OS) 1:50,000 Landranger 177 East London, Billericay & Gravesend	Area information, rivers and other watercourses, general site environs, built environment
Geology, hydrogeology	British Geological Survey (BGS, n.d.) 1: 50 000 digital mapping	Site and area geology, groundwater vulnerability.
Environment Agency (EA)	EA – online mapping.	Current flood risk, local flood defences, flood levels, supplementary geology and groundwater information.
Local Planning Authority (LPA)	Thurrock Borough Council	Strategic Flood Risk Assessment, June 2018, Flood Zoning.
Sewerage/Water	Essex & Suffolk Water.	Private system, no public asset data.
Flood Risk Assessment and Planning Guidance	NPPF (2019) Planning Practice Guidance ID7 EA Fluvial Design Guide, 2009.	Outlines Planning Policy requirements and outlines best practice guidelines for the generation of hydraulic models.
Previous consultancy reports	Thurrock Borough Council Level 1 Strategic Flood Risk Assessment (AECOM, 2018).	Lead Local Flood Authority Flood Risk Assessment and mapping.
	South Essex Catchment Flood Management Plan Summary Report December 2009.	The Catchment Flood Management Plan (CFMP) provides an overview of the flood risk in the South Essex area and sets out our preferred plan for sustainable flood risk management over the next 50 to 100 years.

2. Legislation and Guidance

2.1 National Policies and Guidance

National Planning Policy Framework (February 2019).

2.1.1 The NPPF sets out Government planning policies for England and how these are expected to be applied. The framework acts as guidance for local planning authorities and decision-takers, both in drawing up plans and making decisions about planning applications.

2.1.2 Paragraphs 163 -165 set out the need for an appropriate assessment of flood risk on a site specific basis. Guidance on the minimum requirements for such an assessment is contained in PPG ID7.

2.1.3 The NPPF requires the application of a sequential, risk-based approach to determining the suitability of land for development in flood risk areas, and that flood risk assessment should be carried out to the appropriate degree, at all levels of the planning process.

2.1.4 Footnote 50 states that a site-specific flood risk assessment should be provided for all development in Flood Zones 2 and 3. In Flood Zone 1, an assessment should accompany all proposals involving: sites of 1 hectare or more; land which has been identified by the Environment Agency as having critical drainage problems; land identified in a strategic flood risk assessment as being at increased flood risk in the future; or land that may be subject to other sources of flooding, where its development would introduce a more vulnerable use.

Planning Practice Guidance, online.

2.1.5 PPG ID7 Flood Risk and Coastal Change provides guidance to ensure the effective implementation of the NPPF planning policy for development in areas at risk of flooding.

Climate Change

2.1.6 The NPPF sets out how the planning system should help minimise vulnerability and provide resilience to the impacts of climate change. NPPF and supporting planning practice guidance on Flood Risk and Coastal Change explain when and how flood risk assessments should be used. This includes demonstrating how flood risk will be managed now and over the development's lifetime, taking climate change into account.

2.1.7 In February 2016 the Environment Agency (EA) published advice on climate change allowances to support NPPF, which was most recently updated on the 20th of July 2020 to account for the latest climate change projections within UKCP18. New guidance requires that flood risk assessments and strategic flood risk assessments, assess both the central and upper end allowances along with an extreme climate change scenario known as H++ to understand the range of impact.

2.1.8 Climate change allowances are predictions of anticipated change for:

- peak river flow
- peak rainfall intensity
- sea level rise
- offshore wind speed and extreme wave height

2.1.9 Different allowances for different epochs or periods of time over the next century are provided.

Peak river flow allowances

2.1.10 Peak river flow allowances show the anticipated changes to peak flow by river basin district.

2.1.11 The range of allowances is based on percentiles. A percentile is a measure used in statistics to describe the proportion of possible scenarios that fall below an allowance level. The 50th percentile is the point at which half of the possible scenarios for peak flows fall below it and half fall above it. The:

- central allowance is based on the 50th percentile
- higher central allowance is based on the 70th percentile
- upper end allowance is based on the 90th percentile

2.1.12 An allowance based on the 50th percentile is exceeded by 50% of the projections in the range. At the 70th percentile it is exceeded by 30%. At the 95th percentile it is exceeded by 5% of the projections in the range.

2.1.13 Table 2.1 below provides the peak river flow allowances for the Thames River basin district.

Table 2.1: Peak river flow allowances by river basin district (use 1961 to 1990 baseline).

Allowance category	Total potential change anticipated for the '2020s' (2015 to 2039)	Total potential change anticipated for the '2050s' (2040 to 2069)	Total potential change anticipated for the '2080s' (2070 to 2115)
H++	25%	40%	80%
Upper end	25%	35%	70%
Higher central	15%	25%	35%
Central	10%	15%	25%

Peak rainfall intensity allowance

2.1.14 Increased rainfall affects river levels and land and urban drainage systems.

2.1.15 For flood risk assessments the guidance indicates that an applicant should assess both the central and upper end allowances, present in Table 2.2 to understand the range of impact

Table 2.2: Change to extreme rainfall intensity compared to a 1961-90 baseline.

Applies across all of England	Total potential change anticipated for '2020s' 2015- 39)	Total potential change anticipated for '2050s' (2040- 2069)	Total potential change anticipated for the '2080s' (2070-2115)
Upper Estimate	10%	20%	40%
Central Estimate	5%	10%	20%

Sea level allowances

2.1.16 The guidance was updated in December 2019 account for UKCP18 and provides a range of allowances for each region and epoch or time frame for sea level rise. For the Thames river basin district to guidance identifies that the 'south east' sea level rise allowance should be used, which is shown in Table 2.3.

Table 2.3: Sea level allowance for each epoch in millimetres (mm) per year, with total sea level rise for each epoch in brackets (use 1981 to 2000 baseline) by river basin district.

Area of England	Allowance	2000 to 2035 (mm)	2036 to 2065 (mm)	2066 to 2095 (mm)	2096 to 2125 (mm)	Cumulative rise 2000 to 2125 (metres)
South east	Higher End	5.7 (200)	8.7 (261)	11.6 (348)	13.1 (393)	1.2
	Upper End	6.9 (242)	11.3 (339)	15.8 (474)	18.2 (546)	1.6

2.1.17 The H++ scenario associated with sea level rise is a single total annual allowance of 1.9 m. There is no H++ value beyond 2100.

2.1.18 The climate change guidance notes that the allowances provided have been derived from national scale research. There may be cases where local evidence supports the use of other local climate change allowances.

2.2 Local Policies

Thurrock Local Development Framework, Core Strategy and Policies for Management of Development. Development Plan Document Adopted December 2011

2.2.1 The Core Strategy is the central document of the Local Development Framework and sets out the vision, aims and strategy for spatial development in the Borough. It provides the framework for the formulation of the more detailed generic and site specific policies.

2.2.2 The policies relevant to hydrology are summarised below.

Policy CSTP25 – Addressing Climate Change

"IV. Developers must consider the potential effects of climate change on their development, including:

i. Water conservation and drainage; …
iv. Flood risk from tidal, fluvial and surface water."

CSTP27 – Management and Reduction of Flood Risk

"I. The Council will ensure that flood risk management is implemented and supported through effective land use planning. The Sequential, and where necessary Exception

Test, as set out in PPS25 will be employed when allocating sites for development and an Emergency Plan for the Borough will be completed.

II. The Council will also continue to work collaboratively with the EA by supporting the area based policy approach adopted in the Thames Estuary 2100 Project. In particular the Council will seek to safeguard existing flood defences and new areas for flood defences, water storage and drainage areas, as well as seeking secondary defences for key assets.

III. The Council will support the work of the EA in the Environmental Enhancement Project for the Mucking Flats and Marshes to ensure the delivery of appropriate flood mitigation and environmental enhancement measures.

IV. The Council will work with the EA and other main stakeholders to ensure that fluvial and surface water flood risk is managed within Thurrock. This will include supporting the policies identified in the South Essex Catchment Flood Management Plan, such as identifying and safeguarding areas of land for existing and future areas of water storage in Policy Units 9, 10, 11 & 12 and in formulating System Asset Management Plans (SAMP) and the Integrated Urban Drainage Plans for Stanford-le-Hope, Tilbury and Purfleet. A Surface Water Management Plan will also be carried out to assist in the identification and mapping of areas susceptible to surface water flooding as recommended by Defra and the Pitt Review. Development proposals that will affect these locations will be expected to contribute towards infrastructure improvements in these locations to enable the development to proceed.

V. The Council will ensure that, where necessary, new development throughout the Borough contains space for water including naturalisation and environmental enhancement.

VI. Developers will be required to contribute towards flood risk management infrastructure where appropriate.

VII. Planning applications received for sites within Flood Zone 3 will be treated in accordance with PPS25, this policy and Policy PMD15."

Policy PMD15 – Flood Risk Assessment

2.2.3 Sites not covered by the Thurrock Sequential Test will be required to provide a site-specific Sequential Test to demonstrate compliance with PPS25 or any successor to be provided by the applicant. To reflect the nature of Thurrock's defended floodplain, particular reference should be made to the hazard rating for each site where covered by the Thurrock Strategic Flood Risk Assessment (AECOM, 2018).

2.2.4 Only those applications classified under the 'minor development' or 'changes of use' categories will be exempt from applying the Sequential Test, but will still be expected to meet the requirements for Flood Risk Assessments and flood risk reduction as set out in Annex E of PPS25 and the associated Design and Sustainability Supplementary Planning Document.

2.2.5 Development proposals subject to the Exception Test in Thurrock must show that the following criteria have been met (in addition to FRA requirements outlined in PPS25):

- To assist with part a) of the Exception Test, reference should be made to the main assessment criteria outlined in the Thurrock Sustainability Appraisal and any opportunities to reduce the overall flood risk posed to the community, including schemes to make space for water;
- The FRA must demonstrate that the development will be 'safe', without increasing flood risk elsewhere, and where possible will reduce flood risk overall. For Thurrock, this will mean addressing the following points in particular:
- Flood hazard must be fully considered and reference should be made in the site-specific FRA to the SFRA, or site-specific modelling. This should be used to inform a sequential approach to planning within the site;
- Where it is deemed acceptable to reduce flood storage as a result of development, level for level compensation storage must be provided to ensure that there is no increased flood risk elsewhere;
- Where appropriate, an emergency plan for the development must be submitted that is consistent with the emergency plan for the area. This will include evidence that 'more vulnerable' development can achieve safe access/egress to a communal refuge point or unaffected area accessible to the emergency services. In highly exceptional cases where access/egress to a place of safe refuge cannot be achieved, these will be considered on their individual merits;
- Where appropriate, flood avoidance, flood resistance and flood resilience measures must be incorporated into the design of any development;
- Evidence that surface water management schemes, and other flood defence measures that are required on-site in order to allow a development to take place will be adequately maintained for the lifetime of that development by the site owner; and
- Evidence that the proposed development will not interfere with the potential for future maintenance or improvements to flood defences.

2.2.6 Developers may be required to provide Developer Contributions towards the improvement of Emergency Planning services and flood defence measures within Thurrock as part of flood management mitigation.

2.2.7 Developments will be expected to incorporate Sustainable Drainage Systems (SUDS) to reduce the risk of surface water flooding, both to the site in question and to the surrounding area. Where the potential for surface water flooding has been identified, site specific Flood Risk Assessments should ensure that suitable SUDS techniques are incorporated as part of the redevelopment.

3. Site Setting

3.1 Site Location

3.1.1 The main development site comprises an irregular shaped parcel of land covering approximately 20 ha in Thurrock, Essex. The site is split into two distinct fields (north and south) by a land drainage network.

3.1.2 Zone G includes a section of the Thames tidal flood defence, which would be cut to provide vehicle access to the foreshore and proposed causeway.

3.1.3 Further details of the site location and application boundary overall can be found in Volume 2, Chapter 2: Project Description of the Environmental Statement (ES).

3.2 Surrounding Area

3.2.1 The site sits within an area with mixed agricultural and industrial use, bound to the west and east by agricultural land, to the south by a National Grid substation with the River Thames and its associated mud and salt flats beyond, and to the north an embanked railway line with agricultural land beyond.

3.3 Existing Development

3.3.1 The site (Zone A) is presently utilised as agricultural land and Common Land with grazing rights.

3.4 Proposed Development

3.4.1 The application is for the development of a Flexible Generation Plant including the following main elements within Zone A. Full details are provided in Volume 2, Chapter 2: Project Description. An illustrative site layout with conceptual drainage design is shown in the Conceptual Drainage Strategy (application document A7.3).

- Gas engines, air pollutant control and cooling;
- Substations;
- Battery storage;
- Gas connection compound;
- Carbon Capture Ready area;
- Underground electrical cabling connecting to the National Grid substation; and
- Internal access roads.

3.4.2 As a consequence of the development there will be an increase in low permeability cover of approximately 6.35 ha.

3.4.3 To facilitate a gravity drainage system, it is proposed Zone A areas including the gas fired facility, battery storage and customer substation are to be raised to 2.0 m Above Ordnance Datum (AOD) as set out in the Conceptual Drainage Strategy (application document A7.3).

3.4.4 The proposed development will be lightly manned by 4-6 full-time equivalent staff during the majority of the operational phase, being largely remotely operated and monitored, with occasional access by around 20 contractors for maintenance.

3.5 Topographical Survey

3.5.1 A topographical survey of the site has been undertaken (Annex A) which indicates that the north field has a gentle slope from northwest with levels circa 1.4 m AOD to the south east level c.1.23 m AOD.

3.5.2 The south field has general slope from west to east from 1.55 m AOD to 1.3 m AOD. However, there are numerous localised areas of elevated land with levels ranging from 1.6 m AOD to 1.8 m AOD.

4. Flood Risk Assessment

4.1 Hydrological overview

4.1.1 The closest watercourse to the site is the EA designated main River Thames.

4.1.2 The River Thames drains a catchment area of over 12,000 km^2, tidally influenced for about 90 km of its length all the way up to the town of Teddington in Middlesex.

4.1.3 The Thames has posed a risk of flooding to London for as long as the settlement has been there. As London has grown, the river has become more and more constrained by the urban development. The natural floodplain of the River Thames within London is now almost fully developed and is heavily dependent upon manmade flood defences to protect it against the risk of flooding.

4.1.4 The southern boundary of Thurrock Council administrative boundary sits immediately adjacent to the River Thames. Historically, the River Thames floodplain in this area was substantially wider than it is today and the dense urban area of Greater London heavily constrains the passage of the river corridor as it winds its way towards the sea.

4.1.5 The River Thames has been heavily modified over time with the growth of London, including the construction of raised defences along much of its length. As a result, the direct risk to Tilbury as a result of fluvial flooding alone from the River Thames is negligible. OS mapping indicates that the site is surrounded by a number of unnamed drains, shallow ditches and water features. Surface water within the main body of the site flows in a general southerly and easterly direction discharging into West Tilbury Main c.500 m to the east, finally outfalling into the Thames.

4.1.6 The majority of the site drains into channels which outfall into open land drains which border the site, eventually discharging into the River Thames.

4.2 Flood Risk

4.2.1 The EA (n.d.) flood zone mapping (Figure 4.1 and Annex B) indicates that the site is situated within undefended Flood Zone 2 and 3a, which is land assessed as having a 1 in 1,000 or greater annual probability of river and/or sea flooding.

4.2.2 EA Rivers and Sea flood mapping, which takes into account the effect of any flood defences that may be in this area, indicates the site is at low risk of fluvial or tidal flooding. Defined as areas with between 0.1% and 1% chance of flooding each year.

4.2.3 The Thurrock Borough Council SFRA Flood Map (AECOM, 2018) indicates the site is located within Flood Zone 3a (Volume 6, Appendix: 15.2: Flood Zones and Model Data). However, is afforded flood protection by defence with a 1 in 1,000 year standard of protection (SoP).

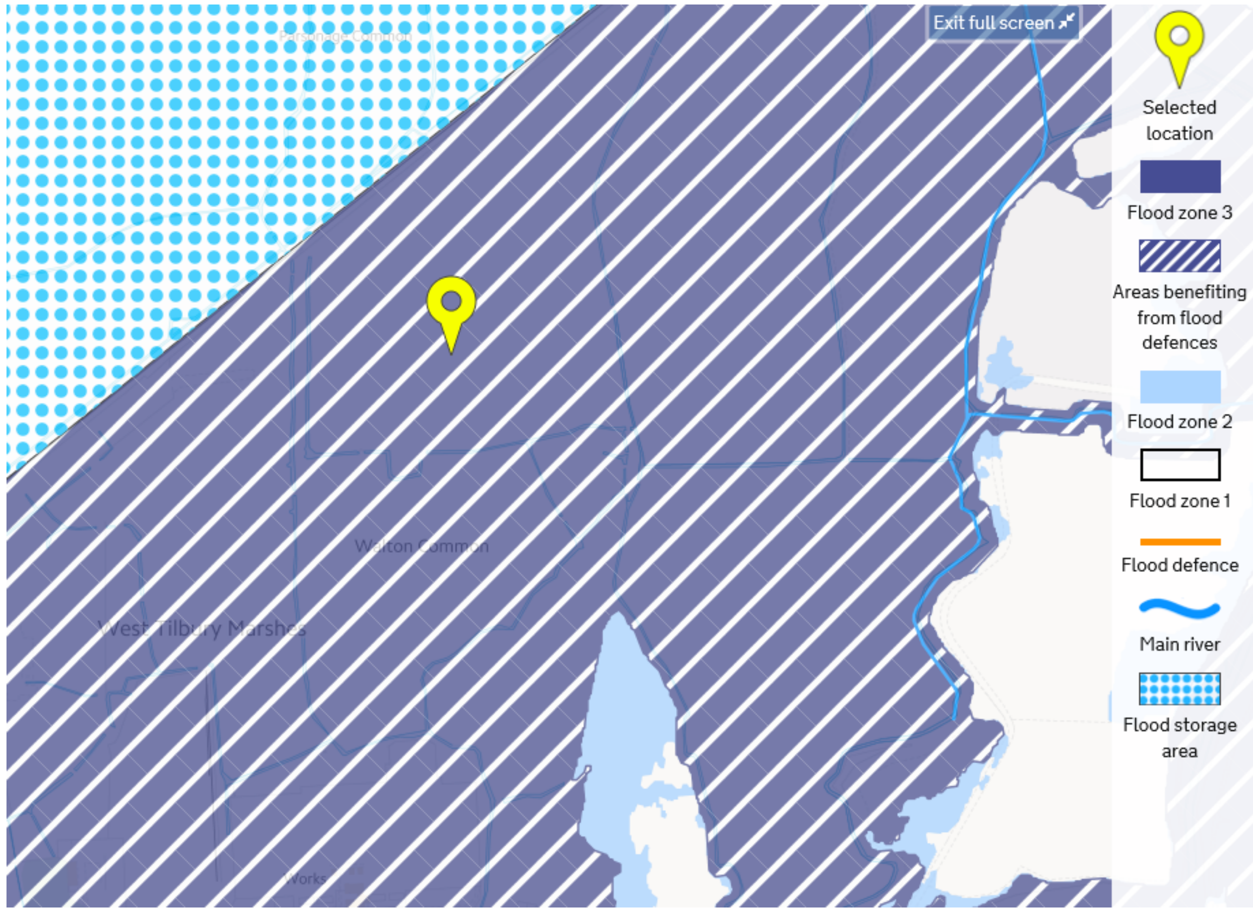

Figure 4.1:EA Planning Flood Zone map (September 2018).

Fluvial Flooding

4.2.4 EA data and previous flood reporting outlines that water levels in the Thames Estuary is dominated by tidal forces, with fluvial flows within the catchment generating a minimal impact. Extreme tidal water levels are far higher than those resulting from a major fluvial events, therefore fluvial flood risk is not considered any further.

Tidal Flooding

4.2.5 No above ground permanent assets or ground profiling is proposed within areas of designated floodplain (Flood Zone 3b) located to the north of the railway line, as shown on Thurrock Borough Council SFRA Level 2 flood zones (2018), reproduced in Volume 6, Appendix 15.2: Flood Zones and Model Data.

4.2.6 Taking into account the presence of tidal flood defence, which provide a SoP for events with up to a 1 in 1,000 year return period the tidal flood risk posed to the site is considered to be low.

4.2.7 Flood data extracted from the Thurrock Borough Council SFRA (AECOM, 2018) presents a number of model simulations including a tidal breach within flood defences in close proximity to the proposed development. The results are summarised in Table 4.1.

4.2.8 The breach location was informed by Thurrock Borough Council SFRA (see Volume 6, Appendix 15.2: Flood Zones and Model Data).

Table 4.1: Summary of breach model outputs (Tilbury2).

Breach location	Run period	Average Flood Level (m AOD)	Average Flood depth (m)	Hazard Rating	Time to Inundation (hours)
TIL02	1 in 200 year (2116)	1.57	0.25	Significant	➢ 20 hours
	1 in 1,000 year (2116)	1.80	0.42	Significant	➢ 16 hours
TIL03	1 in 200 year (2116)	1.87	0.50	Significant	➢ 16 hours
	1 in 1,000 year (2116)	2.85	1.40	Extreme	➢ 16 hours
TIL04	1 in 1,000 year (2116)	2.21	0.80	Extreme	➢ 20 hours
TIL05	1 in 200 year (2016)	1.90	0.46		
	1 in 200 year (2116)	2.29	0.91	Extreme	➢ 1 hour
	1 in 1,000 year (2016)	2.13	0.69		
	1 in 1,000 year (2116)	2.45	1.01	Extreme	➢ 1 hour

4.2.9 It is noted that the Thurrock SFRA (2018) and supporting hydraulic modelling applied a medium emissions scenario (95th percentile) projections from UKCP09 to generate the extreme water levels with allowances for sea level rise for the 2116 scenarios. As identified in Section 2.1, on 17 December 2019 climate change sea level allowances were updated taking into account revised climate modelling projections in UKCP18. The updated sea level rise allowances are very similar to the previous allowances for the comparable 'Higher central' scenario from the previous UKCP09-based guidance but now provide an additional 'Upper end' scenario with possible greater sea level rise.

4.2.10 The maximum variation in projected sea level rise between the current and previous guidance is +0.39 m or +390 mm. This increase has therefore been added to the SFRA breach model flood levels for main development site (shown in Table 4.1 before addition) for the assessment of flood risk and design of appropriate resilience measures to account for the Upper End sea level climate change allowances as shown in Table 2.3. This approach represents a worst-case increase in potential flood depth, which is considered to be a proportionate and conservative approach in the absence of an up-to-date breach model taking into account UKCP18 available from the Thurrock Strategic Flood Risk Assessment for planning. The approach has been agreed with the Environment Agency via a consultation response on 09 April 2020, as detailed in the consultation table in Volume 3, Chapter 15.

4.2.11 The modelled flood level for the closest breach at TIL05 for a worst-case 1 in 1,000 year 2116 event (approximately 2.45 m AOD) plus an additional allowance of 0.39 m (to account for the latest UKCP18 sea level rise), generating a flood level of 2.84 mAOD, has been assessed as the mostly likely event to impact the site. It is proposed that the development would incorporate flood resilience and/or resistance measures to ensure critical assets are afforded an appropriate level of flood protection to meet this level, as detailed in Section 6. This would also afford the proposed development flood resilience/resistance against the majority of model breach scenarios.

4.2.12 The SFRA identifies that there is a residual risk of a breach or failure of the lock gates during a tidal surge (TIL03) which could result in overtopping of the dock walls and flooding of the surrounding area. Model outputs indicate that a 'breach' or failure at TIL03 would lead to higher flood levels than those presented for TIL05. However, the TIL03 scenario represents a catastrophic passive failure in the operation of the Tilbury tidal barrier resulting in tidal inundation of the majority of Tilbury and deemed highly unlikely, as the barrier protects over 5,000 properties locally.

4.2.13 However, model outputs indicate that at the onset of 'failure' of the barrier flood water would propagate northwards and eastwards from the breach firstly into Tilbury town centre before extending east towards the site. Given the site's location, on the eastern extent of the flood cell, it is likely to be one of the last places to be affected during a failure at TIL03, and therefore afforded plenty of warning time to action the evacuation plan. Although a failure at TIL03 is highly unlikely, flood resilience measures have been incorporated into the development design which takes into consideration a failure at TIL03 (3.24 mAOD, which is 2.85 mAOD plus 0.39 m for climate change)

4.2.14 For both worst-case breach events (TIL05 and TIL03) an additional 300 mm has been taken into consideration associated with the potential future impacts of the H++ climate change scenario which generates flood levels of 3.14 mAOD and 3.54 mAOD respectively.

4.3 Flood defences

4.3.1 The site is located within an area benefiting from flood defences (see Volume 6, Appendix 15.2: Flood Zones and Model Data). 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.

4.3.2 EA records indicate that the standard of protection of the flood defences in close proximity to the site is 0.1% Annual Event Probability (AEP); designed to defend London up to a 1 in 1,000 year tidal flood event. The crest height of the flood defence wall protecting the site ranges from 6.48 m AOD to 6.70 m AOD.

4.3.3 The current condition grade for defences in the area ranges from fair to very poor, with the potential for severe defects resulting in complete performance failure, although it is noted that the EA has a duty to maintain these defences. The potential consequences of flood defence breach and design resilience measures have been assessed in Section 6.

4.3.4 Considerable investment has been made in the provision of the Thames Tidal Defences (TTD) to protect Greater London from tidal flooding. The tidal defences downstream of the Thames Barrier are maintained to a level of 7 m AOD, which, at the current time, provides a Standard of Protection (SoP) equivalent to the 0.1% AEP (1 in 1,000 year) tidal event. The EA is working with the Port of Tilbury on a £14 million project to replace the existing Tilbury flood defence barrier with a new dual function lock gate at the Port of Tilbury in Essex that will also act as a flood defence. The existing barrier built in 1981 forms part of the Thames defences that reduce flood risk to over 9,000 homes in the Purfleet, Grays and Tilbury area. The partnership project with the Port of Tilbury is due to complete in 2019/20.

4.4 Flooding from rising / high groundwater

4.4.1 Groundwater can be a problem at sites located on permeable strata, either superficial deposits such as river alluvium or bedrock such as fissured sandstone or limestone. Groundwater ingress can be a particular problem in alluvial sands and gravels during flooding where rising river levels cause rises in groundwater levels in deposits that are in hydraulic continuity with the river or flood water.

4.4.2 Geological mapping indicate that the site and surrounding area is underlain by Flandrian Alluvium comprising soft to firm consolidated, compressible silty clay, but can contain layers of silt, sand, peat and basal gravel. Seaford Chalk Formation and Newhaven Chalk Formation Composed of soft to medium hard, smooth white chalks with numerous marl seams and flint bands. A detailed assessment of the underlying geology is provided within Volume 3, Chapter 16: Geology, Hydrogeology and Ground Conditions.

4.4.3 Taking into account the above information and confidence limit, the risk of groundwater flooding is considered to be low.

4.5 Source Protection Zones

4.5.1 EA mapping shows the proposed development is site not located within a Source Protection Zone.

4.6 Surface water flooding

4.6.1 Surface water flooding is caused by rainfall generated overland flow, before the runoff enters a watercourse or sewer. In such events sewerage and drainage systems and surface watercourses may be entirely overwhelmed. Surface water flood risk is assessed by simulating an extreme rainfall event over a 6.5 hours duration designed to completely overwhelm urban drainage systems, with 2D modelling used to identify overland flow routes and areas where surface water will pond.

4.6.2 EA mapping (Figure 4.2) indicates that the majority of the site is at very low risk of surface water flooding.

4.6.3 However, localised areas within the assessment area (in blue) are at low to high risk, defined as having between 1 in 1000 (0.1%) and 1 in 100 (1%) chance of flooding in any year, and areas with a greater than 3.3% chance of flooding in any year respectively. These areas have been assessed to be associated with localised areas of low lying land.

4.6.4 Based on EA mapping and site observations the overall surface water flood risk to the site has been assessed to be low.

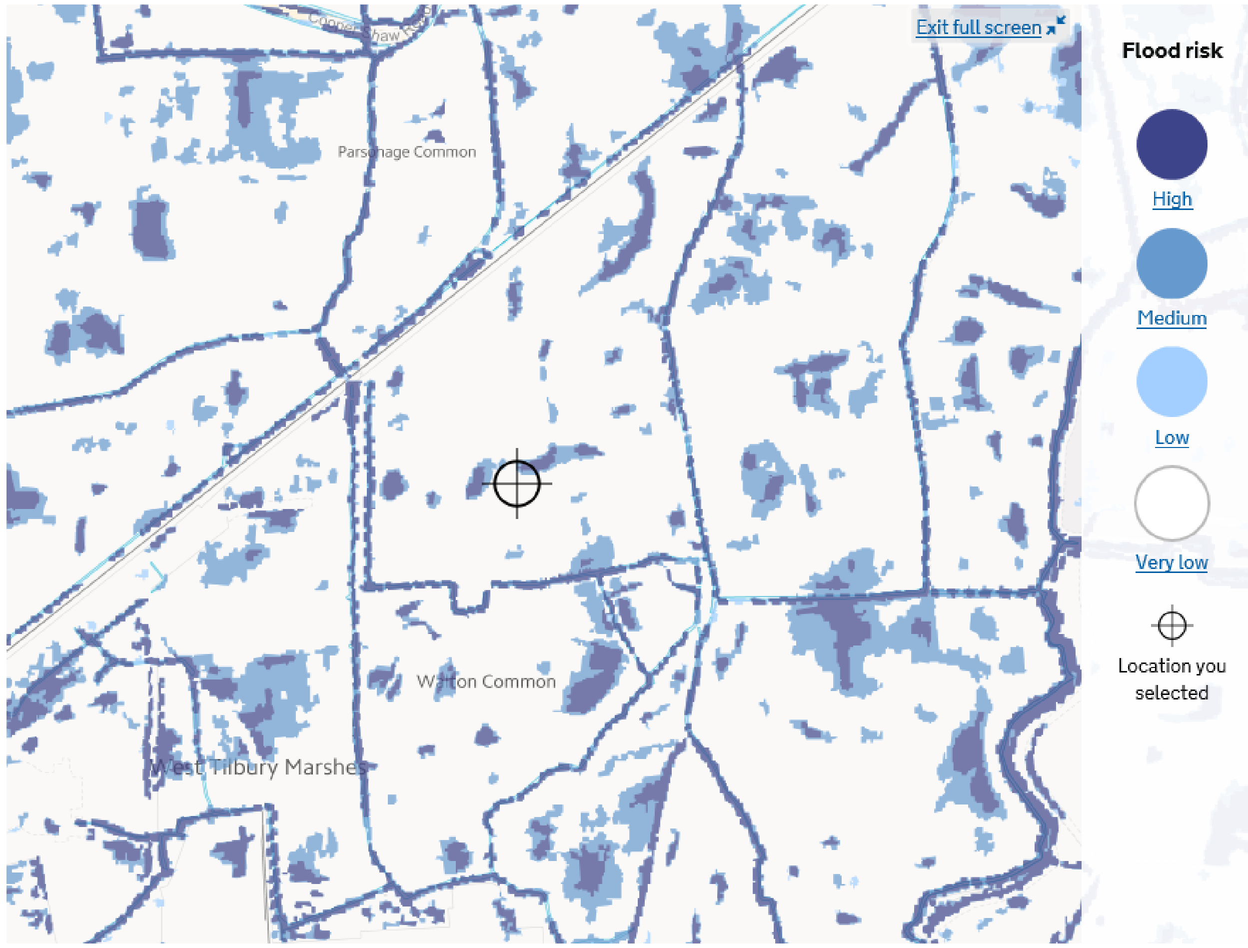

Figure 4.2: EA surface water risk map (September 2018).

4.7 Flood Warning Area

4.7.1 The site is located within a flood warning area. Full details on flood warning areas can be found at https://flood-warning-information.service.gov.uk/warnings.

4.8 Reservoir Failure Assessment

4.8.1 EA reservoir flood risk mapping shows that the site is not at risk of reservoir flooding.

4.8.2 The EA acknowledges that reservoir flood mapping indicates the 'worst case' extents and are very unlikely to happen, as this would require total loss of all water from the affected reservoir(s).

4.8.3 Generally, the safety of the reservoir is the responsibility of the owners or operators who are required to maintain an adequate degree of protection. This is achieved by carrying out regular inspections, risk assessments and through the production and maintenance of Reservoir Flood Plans.

4.9 Sewer/Water Main Failure Assessment

4.9.1 No drainage records are available for the site. The land is currently agricultural land and therefore it is assumed that land/field drainage systems will be present within the site area.

4.9.2 Under the DG 5 register requirements all water companies are obliged to keep a record of properties that have been affected by sewer flooding. The Thurrock Borough Council SFRA (AECOM, 2018) historical drainage/sewer flooding map indicates that are no incidents of sewerage flooding within the immediate area of the site.

4.9.3 Taking into account the above the overall risk of flooding from sewerage failure is assessed as low.

4.10 Infrastructure Failure Assessment

4.10.1 No flooding due to infrastructure failure has been recorded for the site.

4.11 Historical flood events

4.11.1 Thurrock Borough Council SFRA (AECOM, 2018) notes that South Essex has been subject to two major flood events in 1928 and 1953. In January 1953, a major storm surge coincided with a high spring tide and resulted in the widespread flooding. Flood levels at Tilbury reached c.1.8 m above its predicted level and inundation depths were approximately 2-3 m.

4.11.2 The 1953 event lead to the construction of an improved flood defence schemes at Purfleet, Grays, Tilbury, Tilbury Fort, Shell, Refinery, Canvey Island and the Holehaven and Benfleet barriers.

4.12 Present Flood Risk

4.12.1 The EA has confirmed that the site is located within Flood Zone 2 and 3, which is land assessed as having a 1 in 1,000 or greater annual probability of river and sea flooding.

4.12.2 Tidal flooding has been determined to pose the greatest risk to the site. Tidal defences are recorded to provide a SoP for tidal events with up to a 1 in 1,000 year return period. Therefore, the main flood risk to the site is as a consequence of a breach in local flood defences.

4.12.3 EA (n.d.) and the Thurrock 2018 SFRA (AECOM, 2018) mapping indicates the site is at flood risk due to fluvial flooding. The site is at low to medium risk of surface water and groundwater flooding.

5. Flood Risk Vulnerability Classification

5.1 Vulnerability Classification

5.1.1 In accordance with the Flood Risk Vulnerability Classification in Table 2 of the Planning and Practice Guidance Flood Risk and Coastal Change, Flexible Generation Plant is classified as 'Essential Infrastructure' development in flood risk terms.

5.1.2 The site is located within an area identified as Flood Zone 3a. Table 3 of Planning Practice Guidance (reproduced in Table 5.1 below) indicates that Essential Infrastructure uses are acceptable for locations in Flood Zone 3a, but subject to an Exception and Sequential test.

Table 5.1: Flood Risk Vulnerability and Flood Zone 'Compatibility'

Flood Risk Vulnerability classification (see Table 3 of Planning Practice Guidance)	Essential Infrastructure	Water Compatible	Highly Vulnerable	More Vulnerable	Less Vulnerable
Zone 1	Yes	Yes	Yes	Yes	Yes
Zone 2	Yes	Yes	Exception test required	Yes	Yes
Zone 3a	Exception test required	Yes	No	Exception test required	Yes
Zone 3b Functional Floodplain	Exception test required	Yes	No	No	No

5.2 Sequential Test

5.2.1 The aim of the Sequential Test is to steer new development to areas with the lowest probability of flooding. As part of this process the developer will need to provide evidence to the Local Planning Authority that there are no other reasonably available sites where the development could be located.

5.2.2 When considering alternatives sites, the geographical location for the search area needs to consider the functional arrangements of the proposed development.

5.2.3 The site selection exercise underpinning the choice of proposed development location is presented the Statement of Case and Green Belt Statement, application document A8.3.

6. Flood Management

6.1 Introduction

6.1.1 Section 4.2.6 notes that once the presence of existing tidal flood defences, which provide a 1 in 1,000 year SoP, are taken into account the fluvial and/or tidal risk is low.

6.1.2 Outputs from the Thurrock Borough Council SFRA breach model (AECOM, 2018), which accounts for a worst case scenario from the nearest breach at location TIL05, indicates that flood depths at the main development site in the event of a breach are around 0.91 m and 1.01 m above existing ground level for the 1 in 200 year event and the 1 in 1,000 year event respectively, including climate change allowance based on UKCP09. These levels translate to 2.30 mAOD and 2.45 mAOD (see Table 4.1).

6.1.3 With the addition of 0.39 m to the flood depth to account for the greatest increase in sea level projected in EA guidance based on UKCP18 (see discussion in Section 4.2) the 1 in 1,000 year event level is 2.84 mAOD.

6.1.4 The potential impacts for a failure at the Tilbury Tidal barrier (TIL03) have also been considered, with flooding calculated to reach a level of 3.24 mAOD inclusive of 0.39 m for UKCP18 climate change.

6.1.5 Taking into account the essential infrastructure development designation, the following section summarises potential mitigation options to provide flood protection for the 1 in 1,000 year plus climate change breach scenario (3.24 mAOD). The design also includes a degree of flexibility to account for a potential H++ scenario (3.54 mAOD based on failure at TIL03).

6.1.6 The options provided are not exhaustive and are presented as a guide to further consideration during detailed design.

6.2 Mitigation Options

6.2.1 Mitigation options to reduce the exposure to flood risk have been designed in line with Flood Risks to People, Phase 2; Improving the Flood Performance of New Buildings and Planning Practice Guidance ID7 and are presented below.

6.2.2 Taking into account the proposed ground raising to achieve a 2 mAOD profile for drainage (see the Conceptual Drainage Strategy, application document A7.3) and modelled flood level (3.24 mAOD) the maximum potential flood depth for which further resilience could be required has been calculated to be 1.24 m.

6.2.3 To mitigate against the impacts of flooding on the development, the proposed design and build would include the following measures taken from ENA ETR138 Resilience to Flooding of Grid and Primary Substations (2018):

- development platform raise of the gas engines and battery units;
- use of flood resistant and resilient materials where practicable; and
- a flood evacuation plan (application document A8.5).

6.2.4 Current EA guidance 'Preparing a flood risk assessment: standing advice' recommends that the minimum ground floor levels of new developments are set at the 1 in 200 annual probability plus allowance for climate change, and at appropriate level for the lifetime of the proposed development. Based on the essential nature of the proposed development and in accordance with electricity industry guidance in ENA ETR138 (Energy Networks Association, 2018), a higher degree of protection may be required, which would be assessed on a cost-benefit basis by the applicant.

6.2.5 It is proposed that an initial 0.3 m of resilience is afforded by a development slab. The remaining 0.94 m will be provided via additional flood resistance and resilience measures as follows.

6.3 Flood Protection Options

6.3.1 There are several flood risk management and mitigation measures that will be incorporated into the site design to provide additional flood resilience and resistance, including:

- Raising assets:
  - Raising assets above anticipated flood levels. This will be focussed primarily on external 'exposed' equipment.
- Bespoke building protection:
  - Elevating bunds surrounding transformers, cable ducts sealed with bentonite or with a fire resistant, waterproof system backing onto rubber insert sleeves. Air vents protected by a permanent rising flue. Doors reinforced and sealed, or building bunded to provide appropriate protection. With specific reference to the gas engine housing it is proposed to adhere a low permeable waterproofing membrane to the outer wall (Figure 6.2) with buildings access via either a water sealed door or bunded entrance (Figure 6.3 and Figure 6.4)

6.3.2 Examples illustrating typical measures that can be employed, drawn from the ETR138 guidance, are shown below.

Figure 6.1:Raised bund and access platform around a transformer (ENA ETR138 Annex 1)

Figure 6.2: Exterior of building flood protection (ENA ETR138 Annex 1)

Figure 6.3: Access to Substation entrance (ENA ETR138 Annex 1)

Figure 6.4: Exterior of building displaying flood protection and bunding to access and emergency exit doors (ENA ETR138 Annex 1)

Figure 6.5: removable flood panels (ENA ETR138 Annex 1)

Figure 6.6: Flood protection gates (ENA ETR138 Annex 1)

Figure 6.7: Container walls filled with sand / stone (ENA ETR138 Annex 1)

Figure 6.8: Raising bunding to critical plant using metal panelling (ENA ETR138 Annex 1)

Figure 6.9: Raising bunding to critical plant using metal panelling (ENA ETR138 Annex 1)

Figure 6.10: Temporary flood defence system (ENA ETR138 Annex 1)

6.3.3 The details of resilience measures to be applied to each structure or asset of the proposed development would be developed during detailed design. The design objective of providing up to 0.84 m resilience for critical infrastructure assets where appropriate (above the 2 mAOD proposed site level for applicable buildings and structures) could be secured via a suitably worded requirement within the Development Consent Order.

6.4 Extreme Climate Change Scenario (H++)

6.4.1 As outline above there are a number of practicable flood resilience and resistance measures which could be either designed-in to the development or deployed during an extreme tidal event to reach the calculated 1.24 m flood depth. Long-term flood resilience planning to achieve flood resilience/resistance to the H++ scenario which may result in an additional 300 mm flood risk has also considered. In the event a H++ scenario appears likely it would be practicable to increase the height of the low permeable membrane adhered to the gas engine housing. Furthermore, critical external equipment could be raised along with the containerised units. This may also include the use of demountable flood defences and/or individual asset protection.

6.5 Flood Compensation

6.5.1 As a consequence of the proposed ground profiling exercise, to 2 mAOD, there is potential for impacts on localised water flow regimes during an extreme flood event. A detailed analysis of the modelled outputs presented within the Thurrock SFRA has been undertaken. This identified that the flood cell within which the site is located covers an area of approximately 14 km^2. It is proposed that c. 55,850 m^2 is raised to 2 mAOD, equivalent to c. 0.056 km^2. This equates to c. 0.4% of the flood cell. The limited area of raising would have negligible impact on the flood model and could be potentially accounted for within models' margin of error, standard deviations, and/or errors in the models bathymetry/ground level data throughout the cell. However, a detailed assessment of the local topography has been undertaken, which identifies that in general the site has a slight slope to the northwest. Given the minimal ground raising being undertaken and also the prolonged nature of flood water inundation (hours) it is unlikely that the raising of the site would have significant impact on tidal flood propagation. Topographical data also records elevations along the northern boundary of the site, which are 200 mm to 300 mm higher than the development site itself. Therefore, any impacts of flood flows as a consequence of ground rising would be confined to the development site.

6.5.2 Based on the above, additional modelling to account for the proposed site profiling within the flood cell would not produce results up on which the impacts specific to the development could be reasonably quantified.

6.6 Flood Warning

6.6.1 The EA aims to provide several hours' notice prior to the issue of a Flood Warning. It is recommended that the site operator registers on the EA Flood Warning System and implements on site management strategies to ensure that they can communicate flood warnings efficiently in order that the site can be evacuated when construction or maintenance staff are present.

6.6.2 A Flood Evacuation Plan has been developed (application document A8.5). Staff training would also be required, with the plan including information on what to do upon receipt of a flood warning, together with evacuation procedures and routes.

6.6.3 Flood plans should be practiced regularly in order to minimise the risk to people.

6.6.4 Suitably trained staff would need to convey flood warning information and emergency procedures to occupants. All site personnel would be required to be familiar with the flood action plan. Appropriate signage across the site (i.e. exits and assembly points) should be installed.

6.6.5 Additional information on the EA Flood Warnings and advice can be found on the EA's website (https://flood-warning-information.service.gov.uk/warnings).

6.7 Safe Access/Egress

6.7.1 As noted in section 6.6, there is likely to be several hours warning before floodwater impact upon the site. As set out in the Flood Evacuation Plan (application document A8.5) there should be sufficient time to safely evacuate the site. Specific evacuation routes through the site itself to be confirmed at detailed design stage when the final site layout is confirmed.

6.7.2 As flood water propagates across the floodplain towards the site from the south and/or west it is proposed that personnel would evacuate the site on to Station Road and directed north towards West Tilbury Village Hall located within an area designated as Flood Zone 1.

6.7.3 The incorporation of flood resistance and resilience measures at the site, together with the implementation of a flood evacuation plan, would reduce the risk of damage and ensure the safety of occupants.

7. Drainage

7.1 Surface Water and Drainage Strategy

7.1.1 The sustainable management of surface water is an essential element of reducing future flood risk to the site and its surroundings.

7.1.2 Undeveloped sites generally rely on natural drainage to convey or absorb rainfall, the water soaking into the ground or flowing across the surface into watercourses.

7.1.3 The effect of development is generally to reduce the permeability of at least part of the site, which markedly changes the site's response to rainfall. Without specific measures to manage surface water the volume of water and peak flow rate are likely to increase. Inadequate surface water drainage arrangements can threaten the development itself and increase the risk of flooding to others.

7.1.4 Surface water arising from a developed site should as far as is practicable be managed in a sustainable manner to mimic the surface water flows arising from the site prior to the proposed development while reducing the risk of flooding at the site and elsewhere, taking climate change into account.

7.1.5 A Conceptual Drainage Strategy has been produced for the development (application document A7.3).

7.2 Sustainable Drainage Options

7.2.1 The NPPF and associated Planning Practice Guidance ID7, CIRIA C753 SUDS Manual (2015) and also Local Authority Policy promotes sustainable water management through the use of SuDS. A hierarchy of techniques is identified:

- Prevention – the use of good site design and housekeeping measures on individual sites to prevent runoff and pollution (e.g. minimise areas of hard standing).
- Source Control – control of runoff at or very near its source (such as the use of rainwater harvesting).
- Site Control – management of water from several sub-catchments (including routing water from roofs and car parks to one/several large soakaways for the whole site).
- Regional Control – management of runoff from several sites, typically in a detention pond or wetland.

7.2.2 The implementation of SuDS as opposed to conventional drainage systems, provides several benefits by:

- Reducing peak flows to watercourses or sewers and potentially reducing the risk of flooding downstream;
- Reducing the volumes and frequency of water flowing directly to watercourses or sewers from developed sites;
- Improving water quality over conventional surface water sewers by removing pollutants from diffuse pollutant sources;
- Reducing potable water demand through rainwater harvesting;
- Improving amenity through the provision of public open spaces and wildlife habitat; and
- Replicating natural drainage patterns, including the recharge of groundwater so that base flows are maintained.

7.3 Surface Water Drainage Constraints

7.3.1 Constraints placed on the design of surface water drainage serving the proposed development are as follows:

- Surface water drainage discharge methods will be limited to either soakaway drainage (if proven to be viable via infiltration testing) or discharge to watercourse. Discharge to public sewer is deemed unviable;
- Runoff from new development impermeable areas to be discharged at equivalent Greenfield runoff rates, requiring consideration of on-site surface water attenuation provision for extreme rainfall events; and
- Below ground electricity supply and distribution cabling associated with the development may impose restrictions on location and depth of below ground surface water drainage pipework runs.
- The proposed drainage system needs to provide resilience against occasional blockages or malfunction, and have minimal regular maintenance requirements.

7.4 Runoff Calculations

7.4.1 An assessment of the current and proposed runoff rates was undertaken to determine the surface water attenuation requirements for the site in line with The SuDS Manual (Ciria, 2015), which indicates that for previously developed sites the flow rate discharged from the site must not exceed that prior to the proposed development for the:

- 1 in 1 year event;
- 1 in 30 year event; and
- 1 in 100 year event.

7.4.2 The rates of runoff were determined using the current 'industry best practice' guidelines as outlined in the Interim Code of Practice for SuDS (National SuDS Working Group, 2004). The Defra/EA recommended methodology for sites up to 50 ha in area is the Institute of Hydrology Report (1993) 124 method (IoH 124). The runoff rates were calculated using the MicroDrainage software suite.

7.5 Current Runoff Rate

7.5.1 The site is presently covered by permeable agricultural land. The following parameters were incorporated into the existing site runoff calculations:

- Catchment Area: 20.00 ha (assume 100% permeable (landscaping) and 0% low permeable surfacing (hardstanding/buildings));
- Standardised Average Annual Rainfall (SAAR): 550 mm/year;
- Soil: 0.450; and
- Region No: 6.

7.5.2 RPS has also calculated the runoff rate specific to the change low permeable surfacing (Table 7.1).

Table 7.1: Runoff characteristics

Annual Probability (Return Period, years)	Current Runoff (l/s)	Current Runoff (l/s/ha)
100% (1)	56.40	2.82
QBAR urban	66.30	3.315
3.33% (30)	150.20	7.51
1% (100)	211.50	10.58
1% + 40% Climate Change	296.10	14.81

Note: 40% added to rainfall data to account for long-term climate change

7.6 Attenuation Requirements

7.6.1 The attenuation volume required to restrict the surface water runoff rate from the additional low permeable surfacing to 56.4 l/s for a 1 in 100 year rainfall event plus climate change (+40%) has been determined using the industry standard MicroDrainage software suite incorporating the following parameters:

- Catchment Area: approximately 20.0 ha;
- Cv (proportion of rainfall forming surface water runoff): assume a factor of 75% for the development in summer, and 84% in winter (weighted average based on proposed land use);
- Runoff Rate: 56.4 l/s; and
- Assuming no infiltration losses.

7.6.2 The system was modelled within MicroDrainage as a tank/pond with controlled discharge via a hydrobrake outflow control. The MicroDrainage calculation sheets are included at Annex C.

7.6.3 The attenuation volume required to restrict runoff to 56.4 l/s from a 1 in 100 year storm event plus a 40% allowance for climate change has been determined to be approximately 20,100 m^3 for the site.

7.7 Proposed Surface Water Drainage

7.7.1 The proposed new surface water drainage system will be designed using current MicroDrainage analysis software, to take account of planning guidance, Lead Local Flood Authorities and EA guidance to prevent uncontrolled flooding off the site to surrounding areas.

7.7.2 Surface water runoff from the proposed development will be collected as follows:

- Permeable gravelled areas, unbound stone access roads and hardstanding – Runoff will be allowed to infiltrate naturally into the underlying geology; and
- Impermeable building roof areas – traditional gravity gutters and downpipes, connected into a surface water attenuation system.

7.7.3 Surface water runoff will be collected and discharged to a below ground gravity to the local surface water drainage network via an on-site surface water attenuation ponds totalling c. 26,790 m^2, designed to provide detention of flows during low intensity rainfall events and enough storage (c. 20,100 m^3) during extreme rainfall events, to prevent uncontrolled flooding of the site. The pond will assist with the removal of sedimentation from rainwater runoff, and the downstream outlet of the pond will include a sump / catchpit for removal of silt and debris.

7.7.4 Whilst focusing on water quantity, the proposed system will also provide benefits in terms of water quality and biodiversity. A water quality risk assessment will be carried out using the SuDS hazard mitigation indices in accordance with Chapter 26, of the CIRIA (2015) C753 SuDS Manual.

7.7.5 Discharge of surface water from the site will be controlled to greenfield runoff rates by use of a vortex (Hydrobrake) flow control device fitted to the first upstream manhole from the surface water drainage outfall.

7.7.6 Discharge points will be to an offsite existing watercourse to the west of the development site.

7.7.7 The location of the proposed attenuation can be seen in the Concept Drainage Plan (application document A2.10). Preliminary sizing of the attenuation pond has been calculated using the MicroDrainage software. From the calculations it is evident that the proposed storage is of sufficient size to accommodate runoff from the catchment area for all storms up to and including the 1 in 100 year rainfall event including a 40% allowance for climate change.

7.8 Construction Stage Drainage

7.8.1 During construction of the development, the building contractor will be responsible for management and disposal of rainwater runoff generated from the site in its temporary condition.

7.8.2 The contractor shall develop a formal site management plan, which will address pollution management and control in relation to site plant and vehicles, raw materials storage and waste generation, to ensure that all surface water runoff generated in the temporary condition will be free of contamination.

7.8.3 The site will be subject to topsoil strip and bulk earthworks to prepare the site to the correct level for development. The contractor shall provide temporary drainage measures to contain runoff within the development site boundary ensuring that this is sized appropriately, and that means to remove excess surface water are available for use at all times.

7.8.4 Surface water discharge from the site shall be passed to the receiving watercourse or soakaway ensuring that it is first passed via a silt filtration and removal device (Siltbuster) and that discharge will be via a controlled flow rate pump to the final receiving watercourse / soakaway at a rate no greater than the greenfield runoff rate for the site.

7.9 Water Quality / Pollution Control

7.9.1 The surface water drainage system will feature a number of SuDS measures that will be designed in accordance with CIRIA (2015) C753. As well as controlling the quantity of surface water run-off from the site, these features will also help to prevent the discharge of potential pollutants into the water environment downstream of the development.

8. Summary and Conclusions

8.1 Summary

8.1.1 A site-specific FRA in accordance with the NPPF and Planning Practice Guidance has been undertaken for the proposed development, focusing on the main flexible generation plant site (zone A) on a parcel of land off Station Road, Tilbury, Thurrock.

8.2 Flood Risk

8.2.1 EA and Thurrock Borough Council SFRA (AECOM, 2018) mapping shows that the proposed gas engine, battery storage and substation (Zone A), and causeway (Zone G) is entirely located in Flood Zone 3a and is consequently at 'high' risk of fluvial or tidal flooding before consideration of flood defences.

8.2.2 EA records identify that the proposed development is protected by flood defences with a standard of protection in excess of 1 in 1,000 years. Taking into account the presence of the tidal flood defences, the tidal flood risk posed to the site is considered to be low.

8.2.3 Based on breach model outputs supplied within the Thurrock 2018 SFRA report for the TIL05 breach location modelled for a 1 in 1,000 year 2116 event scenario, the residual flood risk to the proposed development as a consequence of defence failure is 1 m above existing ground level or 2.45 mAOD. Upon including an additional 0.39 m of sea level rise to account for UKCP18 climate change updates, the depth increases to c.1.39 m above ground level or 2.84 mAOD. A passive failure at the tilbury barrier (TIL03) would result in a flood level of 2.85 mAOD rising to 3.24 mAOD including sea level rise to account for UKCP18 climate change. Based on a potential H++ scenario the flood levels increase to 3.14 mAOD and 3.54 mAOD respectively.

8.2.4 SFRA records indicate the sites flooded most recently in January 1953, due to a major storm surge that coincided with a high spring tide.

8.2.5 The majority of the site is located at low susceptibility of surface water flooding. Isolated areas of low lying land are at medium to high risk of surface water flooding.

8.2.6 The susceptibility to groundwater flooding is low.

8.2.7 SFRA mapping indicate that no sewerage flooding incidents have been reported in close proximity to the site. The risk of flooding from sewerage failure is therefore considered to be low.

8.2.8 The risk of flooding from reservoir failure has been assessed as low.

8.2.9 Following profiling of the site to 2 m AOD, the residual flood risk to critical development assets will be 1.24 m. An initial 0.3 m of resilience will be offered by the development platform/construction slabs, with the remaining 0.94 m comprising a mix of appropriate resilience/resistance measure incorporated into the site design.

8.2.10 The attenuation volume required to restrict runoff for low permeable surfacing to the greenfield 56.4 l/s runoff rate from a 1 in 100 year storm event plus a 40% allowance for climate change has been determined to be approximately 20,100 m^3 for the site. A Conceptual Drainage Strategy showing indicative arrangements for runoff attenuation has been produced (application document A7.3).

8.3 Conclusion

8.3.1 This FRA and supporting documentation illustrates that the application area is at risk of flooding from tidal sources, but meets the requirements of the NPSs, NPPF and Planning Practice Guidance taking into account the an allowance to meet UKCP18 climate projections.

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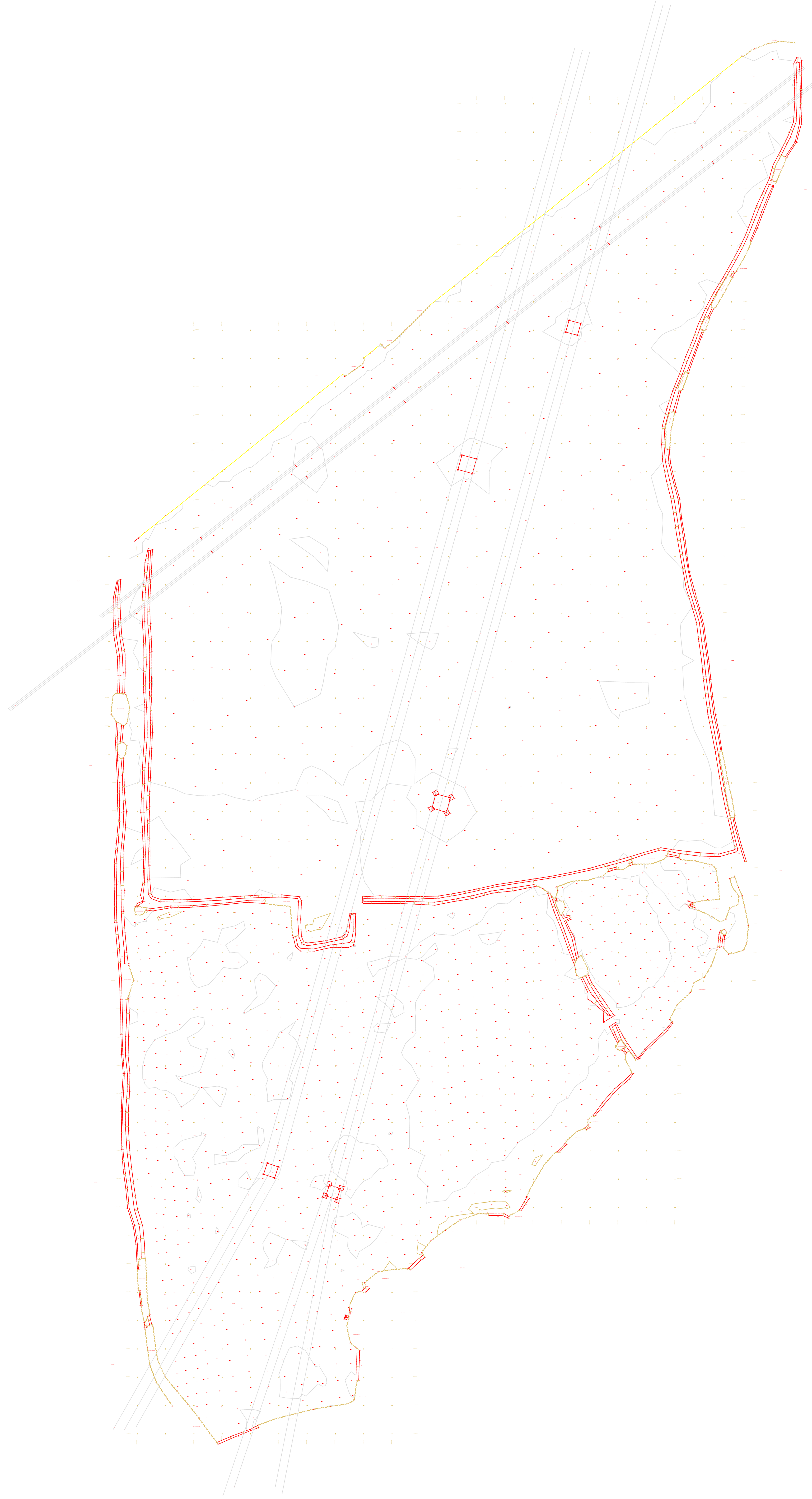
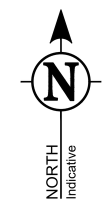
Annex A: Topographical survey





TOPOGRAPHICAL & MEASURED BUILDING SURVEYS

ABBREVIATIONS & SYMBOLS

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REV	DESCRIPTION	DRAWN	APPR	DATE

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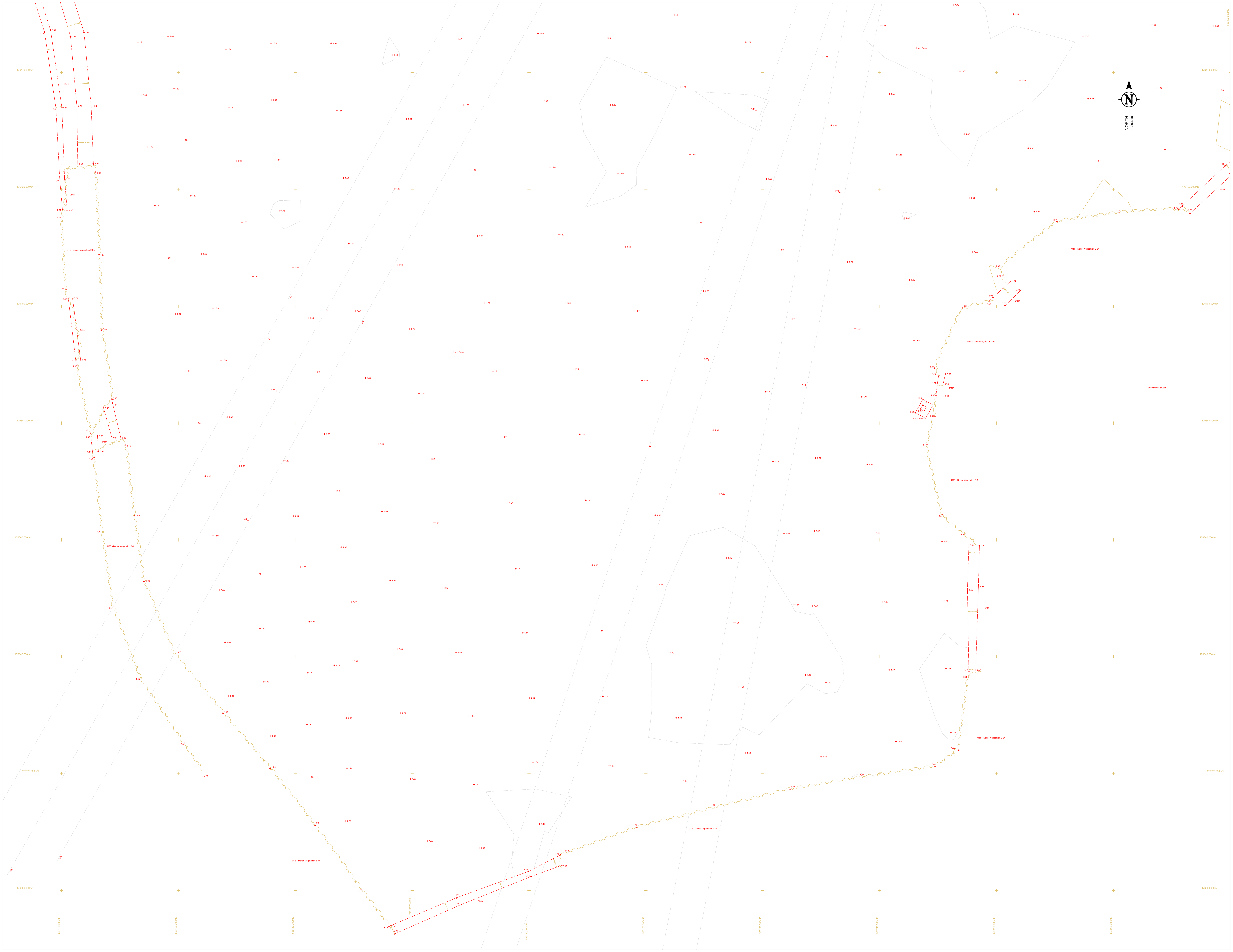
LAND SURVEYING BUILDING SURVEYING UNDERGROUND SURVEYING

PROJECT TITLE
TILBURY POWER STATION, STATION ROAD, TILBURY, ESSEX

DRAWING DETAIL
TOPOGRAPHICAL SURVEY
Sheet 1 of 11

CLIENT				SCALE
SLIGHTLINE LANDSCAPE LTD				1:1500
SURVEYOR	SURVEY DATE	CHECKED BY	APPROVED BY	DWG STATUS
AD/BB/SB/RH	28/02/2018	MB	JM	FINAL
DRAWING NUMBER			REVISION	ISSUE DATE
21360se-Overall				13/03/2018

Original Sheet Size A0H



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Original Sheet Size A0H

TOPOGRAPHICAL & MEASURED BUILDING SURVEYS

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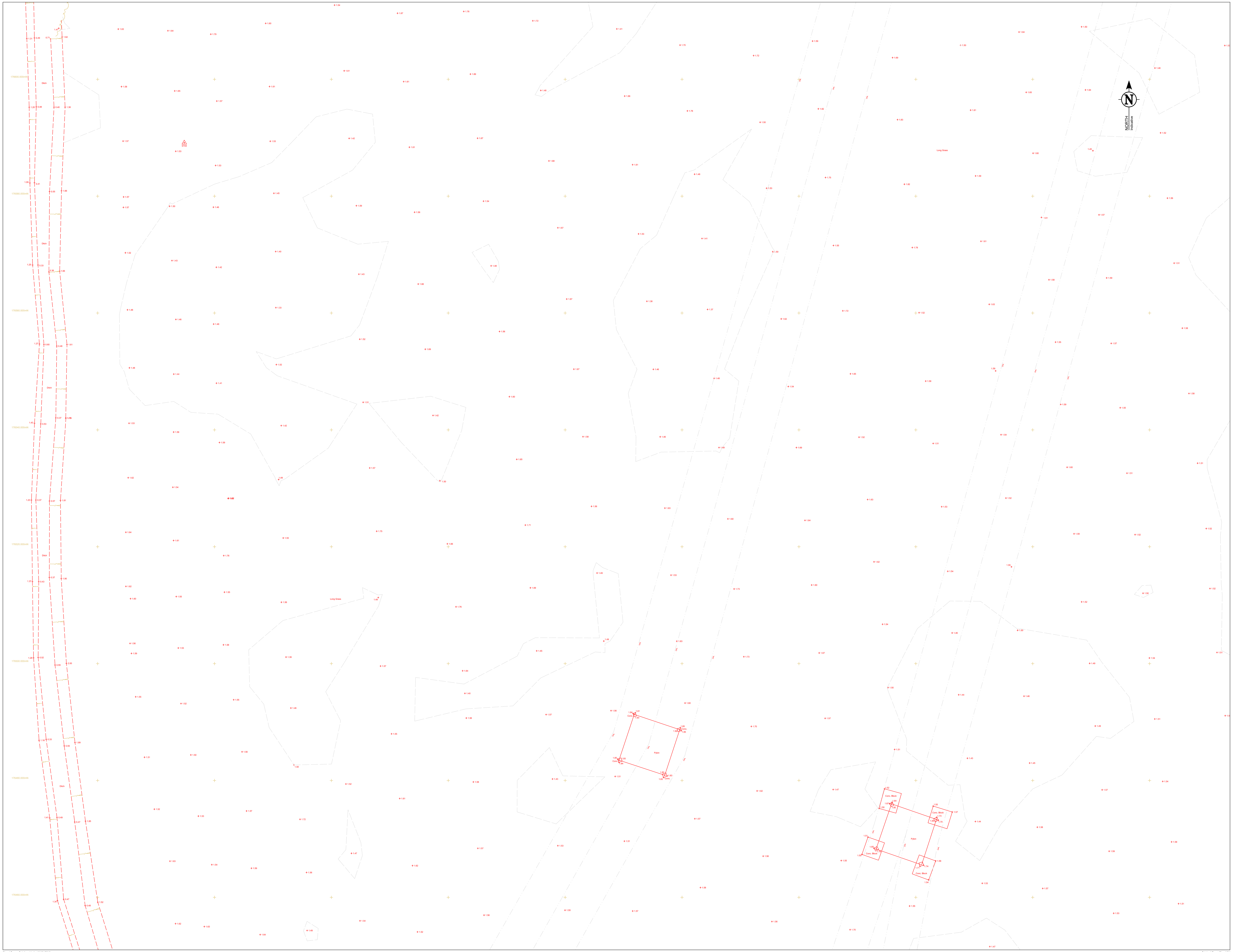
LAND SURVEYING BUILDING SURVEYING UNDERGROUND SURVEYING

PROJECT TITLE TILBURY POWER STATION, STATION ROAD, TILBURY, ESSEX				
DRAWING DETAIL TOPOGRAPHICAL SURVEY Sheet 2 of 11				
CLIENT SLIGHTLINE LANDSCAPE LTD				SCALE 1:200
SURVEYOR AD/BB/SB/RH	SURVEY DATE 28/02/2018	CHECKED BY MB	APPROVED BY JM	DWG STATUS FINAL
DRAWING NUMBER 21360se-01			REVISION	ISSUE DATE 13/03/2018



TOPOGRAPHICAL & MEASURED BUILDING SURVEYS

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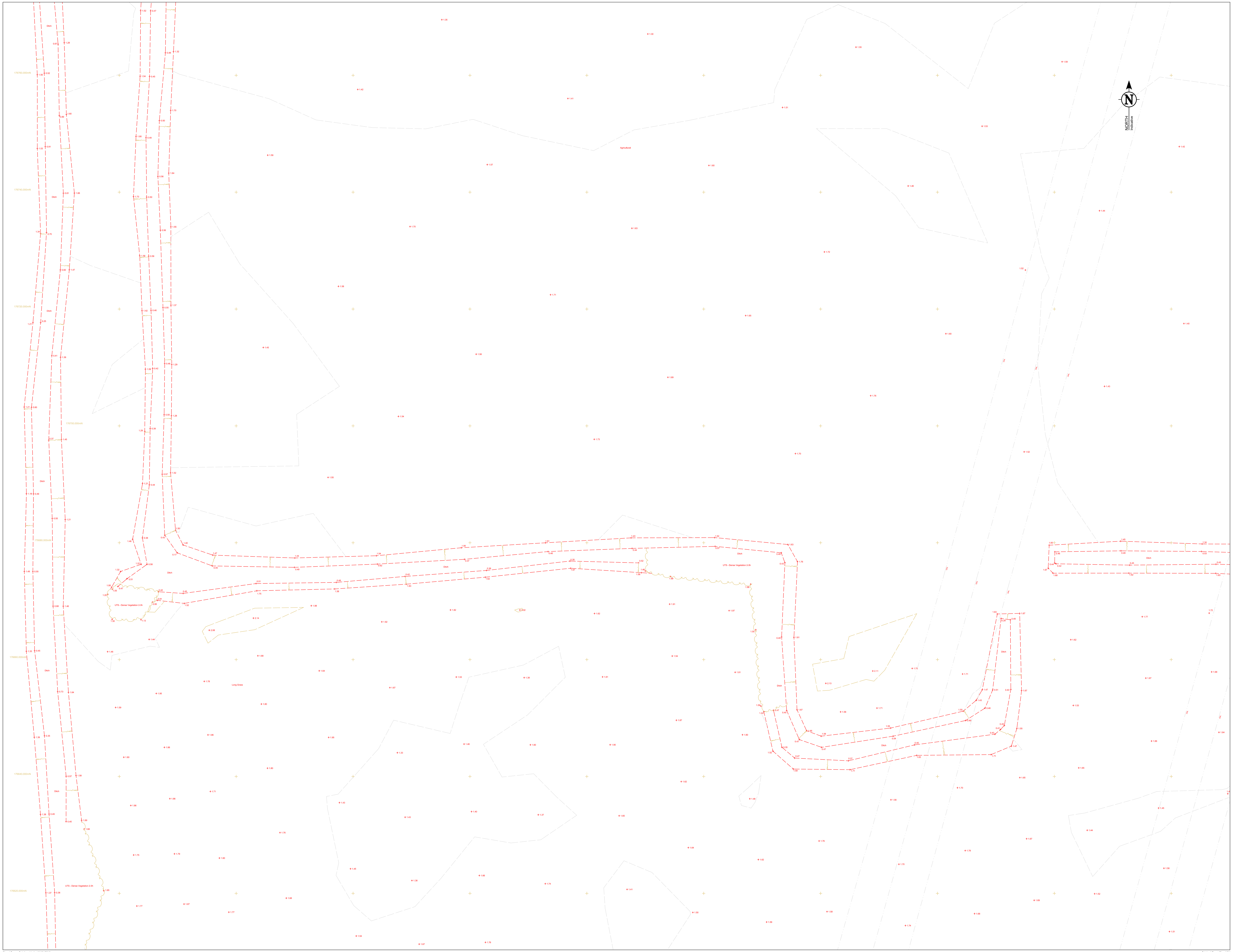
LAND SURVEYING BUILDING SURVEYING UNDERGROUND SURVEYING

PROJECT TITLE TILBURY POWER STATION, STATION ROAD, TILBURY, ESSEX				
DRAWING DETAIL TOPOGRAPHICAL SURVEY Sheet 3 of 11				
CLIENT SLIGHTLINE LANDSCAPE LTD				SCALE 1:200
SURVEYOR AD/BB/SB/RH	SURVEY DATE 28/02/2018	CHECKED BY MB	APPROVED BY JM	DWG STATUS FINAL
DRAWING NUMBER 21360se-02			REVISION	ISSUE DATE 13/03/2018

Original Sheet Size A0H



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LAND SURVEYING BUILDING SURVEYING UNDERGROUND SURVEYING

PROJECT TITLE
TILBURY POWER STATION, STATION ROAD, TILBURY, ESSEX

DRAWING DETAIL
TOPOGRAPHICAL SURVEY
Sheet 4 of 11

CLIENT				SCALE
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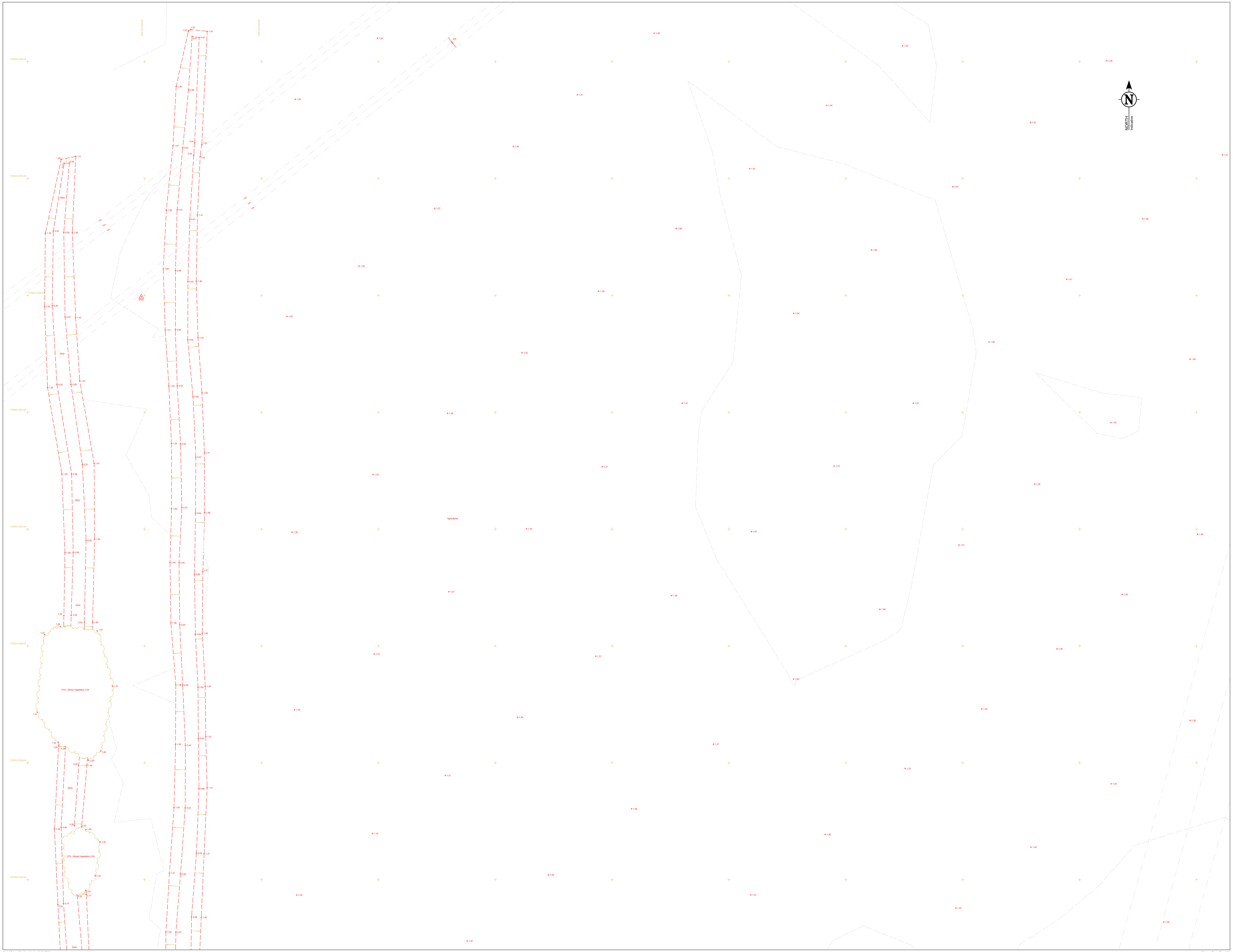
21360se-03				13/03/2018



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STATIONS	EASTINGS	NORTHINGS	LEVEL	DESCRIPTION
ST01	566418.800	177182.887	1.653	Peg & Nail
ST02	566259.590	177053.866	1.722	Peg & Nail
ST03	566099.425	176879.745	1.675	Peg & Nail
ST04	566114.828	176589.131	1.688	Peg & Nail

SURVEY GRID AND LEVEL DATUM

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REV	DESCRIPTION	DRAWN	APPR	DATE

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LAND SURVEYING BUILDING SURVEYING UNDERGROUND SURVEYING

PROJECT TITLE TILBURY POWER STATION, STATION ROAD, TILBURY, ESSEX				
DRAWING DETAIL TOPOGRAPHICAL SURVEY Sheet 5 of 11				
CLIENT SLIGHTLINE LANDSCAPE LTD				SCALE 1:200
SURVEYOR AD/BB/SB/RH	SURVEY DATE 28/02/2018	CHECKED BY MB	APPROVED BY JM	DWG STATUS FINAL
DRAWING NUMBER 21360se-04			REVISION	ISSUE DATE 13/03/2018

Original Sheet Size A0H

TOPOGRAPHICAL & MEASURED BUILDING SURVEYS

ABBREVIATIONS & SYMBOLS

AH	Arch Head Height	FH	Fire Hydrant	RSJ	Rolled Steel Joist
AR	Assumed Route	FBD	Floor Board Direction	SI	Sign Post
AV	Air Valve	FH	Fire Hydrant	SP	Arch Spring Point Height
BB	Belisha Beacon	FL	Floor Level	SV	Stop Valve
BH	Bore Hole	FP	Flag Pole	SW	Surface Water
BL	Bed Level	FW	Foul Water	SY	Stay
BO	Bollard	GG	Gully Grate	Tac	Tactile Paving
BrP	Brace Post	GV	Gas Valve	TC	Telecom Cover
BS	Bus Stop	HH	Head Height	TH	Trial Pit
BU	Bush	IC	Inspection Cover	THL	Threshold Level
B/W	Barbed Wire Fence	IL	Invert Level	TL	Traffic Light
BX	Box (Utilities)	I/R	Iron Railings	ToW	Top of Wall
C/B	Close Board Fence	KO	Kerb Outlet	TP	Telegraph Pole
CH	Cill Height	LP	Lamp Post	TV	Cable TV Cover
CL	Cover Level	MH	Manhole	UB	Universal Beam
C/L	Chain Link Fence	MP	Marker Post	UC	Unknown Cover
C-Lev	Ceiling Level	NB	Name Board	UK	Unknown Tree
Col	Column	OHL	Overhead Line (approx)	USB	Under Side Beam
C/P	Chestnut Paling Fence	Pan	Panel Fence	UTL	Unable To Lift
CR	Cable Riser	PB	Post Box	VP	Vent Pipe
DC	Drainage Channel	PM	Parking Meter	WB	Waste Bin
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LAND SURVEYING BUILDING SURVEYING UNDERGROUND SURVEYING

PROJECT TITLE
TILBURY POWER STATION, STATION ROAD, TILBURY, ESSEX

DRAWING DETAIL
TOPOGRAPHICAL SURVEY
Sheet 6 of 11

CLIENT	SCALE
SLIGHTLINE LANDSCAPE LTD	1:200

SURVEYOR	SURVEY DATE	CHECKED BY	APPROVED BY	DWG STATUS
AD/BB/SB/RH	28/02/2018	MB	JM	FINAL

DRAWING NUMBER	REVISION	ISSUE DATE
21360se-05		13/03/2018

Original Sheet Size A0H

Original Sheet Size A0H

TOPOGRAPHICAL & MEASURED BUILDING SURVEYS

ABBREVIATIONS & SYMBOLS

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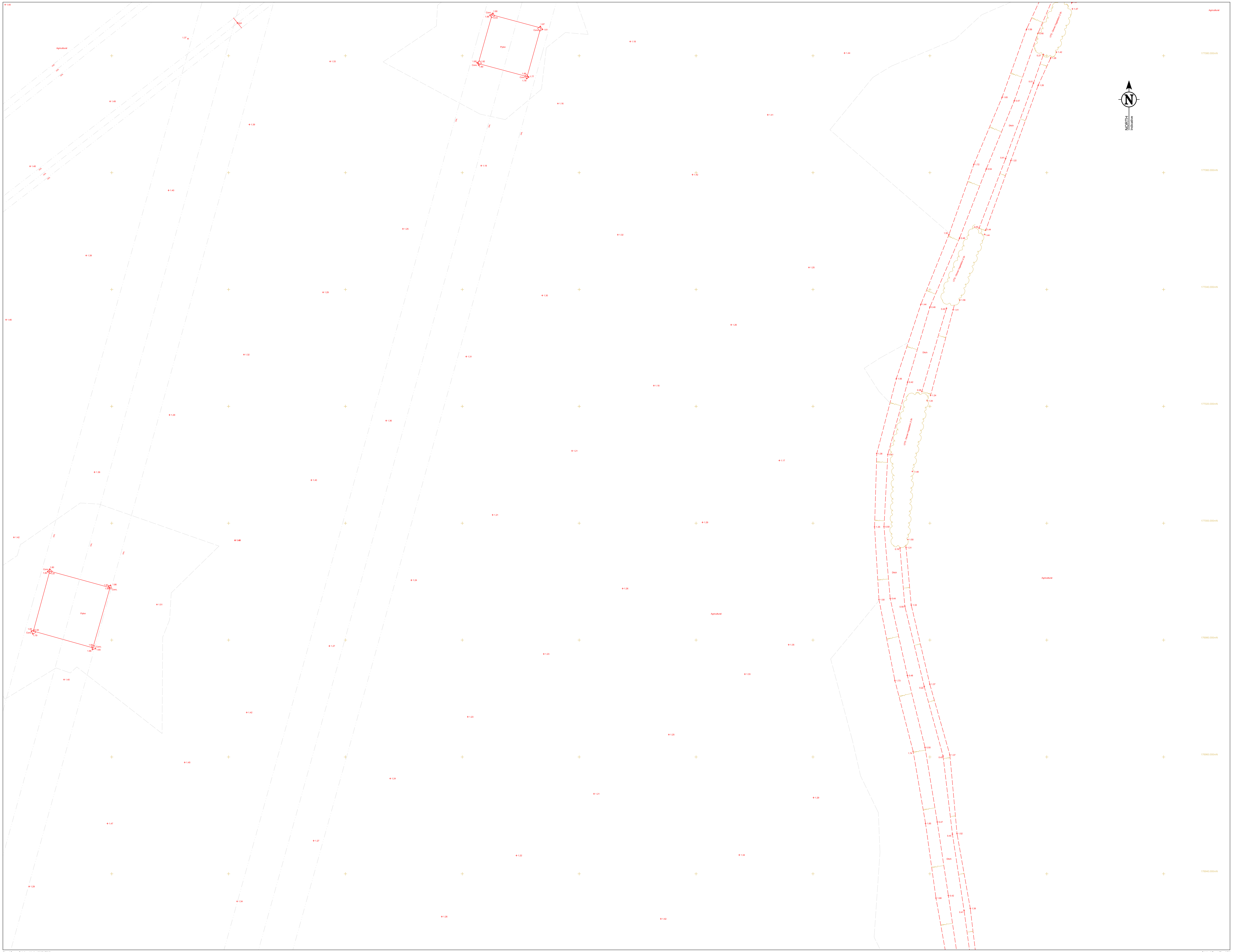
LAND SURVEYING BUILDING SURVEYING UNDERGROUND SURVEYING

PROJECT TITLE TILBURY POWER STATION, STATION ROAD, TILBURY, ESSEX				
DRAWING DETAIL TOPOGRAPHICAL SURVEY Sheet 7 of 11				
CLIENT SLIGHTLINE LANDSCAPE LTD				SCALE 1:200
SURVEYOR AD/BB/SB/RH	SURVEY DATE 28/02/2018	CHECKED BY MB	APPROVED BY JM	DWG STATUS FINAL
DRAWING NUMBER 21360se-06			REVISION	ISSUE DATE 13/03/2018



TOPOGRAPHICAL & MEASURED BUILDING SURVEYS

ABBREVIATIONS & SYMBOLS

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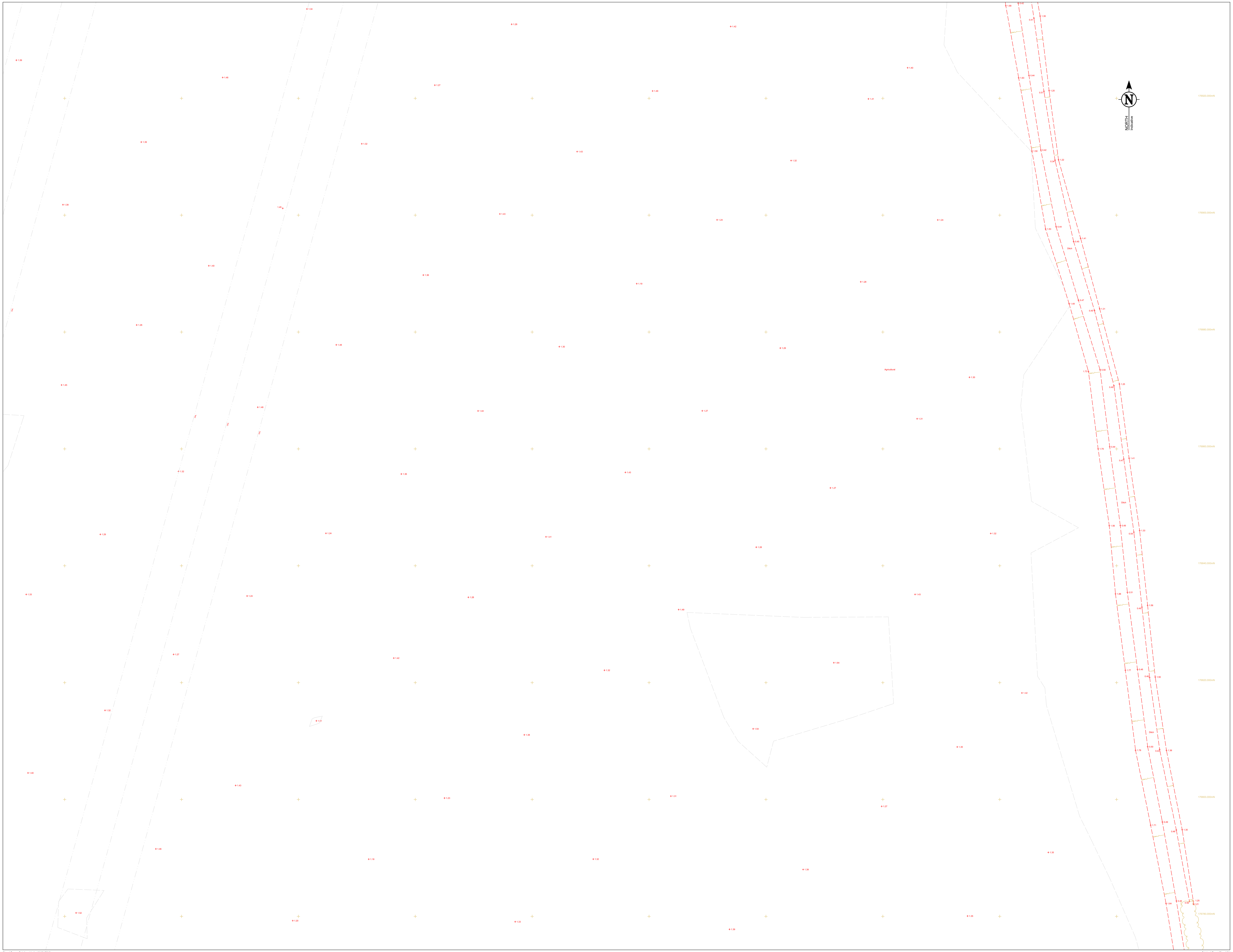
LAND SURVEYING BUILDING SURVEYING UNDERGROUND SURVEYING

PROJECT TITLE
TILBURY POWER STATION, STATION ROAD, TILBURY, ESSEX

DRAWING DETAIL
TOPOGRAPHICAL SURVEY
Sheet 8 of 11

CLIENT				SCALE
SLIGHTLINE LANDSCAPE LTD				1:200
SURVEYOR	SURVEY DATE	CHECKED BY	APPROVED BY	DWG STATUS
AD/BB/SB/RH	28/02/2018	MB	JM	FINAL
DRAWING NUMBER			REVISION	ISSUE DATE
21360se-07				13/03/2018

Original Sheet Size A0H



TOPOGRAPHICAL & MEASURED BUILDING SURVEYS

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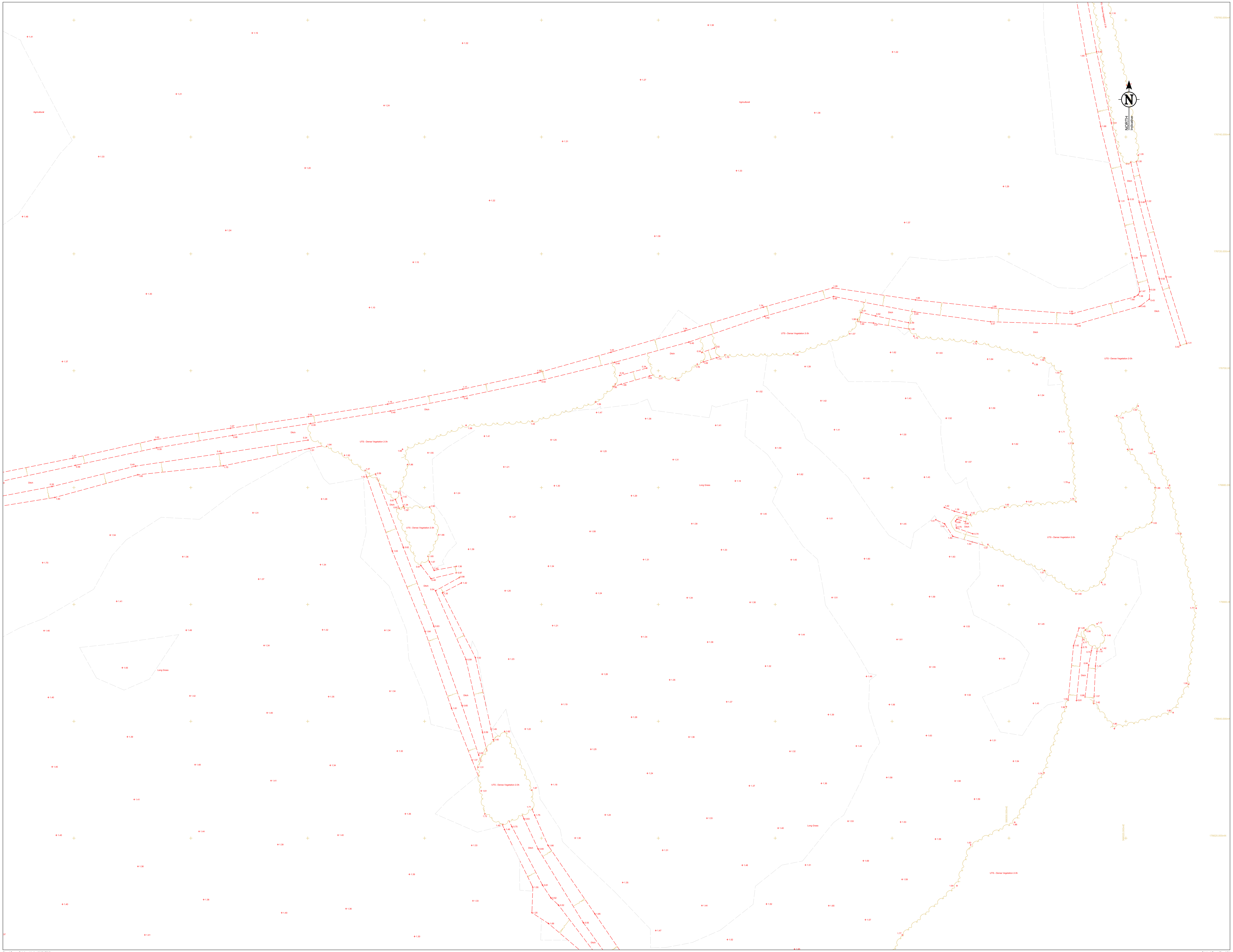
LAND SURVEYING BUILDING SURVEYING UNDERGROUND SURVEYING

PROJECT TITLE
TILBURY POWER STATION, STATION ROAD, TILBURY, ESSEX

DRAWING DETAIL
TOPOGRAPHICAL SURVEY
Sheet 9 of 11

CLIENT				SCALE
SLIGHTLINE LANDSCAPE LTD				1:200
SURVEYOR	SURVEY DATE	CHECKED BY	APPROVED BY	DWG STATUS
AD/BB/SB/RH	28/02/2018	MB	JM	FINAL
DRAWING NUMBER			REVISION	ISSUE DATE
21360se-08				13/03/2018

Original Sheet Size A0H



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The accuracy of the digital data is the same as the plotting scale implies. All dimensions are in metres unless otherwise stated.

The survey control listed is only to be used for topographical surveys at the stated scale. All control must be checked and verified prior to use.

Do not scale from this drawing.

CONTROL CO-ORDINATES

STATIONS	EASTINGS	NORTHINGS	LEVEL	DESCRIPTION
ST01	566418.800	177182.887	1.653	Peg & Nail
ST02	566259.590	177053.866	1.722	Peg & Nail
ST03	566099.425	176879.745	1.675	Peg & Nail
ST04	566114.828	176589.131	1.688	Peg & Nail

SURVEY GRID AND LEVEL DATUM

The co-ordinate system established for this survey is related to Ordnance Survey (OS) national grid at a single point using GPS Smartnet, then orientated to Grid North with a scale factor of 1.000.

The level datum established for this survey is related to Ordnance Survey (OS) using GPS Smartnet.

To avoid discrepancies, any co-ordinated data used in conjuction with this survey must be derived directly from this control data.

The major contour interval is 1 metre, the minor contour interval is 0.500 metres.

Please note snow was present on the ground at the time of the survey which may have obstructed detail.

REV	DESCRIPTION	DRAWN	APPR	DATE

SURVEY SOLUTIONS

Ipswich Coventry Yeovil Norwich Perth Nottingham Brentwood

Tel No: 0845 0405 969
Fax No: 0845 0405 970
www.survey-solutions.co.uk
enquiries@survey-solutions.co.uk

LAND SURVEYING BUILDING SURVEYING UNDERGROUND SURVEYING

PROJECT TITLE
TILBURY POWER STATION, STATION ROAD, TILBURY, ESSEX

DRAWING DETAIL
TOPOGRAPHICAL SURVEY
Sheet 10 of 11

CLIENT				SCALE
SLIGHTLINE LANDSCAPE LTD				1:200
SURVEYOR	SURVEY DATE	CHECKED BY	APPROVED BY	DWG STATUS
AD/BB/SB/RH	28/02/2018	MB	JM	FINAL
DRAWING NUMBER			REVISION	ISSUE DATE
21360se-09				13/03/2018

Original Sheet Size A0H

TOPOGRAPHICAL & MEASURED BUILDING SURVEYS

ABBREVIATIONS & SYMBOLS

AH	Arch Head Height	FH	Fire Hydrant	RSJ	Rolled Steel Joist
AR	Assumed Route	FBD	Floor Board Direction	SI	Sign Post
AV	Air Valve	FH	Fire Hydrant	SP	Arch Spring Point Height
BB	Belisha Beacon	FL	Floor Level	SV	Stop Valve
BH	Bore Hole	FP	Flag Pole	SW	Surface Water
BL	Bed Level	FW	Foul Water	SY	Stay
BO	Bollard	GG	Gully Grate	Tac	Tactile Paving
BrP	Brace Post	GV	Gas Valve	TC	Telecom Cover
BS	Bus Stop	HH	Head Height	TH	Trial Pit
BU	Bush	IC	Inspection Cover	THL	Threshold Level
B/W	Barbed Wire Fence	IL	Invert Level	TL	Traffic Light
BX	Box (Utilities)	I/R	Iron Railings	ToW	Top of Wall
C/B	Close Board Fence	KO	Kerb Outlet	TP	Telegraph Pole
CH	Cill Height	LP	Lamp Post	TV	Cable TV Cover
CL	Cover Level	MH	Manhole	UB	Universal Beam
C/L	Chain Link Fence	MP	Marker Post	UC	Unknown Cover
C-Lev	Ceiling Level	NB	Name Board	UK	Unknown Tree
Col	Column	OHL	Overhead Line (approx)	USB	Under Side Beam
C/P	Chestnut Paling Fence	Pan	Panel Fence	UTL	Unable To Lift
CR	Cable Riser	PB	Post Box	VP	Vent Pipe
DC	Drainage Channel	PM	Parking Meter	WB	Waste Bin
DH	Door Head Height	PO	Post	WH	Weep Hole
DP	Down Pipe	P/R	Post & Rail Fence	WL	Water Level
DR	Drain	P/W	Post & Wire Fence	WM	Water Meter
EL	Eaves Level	P/Wall	Partition Wall	WO	Wash Out
EP	Electric Pole	RE	Rodding Eye	(X.XX)	Floor to Ceiling Height
ER	Earth Rod	RL	Ridge Level		
ET	EP+Transformer	RP	Reflector Post	(X.XX)F/C	Floor to False Ceiling Ht
FB	Flower Bed	RS	Road Sign		
FBD	Floor Board Direction	RSD	Roller Shutter Door	△	Survey Control Station

DRAWING NOTE

Topographical Surveys

Trees are drawn to scale showing the average canopy spread. Descriptions and heights should be used as a guide only.

All building names, descriptions, number of storeys, construction type including roof line details are indicative only and taken externally from ground level.

All below ground details including drainage, voids and services have been identified from above ground and therefore all details relating to these features including; sizes, depth, description etc will be approximate only. All critical dimensions and connections should be checked and verified prior to starting work.

Detail, services and features may not have been surveyed if obstructed or not reasonably visible at the time of the survey.

Measured Building Surveys

Measurements to internal walls are taken to the wall finishes at approx 1m above the floor level and the wall assumed to be vertical.

Cill heights are measured as floor to the cill and head heights are measured from cill to the top of window.

General

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REV	DESCRIPTION	DRAWN	APPR	DATE

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LAND SURVEYING BUILDING SURVEYING UNDERGROUND SURVEYING

PROJECT TITLE
TILBURY POWER STATION, STATION ROAD, TILBURY, ESSEX

DRAWING DETAIL
TOPOGRAPHICAL SURVEY
Sheet 11 of 11

CLIENT				SCALE
SLIGHTLINE LANDSCAPE LTD				1:200
SURVEYOR	SURVEY DATE	CHECKED BY	APPROVED BY	DWG STATUS
AD/BB/SB/RH	28/02/2018	MB	JM	FINAL
DRAWING NUMBER			REVISION	ISSUE DATE
21360se-10				13/03/2018

Original Sheet Size A0H

Annex B: Environment Agency Correspondence

creating a better place

Environment Agency

Mr J Morley
RPS
jonathan.morley@rpsgroup.com

Our ref EAn/2018/92748

Date 13 August 2018

Dear Mr Morley

Enquiry regarding Product 4 for Tilbury

Thank you for your enquiry which was received on 13 July 2018.

We respond to requests under the Freedom of Information Act 2000 and Environmental Information Regulations 2004.

The information we hold and a copy of the Flood Risk Assessment (FRA) advisory note is attached to my email.

Name	Product 4
Description	Detailed Flood Risk Assessment Map centred on 566300, 176685
Licence	Open Government Licence
Information Warnings	None
Information Warning - OS background mapping	*The mapping of features provided as a background in this product is © Ordnance Survey. It is provided to give context to this product. The Open Government Licence does not apply to this background mapping. You are granted a non-exclusive, royalty free, revocable licence solely to view the Licensed Data for non-commercial purposes for the period during which the Environment Agency makes it available. You are not permitted to copy, sub-license, distribute, sell or otherwise make available the Licensed Data to third parties in any form. Third party rights to enforce the terms of this licence shall be reserved to OS.*
Attribution	Contains Environment Agency information © Environment Agency and/or database rights. Contains Ordnance Survey data © Crown copyright 2017 Ordnance Survey 100024198.

INVESTOR IN PEOPLE

Coastal Modelling

We are currently undertaking a hydraulic modelling study for the following Essex, Norfolk and Suffolk Coastal areas: Wells, Cromer, Walcott, Thurne, Hickling and Coast, Great Yarmouth, Lowestoft, Kessingland (Lothingland Hundred), Blyth Estuary, Leiston, Alde & Ore Estuary, Deben Estuary , Stour & Orwell Estuary, Clacton, Colne & Blackwater Estuary, Crouch & Roach Estuary, Southend and the Thames.

You may be aware that some Local Planning Authorities have updated their Strategic Flood Risk Assessments (SFRAs) using data from this modelling study. As SFRA's are not updated regularly we agreed that they could use draft outputs as we wanted to ensure that the SFRA's were not out of date as soon as they were published. However although this information was shared with our external partners to assist them with the creation of their SFRAs the data remains unavailable for external practice until model completion. This is because we need to complete all necessary reviews. The project aims to be completed by summer 2018 and will be available for external practice then.

Additional information
Gifford Gauging station – on the River Mar Dyke.
Please find attached information from our gauging station. The structure has a theoretical modular limit of 0.79mAC however, non-modular flow can occur from as little as 0.2mAC. The structure is an Essex Standard Weir (Modified flat vee crump) and so its modular limit occurs when the crest level is within 70% of the stage. This structure drowns completely on a frequent basis. There is an operational gate downstream of the structure which does have an effect on the modularity of the site. Additionally, in previous years we have had issues with maintenance and weed growth (2000-2012). Finally, there is a river restoration scheme downstream of the weir which is also believed to have an effect on modularity. This has been in place since ~2015. Flood plain storage begins at 1.1MaC.

Groundwater

We have provided a location map showing the location of water abstractions in the area, further details to follow under a separate email in due course.

Information about pollution incidents will follow as soon as possible.

Aquifer vulnerability maps are available on Magic Map using this link:
http://magic.defra.gov.uk/ click search for layers and type in aquifers.

Aquifer designations, soil classifications and Source Protection zones can all be viewed on Magic Map.

Our nearest groundwater observation point monitors the chalk and suggests that ground water levels have varied between 5, and 13.64m below ground level between 1986 and 2008. However, the quality of this data is questionable as it does not seem to fully represent known wet and drought periods.

We only keep records of groundwater flooding events since 2010 and since then we have had no fully verified reports. Groundwater flooding only occurs when the groundwater level exceeds the ground level after periods of high recharge. This typically an uncommon occurrence in this region.

Data Available Online
Many of our flood datasets are available online:

- Flood Map For Planning (Flood Zone 2, Flood Zone 3 ,Flood Storage Areas, Flood Defences, Areas Benefiting from Defences)
- Risk of Flooding from Rivers and Sea
- Historic Flood Map
- Current Flood Warnings

What's In Your BackYard (WIYBY) is no longer available
Most of the data is still available via other sharing services such as DATA.GOV.UK, MAGIC map and new GOV.UK digital services. Where the datasets are no longer available as maps, you will be able to download and use within specialist applications.

To find out all the services the Environment Agency have available, please click here.

For any other enquiries please send your request to us at:
Enquiries_EastAnglia@environment-agency.gov.uk.

For awareness

Please be aware that we now charge for planning advice provided to developers, agents and landowners. If you would like advice to inform a future planning application for this site then please complete our https://www.gov.uk/government/publications/pre-planning-application-enquiry-form-preliminary-opinion and email it to our Sustainable Places team at: planning.ipswich@environment-agency.gov.uk.

They will initially provide you with a free response identifying the following:

- the environmental constraints affecting the proposal;
- the environmental issues raised by the proposal;
- the information we need for the subsequent planning application to address the issues identified and demonstrate an acceptable development;
- any required environmental permits.

If you require any further information from them (for example, a meeting or the detailed review of a technical document) they will need to set up a charging agreement. Further information can be found on our website.

Please note we have published revised climate change allowances, which are available online. These new allowances will need to be reflected in your Flood Risk Assessment. If you want to discuss this please call our Sustainable Places team on 0203 025 5475.

TEAM2100: delivering the first 10 years of investment in tidal flood defences for the Thames Estuary 2100 Plan. For more information, visit the TEAM2100 website or email team2100@jacobs.com

Please get in touch if you have any further queries or contact us within two months if you'd like us to review the information we have sent.

Yours sincerely

Karen Brown

Karen Brown

Customers and Engagement Officer
Direct dial: 02030 255472

East Anglia Area
Ipswich Office, Iceni House, Cobham Road, Ipswich, Suffolk, IP3 9JD
Brampton Office, Bromholme Lane, Brampton, Huntingdon, PE28 4NE
General Enquiries: 03708 506506
Email: enquiries@environment-agency.gov.uk
Website: https://www.gov.uk/government/organisations/environment-agency

Reference: **EAn/2018/92748**
Site Address: **566300,176685**
Date: **23/07/2018**

Included:

- Flood Map
- Historic Flood Outlines Map

Model: Thames TE2100 2008

- Node Map
- Node Levels

Important information to note with your Product:

Flood Risk Assessments (FRAs)
If you are obtaining this information for use within a Flood Risk Assessment (FRA) required for a planning application, please include our unaltered Product 4 data within an appendix of your FRA.

Flood Zones
Please see the attached map showing the Flood Zones (outlines) for the area of the site. Our maps show the site is located in fluvial/ tidal Flood Zone 1/2/3. For further information with regards to Flood Zones, please see below:

Table 1: Flood Zones

These Flood Zones refer to the probability of river and sea flooding, ignoring the presence of defences.

Flood Zone	Definition
Zone 1 Low Probability	Land having a less than 1 in 1,000 annual probability of river or sea flooding. (Shown as 'clear' on the Flood Map – all land outside Zones 2 and 3)
Zone 2 Medium Probability	Land having between a 1 in 100 and 1 in 1,000 annual probability of river flooding; or land having between a 1 in 200 and 1 in 1,000 annual probability of sea flooding. (Land shown in light blue on the Flood Map)
Zone 3a High Probability	Land having a 1 in 100 or greater annual probability of river flooding; or Land having a 1 in 200 or greater annual probability of sea flooding.(Land shown in dark blue on the Flood Map)

Paragraph: 065 Reference ID: 7-065-20140306

Un-Modelled Watercourses
We have not undertaken any detailed modelling for the nearby;

- Chadwell Cross Sewer,
- Pincocks Trough,
- West Tilbury Branch Sewer,
- West Tilbury Main,
- St Clares Sewer, and
- Gobions Sewer.

These sources of flood risk have not been assessed for the purpose of the flood map. They will need to be investigated further in any FRA.

Normally, in these circumstances, an FRA will need to undertake a modelling exercise in order to derive flood levels and extents, both with and without allowances for climate change, for these watercourses, in order to inform the design for the site. Without this information, the risk to the development from fluvial or tidal flooding associated with these main watercourses is unknown.

Historic Flood Events

Examinations of our records of historic flooding show that the general area has previously flooded. Please note that these records show flooding to the land and do not necessarily indicate that properties within the historic flood events were flooded internally. It is also possible that the pattern of flooding in this area has changed and that this area would now flood under different circumstances. Please see the attached PDF for flood history information.

Surface Water

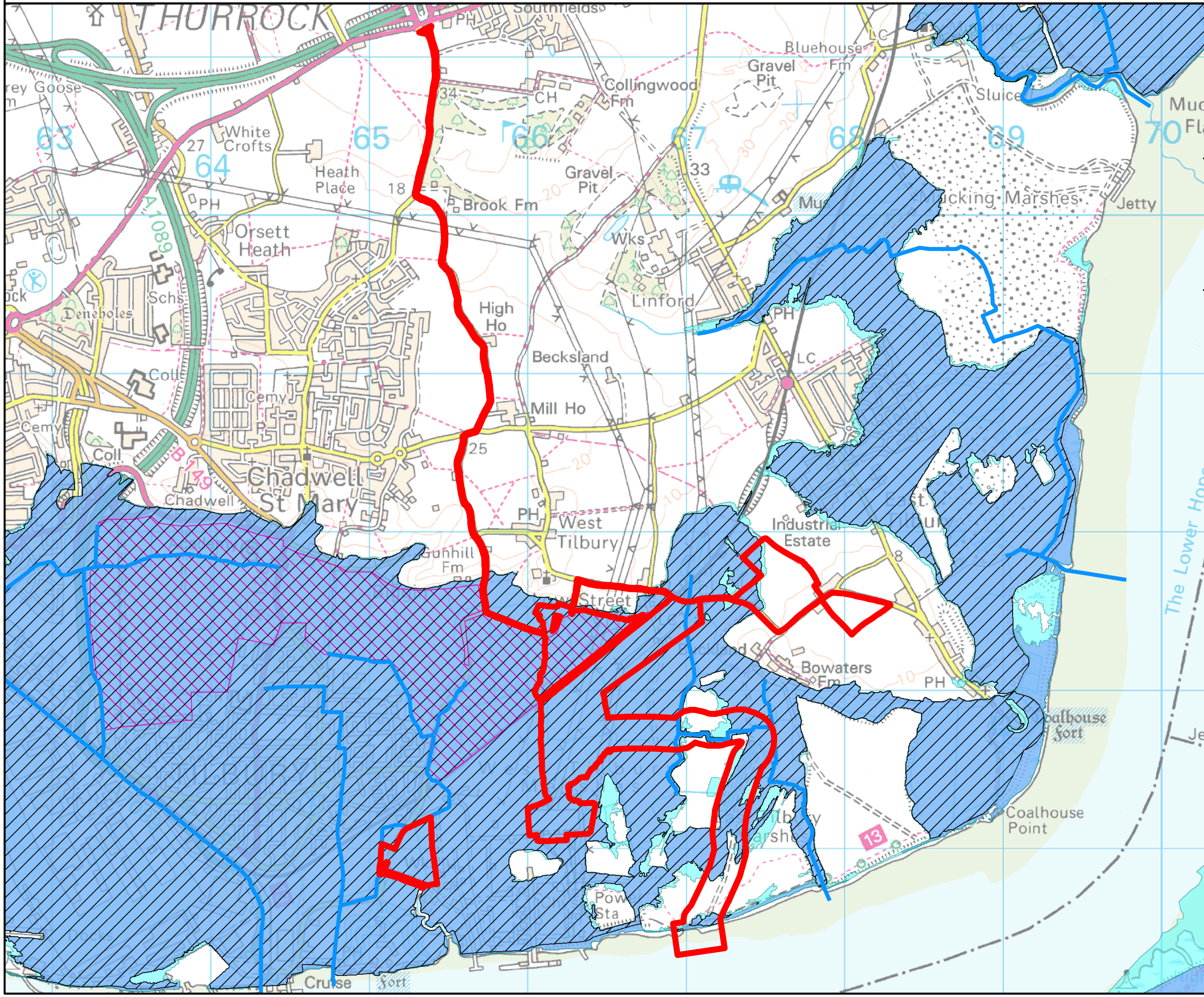
Please be aware that in recent years, there has been an increase in flood damage caused by surface water flooding or drainage systems that have been overwhelmed. We have worked with Lead local Flood Authorities (LLFAs) to develop a map which incorporates the best local and national scale information on surface water flood risk. These maps can be viewed on our website at the following:-
https://flood-warning-information.service.gov.uk/long-term-flood-risk/

Reservoir Flooding

You can obtain a map which shows the extent of flooding if a reservoir was to fail and release the water that it holds. The map shows the worst case scenario. These maps can be viewed on our website at the following:-
https://flood-warning-information.service.gov.uk/long-term-flood-risk/

Flood Map for Planning centred on 566300,176685
Created 23/07/2018 - Ref: EAn/2018/92748

Environment Agency



Environment Agency
Iceni House
Cobham Road
Ipswich
Suffolk
IP3 9JD

N

0 410 820 1,640
Metres
1:35,000

Legend

- Site Location
- Main Rivers
- Areas Benefiting from Defence
- Flood Storage Area
- Flood Zone 3
- Flood Zone 2

Flood Map for Planning (assuming no defences)

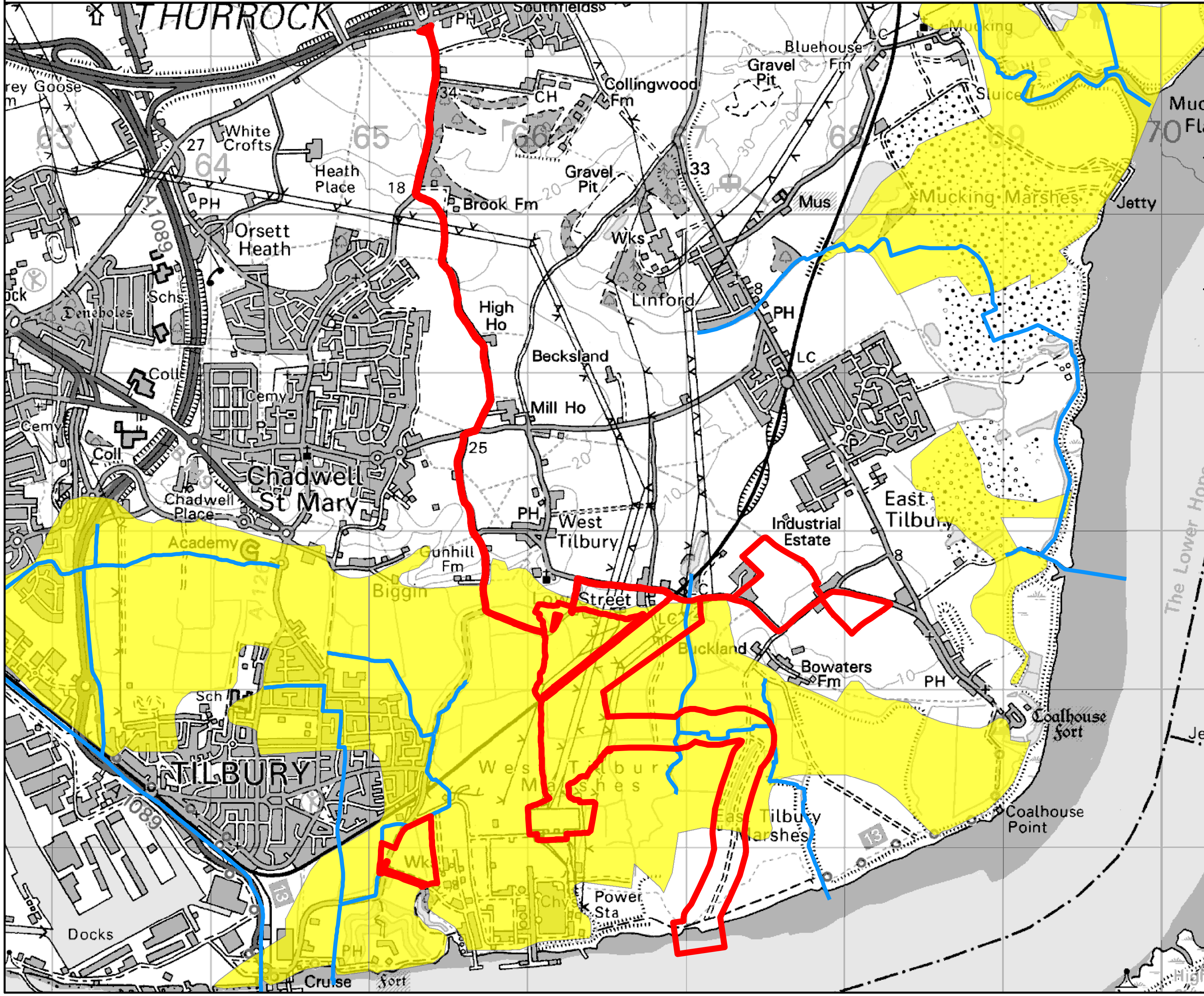
Flood Zone 3 shows the area that could be affected by flooding:
- from the sea with a 1 in 200 or greater chance of happening each year
- or from a river with a 1 in 100 or greater chance of happening each year.

Flood Zone 2 shows the extent of an extreme flood from rivers or the sea with up to a 1 in 1000 chance of occurring each year.

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

Produced by: Partnership & Strategic Overview
East Anglia: Essex, Norfolk & Suffolk

Recorded Flood Events Outlines Map centred on 566300,176685
Created 23/07/2018 - Ref: EAn/2018/92748



Environment Agency
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Metres
1:35,000

Legend

- Site Location
- Main Rivers
- 1953 Outline

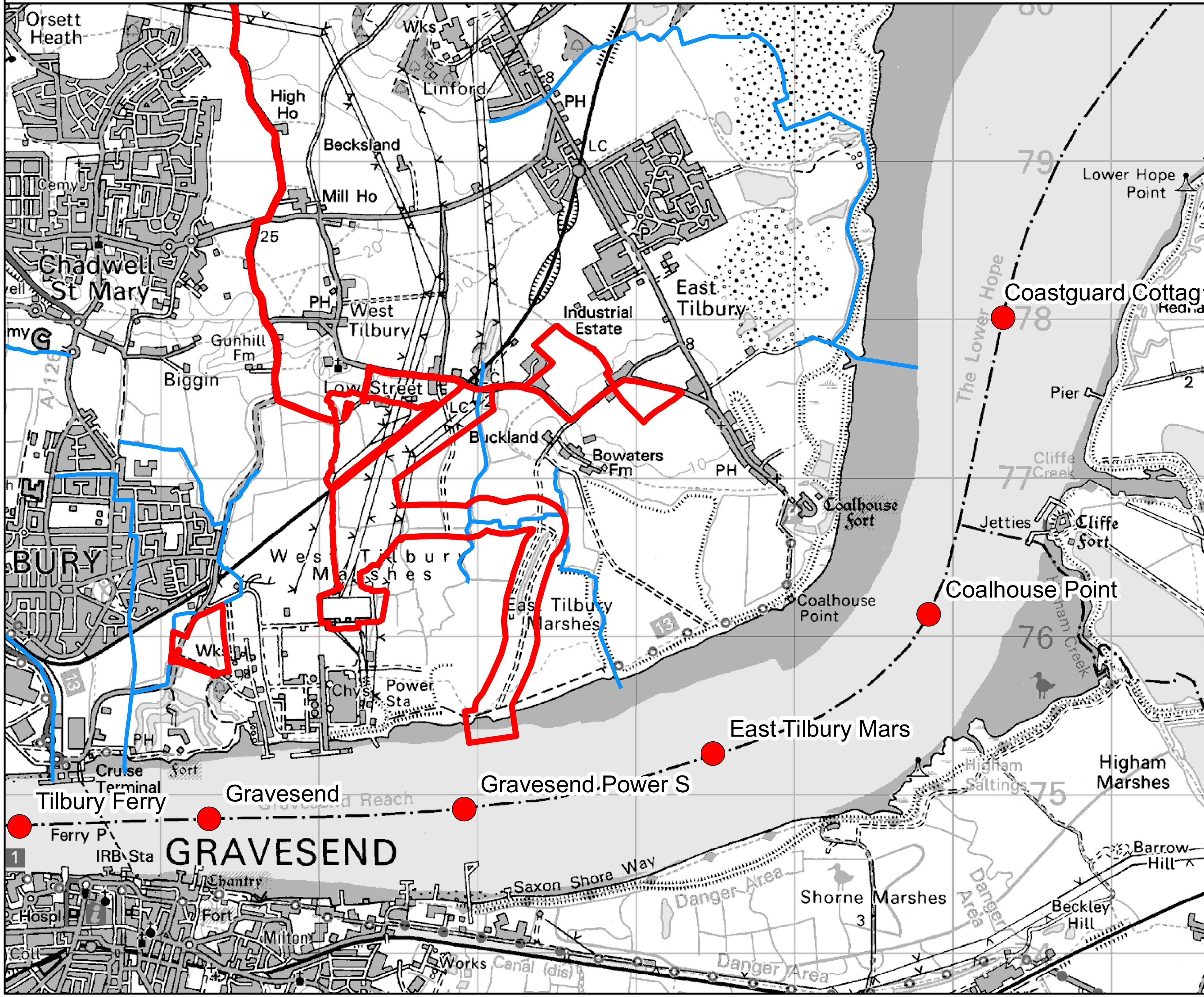
The historic flood event outlines are based on a combination of anecdotal evidence, Environment Agency staff observations and survey.
Our historic flood event outlines do not provide a definitive record of flooding.
It is possible that there will be an absence of datain places where we have not been able to record the extent of flooding.
It is also possible for errors occur in the digitisation of historic records of flooding.

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

Produced by: Partnership & Strategic Overview
East Anglia: Essex, Norfolk & Suffolk

Thames TE2100 Nodes
Map centred on 566300,176685 Created 23/07/2018 - Ref: EAn/2018/92748

Environment Agency



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N

0 410 820 1,640
Metres
1:35,000

Legend

- TE2100 Nodes
- Site Location
- Main Rivers

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 the catchment. Modelled outlines take into account catchment wide defences if present.

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Produced by: Partnership & Strategic Overview
East Anglia: Essex, Norfolk & Suffolk

Thames Estuary 2100 (TE2100)

Location	Node Ref	Easting	Northing	2005		2040		2070		2100		2120		2070 Defence Crest Levels	
				1 in 200 (0.5% AEP)	1 in 1000 (0.1% AEP)	1 in 200 (0.5% AEP)	1 in 1000 (0.1% AEP)	1 in 200 (0.5% AEP)	1 in 1000 (0.1% AEP)	1 in 200 (0.5% AEP)	1 in 1000 (0.1% AEP)	1 in 200 (0.5% AEP)	1 in 1000 (0.1% AEP)	Existing Barrier	New Barrier
Dartford	3.15	554397	178402	5.64	5.97	5.85	6.18	6.00	6.33	6.32	6.65	6.52	6.85	7.60	6.10
Dartford Marshes	3.16	555012	177896	5.62	5.95	5.83	6.16	5.98	6.31	6.30	6.63	6.49	6.82	7.60	6.10
Long Reach	3.17	555831	177179	5.61	5.94	5.82	6.15	5.97	6.30	6.29	6.62	6.48	6.81	7.60	8.50
Dartford Tunnel	3.18	557090	176390	5.61	5.94	5.82	6.15	5.96	6.29	6.27	6.60	6.46	6.79	7.50	8.50
Stone Ness	3.19	558175	175703	5.59	5.92	5.80	6.13	5.95	6.28	6.27	6.60	6.45	6.78	7.50	8.50
West Thurrock	3.20	559355	176131	5.57	5.90	5.78	6.11	5.94	6.27	6.25	6.58	6.43	6.76	7.50	8.50
Swanscombe	3.21	560139	177011	5.56	5.89	5.77	6.10	5.91	6.24	6.22	6.55	6.41	6.74	7.50	8.50
Grays	3.22	561470	176679	5.53	5.86	5.74	6.07	5.91	6.24	6.21	6.54	6.40	6.73	7.50	8.00
Tilbury	3.23	562066	175589	5.52	5.85	5.73	6.06	5.89	6.22	6.19	6.52	6.38	6.71	7.50	8.00
Northfleet	3.24	562675	174950	5.50	5.83	5.71	6.04	5.86	6.19	6.16	6.49	6.36	6.69	7.40	8.00
Tilbury Ferry	3.25	564109	174800	5.48	5.81	5.69	6.02	5.84	6.17	6.14	6.47	6.34	6.67	7.40	8.00
Gravesend	3.26	565307	174848	5.45	5.78	5.66	5.99	5.81	6.14	6.11	6.44	6.32	6.65	7.40	8.00
Gravesend Power S	3.27	566916	174908	5.38	5.71	5.59	5.92	5.75	6.08	6.05	6.38	6.28	6.61	7.40	8.00
East Tilbury Mars	3.28	568488	175258	5.31	5.64	5.52	5.85	5.68	6.01	5.99	6.32	6.23	6.56	7.00	7.00
Coalhouse Point	3.29	569850	176137	5.25	5.58	5.46	5.79	5.60	5.93	5.92	6.25	6.18	6.51	6.48	6.48
Coastguard Cottag	3.30	570320	178011	5.21	5.54	5.42	5.75	5.56	5.89	5.86	6.19	6.13	6.46	6.75	6.75
Mucking Flats	3.31	571235	179824	5.16	5.49	5.37	5.70	5.53	5.86	5.85	6.18	6.12	6.45	7.50	8.10
Corringham Marshe	3.32	573440	180782	5.08	5.41	5.29	5.62	5.48	5.81	5.83	6.16	6.10	6.43	7.50	8.10
Blythe Sands	3.33	575633	181137	5.00	5.33	5.21	5.54	5.43	5.76	5.81	6.14	6.08	6.41	7.50	8.10
Halstow Marshes	3.34	577953	181149	4.95	5.28	5.16	5.49	5.37	5.70	5.76	6.09	6.04	6.37	7.40	8.10
West Point	3.35	579995	181222	4.89	5.22	5.10	5.43	5.33	5.66	5.72	6.05	6.01	6.34	7.40	8.10
East Canvey Point	3.36	583007	181318	4.81	5.14	5.02	5.35	5.30	5.63	5.69	6.02	5.98	6.31	7.40	8.10
Leigh	3.37	585820	181583	4.73	5.06	4.94	5.27	5.27	5.60	5.66	5.99	5.95	6.28	6.70	7.40
Southend	3.38	588653	181517	4.70	5.03	4.91	5.24	5.22	5.55	5.62	5.95	5.92	6.25	6.70	7.40

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.

Details about the TE2100 plan

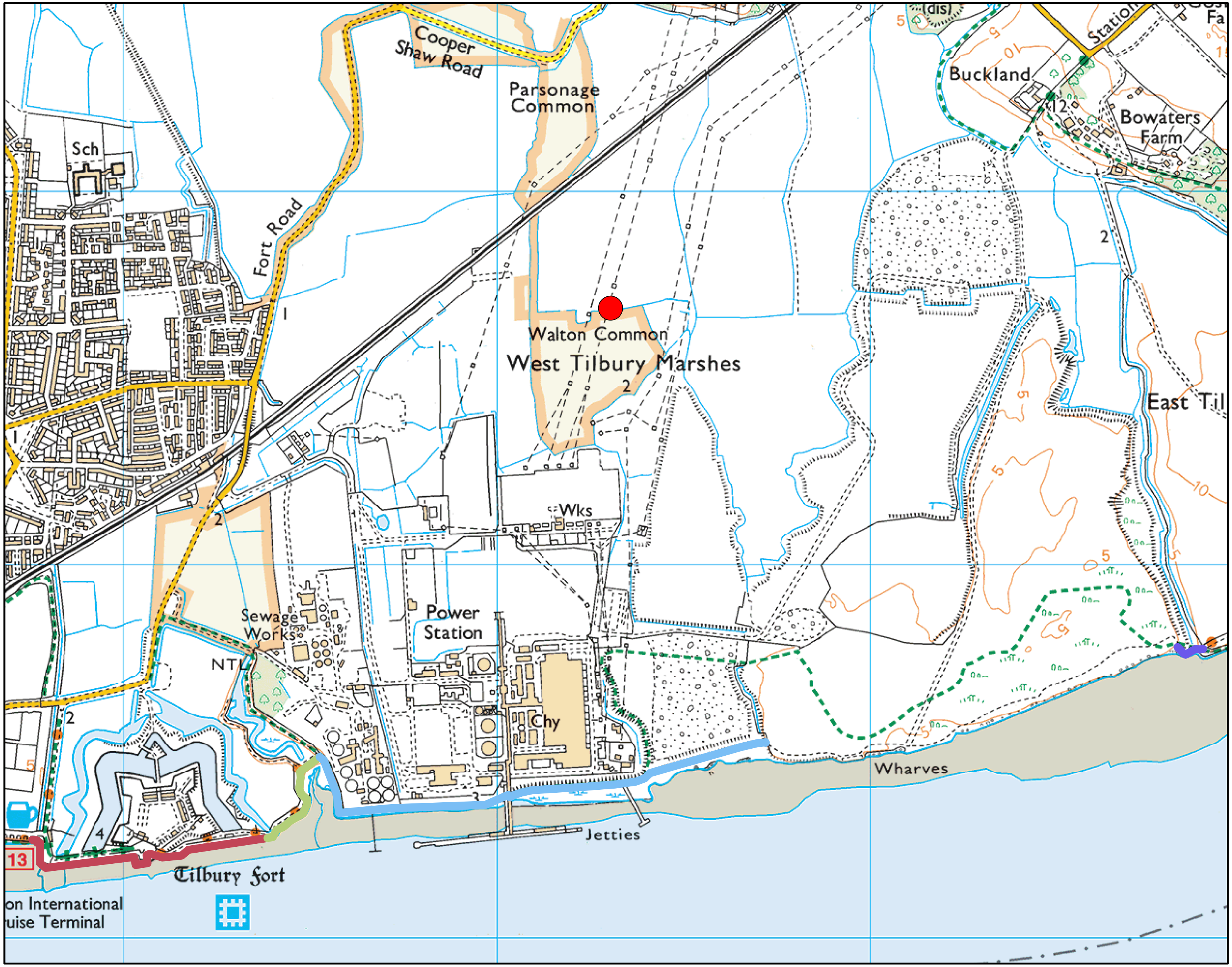
The TE2100 plan is now live and within it are a set of levels on which the flood risk management strategy is based. The plan is the overarching flood management strategy for the Thames Estuary and therefore any development planning should be based on the same underlying data.

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.

Flood Defence Location Map centred on West Tilbury Marshes
Ref: EAN/2018/92748



Environment Agency

Legend

Site

Defences

ASSET_ID

- 109492
- 109493
- 152988
- 475722

Scale 1:15,000

N

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

Date: 18/07/18
Datasheet Reference: EAN/2018/92748

Defence Information

Asset Reference	Maintainer	Bank	Asset Type	Asset Description	Standard of Protection	Overall Condition Grade	Crest Level
109492	Environment Agency	left	wall	Sheet Piling Wall	1000.0	3	6.700
109493	Environment Agency	left	wall	Piling with embankment	1000.0	4	6.670
152988	Environment Agency	left	wall	Wall	1000.0	5	6.480
475722	Environment Agency		wall	Concrete Wall	1000.0	3	6.000

Key to Overall Condition Grades

Grade	Rating	Description
1	Very Good	Cosmetic Defects that will have no effect on performance.
2	Good	Minor defects that will not reduce the overall performance of the asset.
3	Fair	Defects that could reduce performance of the asset
4	Poor	Defects that would significantly reduce the performance of the asset. Further investigation.
5	Very Poor	Severe defects resulting in complete performance failure.

Use of Environment Agency Information for Flood Risk Assessments

Important

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

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.

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/

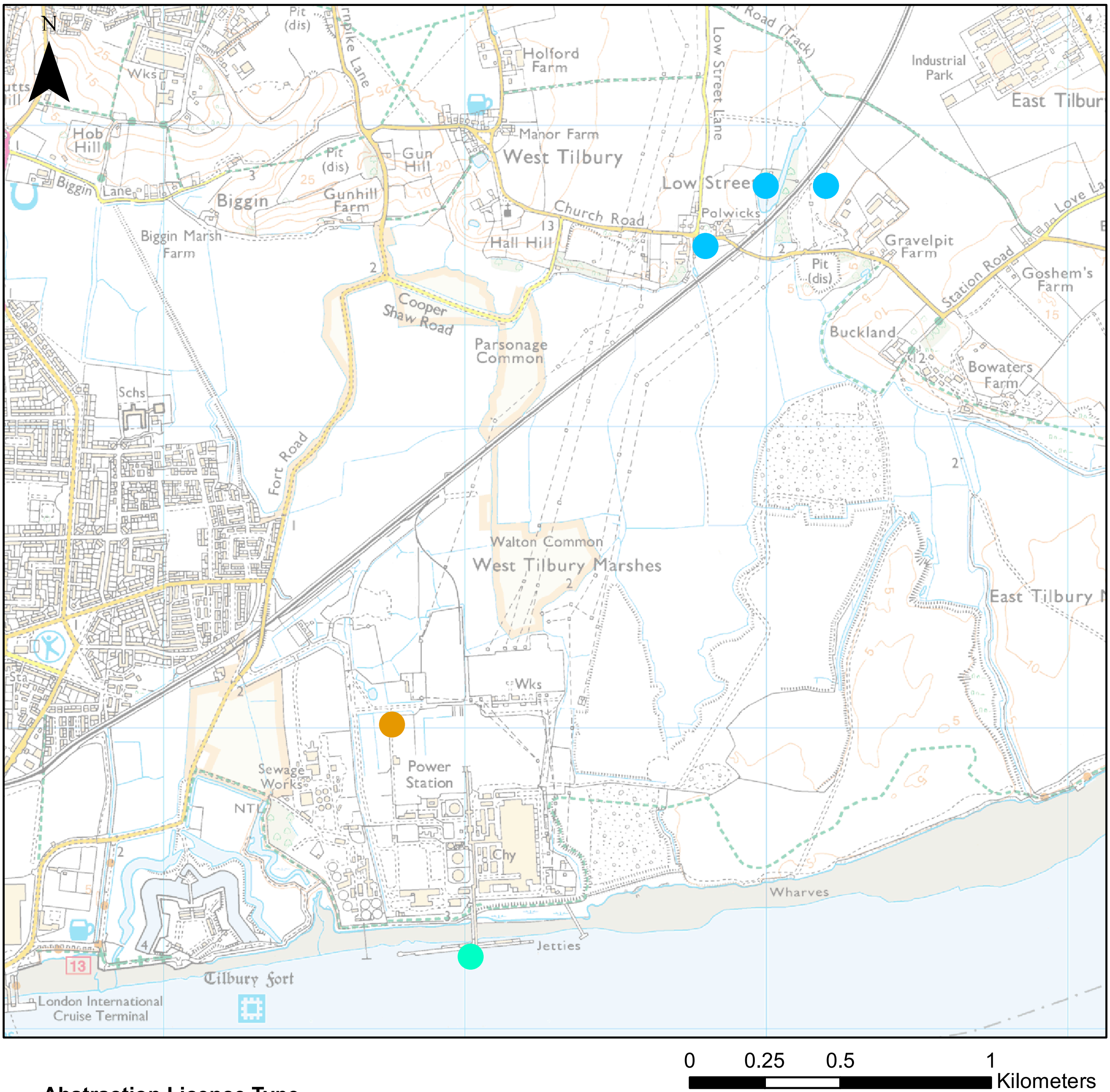
You should also consult the Strategic Flood Risk Assessment or other relevant materials produced by your local planning authority.

You should note that:

1. Information supplied by the Environment Agency may be used to assist in producing a Flood Risk Assessment (FRA) 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 surface water runoff. Information produced by the local planning authority referred to above may assist here.

3. Where a planning application requires an FRA and this is not submitted or is deficient, the Environment Agency may raise an objection.



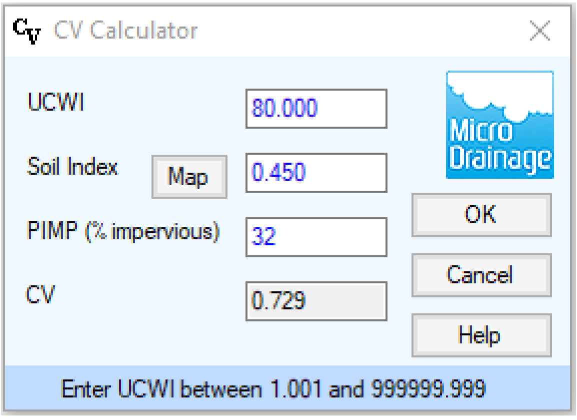
Abstraction Licence Type

- Deregulated
- Groundwater
- Tidal

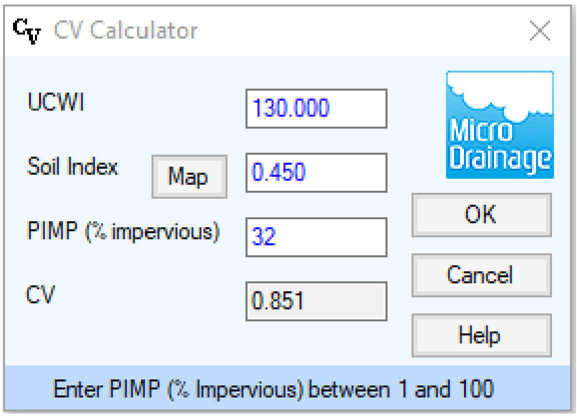
Annex C: MicroDrainage Outputs

B.1 Runoff Coefficient Calculations

Summer CV Calculation



Winter CV Calculation



ICP SUDS Mean Annual Flood

Input

Return Period (years)	1	Soil	0.450
Area (ha)	20.010	Urban	0.000
SAAR (mm)	550	Region Number	Region 6

Results	**l/s**
QBAR Rural	66.3
QBAR Urban	66.3
Q1 year	56.4
Q1 year	56.4
Q30 years	150.2
Q100 years	211.5

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	1.079	0.329	41.2	5819.5	O K
30 min Summer	1.111	0.361	41.5	6401.1	O K
60 min Summer	1.145	0.395	41.6	7023.6	O K
120 min Summer	1.180	0.430	41.7	7672.1	O K
180 min Summer	1.200	0.450	41.7	8049.1	O K
240 min Summer	1.214	0.464	41.7	8306.5	O K
360 min Summer	1.231	0.481	41.7	8640.5	O K
480 min Summer	1.242	0.492	41.7	8842.4	O K
600 min Summer	1.249	0.499	41.7	8968.8	O K
720 min Summer	1.253	0.503	41.7	9045.4	O K
960 min Summer	1.280	0.530	41.7	9566.5	O K
1440 min Summer	1.314	0.564	41.7	10205.5	O K
2160 min Summer	1.338	0.588	41.7	10668.8	O K
2880 min Summer	1.353	0.603	41.7	10946.4	O K
4320 min Summer	1.316	0.566	41.7	10242.4	O K
5760 min Summer	1.282	0.532	41.7	9588.2	O K
7200 min Summer	1.249	0.499	41.7	8968.0	O K
8640 min Summer	1.218	0.468	41.7	8380.6	O K
10080 min Summer	1.189	0.439	41.7	7836.2	O K
15 min Winter	1.132	0.382	41.6	6796.5	O K
30 min Winter	1.169	0.419	41.7	7479.4	O K

Storm Event	Rain (mm/hr)	Flooded Volume (m³)	Discharge Volume (m³)	Time-Peak (mins)
15 min Summer	263.696	0.0	2906.0	27
30 min Summer	145.425	0.0	3153.8	42
60 min Summer	80.200	0.0	5057.5	72
120 min Summer	44.229	0.0	5539.9	130
180 min Summer	31.226	0.0	5807.1	190
240 min Summer	24.392	0.0	5980.4	250
360 min Summer	17.221	0.0	6182.2	368
480 min Summer	13.452	0.0	6275.8	488
600 min Summer	11.106	0.0	6304.3	606
720 min Summer	9.497	0.0	6287.3	726
960 min Summer	7.754	0.0	6197.4	964
1440 min Summer	5.827	0.0	5781.3	1442
2160 min Summer	4.379	0.0	11347.6	1928
2880 min Summer	3.576	0.0	11514.2	2304
4320 min Summer	2.499	0.0	10444.6	3028
5760 min Summer	1.938	0.0	15508.3	3808
7200 min Summer	1.591	0.0	15788.1	4616
8640 min Summer	1.355	0.0	15940.5	5368
10080 min Summer	1.182	0.0	15902.7	6160
15 min Winter	263.696	0.0	3296.1	27
30 min Winter	145.425	0.0	3453.7	41

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	1.209	0.459	41.7	8211.7	O K
120 min Winter	1.249	0.499	41.7	8979.2	O K
180 min Winter	1.273	0.523	41.7	9430.2	O K
240 min Winter	1.290	0.540	41.7	9742.2	O K
360 min Winter	1.311	0.561	41.7	10154.4	O K
480 min Winter	1.325	0.575	41.7	10413.2	O K
600 min Winter	1.334	0.584	41.7	10583.9	O K
720 min Winter	1.340	0.590	41.7	10697.0	O K
960 min Winter	1.374	0.624	41.7	11357.8	O K
1440 min Winter	1.418	0.668	41.7	12220.6	O K
2160 min Winter	1.454	0.704	41.7	12912.4	O K
2880 min Winter	1.470	0.720	41.7	13222.5	O K
4320 min Winter	1.414	0.664	41.7	12142.0	O K
5760 min Winter	1.365	0.615	41.7	11181.0	O K
7200 min Winter	1.316	0.566	41.7	10239.5	O K
8640 min Winter	1.269	0.519	41.7	9343.4	O K
10080 min Winter	1.224	0.474	41.7	8506.3	O K

Storm Event	Rain (mm/hr)	Flooded Volume (m³)	Discharge Volume (m³)	Time-Peak (mins)
60 min Winter	80.200	0.0	5855.7	70
120 min Winter	44.229	0.0	6310.3	128
180 min Winter	31.226	0.0	6526.5	188
240 min Winter	24.392	0.0	6639.2	246
360 min Winter	17.221	0.0	6708.2	362
480 min Winter	13.452	0.0	6668.3	480
600 min Winter	11.106	0.0	6576.8	596
720 min Winter	9.497	0.0	6477.1	714
960 min Winter	7.754	0.0	6267.3	944
1440 min Winter	5.827	0.0	5830.6	1404
2160 min Winter	4.379	0.0	12286.6	2076
2880 min Winter	3.576	0.0	11777.5	2716
4320 min Winter	2.499	0.0	10736.0	3332
5760 min Winter	1.938	0.0	18066.8	4216
7200 min Winter	1.591	0.0	18368.7	5056
8640 min Winter	1.355	0.0	18515.8	5888
10080 min Winter	1.182	0.0	18477.3	6664

Rainfall Details

Rainfall Model	FEH
Return Period (years)	100
FEH Rainfall Version	1999
Site Location	GB 566350 176250 TQ 66350 76250
C (1km)	-0.026
D1 (1km)	0.261
D2 (1km)	0.415
D3 (1km)	0.236
E (1km)	0.320
F (1km)	2.576
Summer Storms	Yes
Winter Storms	Yes
Cv (Summer)	0.729
Cv (Winter)	0.851
Shortest Storm (mins)	15
Longest Storm (mins)	10080
Climate Change %	+40

Time Area Diagram

Total Area (ha) 12.180

Time From:	**(mins) To:**	**Area (ha)**	**Time From:**	**(mins) To:**	**Area (ha)**	**Time From:**	**(mins) To:**	**Area (ha)**
0	4	4.060	4	8	4.060	8	12	4.060

Model Details

Storage is Online Cover Level (m) 1.750

Tank or Pond Structure

Invert Level (m) 0.750

Depth (m)	Area (m²)	Depth (m)	Area (m²)
0.000	17097.0	1.000	20740.0

Hydro-Brake® Optimum Outflow Control

Unit Reference	MD-SHE-0273-4170-1000-4170
Design Head (m)	1.000
Design Flow (l/s)	41.7
Flush-Flo™	Calculated
Objective	Minimise upstream storage
Application	Surface
Sump Available	Yes
Diameter (mm)	273
Invert Level (m)	0.750
Minimum Outlet Pipe Diameter (mm)	300
Suggested Manhole Diameter (mm)	1800

Control Points	Head (m)	Flow (l/s)
Design Point (Calculated)	1.000	41.7
Flush-Flo™	0.421	41.7
Kick-Flo®	0.770	36.8
Mean Flow over Head Range	-	33.9

The hydrological calculations have been based on the Head/Discharge relationship for the Hydro-Brake® Optimum as specified. Should another type of control device other than a Hydro-Brake Optimum® be utilised then these storage routing calculations will be invalidated

Depth (m)	Flow (l/s)	Depth (m)	Flow (l/s)	Depth (m)	Flow (l/s)	Depth (m)	Flow (l/s)
0.100	8.6	1.200	45.5	3.000	70.9	7.000	107.1
0.200	28.1	1.400	49.0	3.500	76.4	7.500	110.7
0.300	40.8	1.600	52.3	4.000	81.5	8.000	114.3
0.400	41.7	1.800	55.3	4.500	86.3	8.500	117.7
0.500	41.4	2.000	58.2	5.000	90.9	9.000	121.1
0.600	40.5	2.200	61.0	5.500	95.2	9.500	124.3
0.800	37.5	2.400	63.6	6.000	99.3		
1.000	41.7	2.600	66.1	6.500	103.3		

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	1.166	0.416	14.7	1989.2	O K
30 min Summer	1.205	0.455	14.7	2187.6	O K
60 min Summer	1.246	0.496	14.7	2398.6	O K
120 min Summer	1.287	0.537	14.7	2615.9	O K
180 min Summer	1.310	0.560	14.7	2740.1	O K
240 min Summer	1.326	0.576	14.7	2823.5	O K
360 min Summer	1.346	0.596	14.7	2928.4	O K
480 min Summer	1.357	0.607	14.7	2988.4	O K
600 min Summer	1.363	0.613	14.7	3022.7	O K
720 min Summer	1.366	0.616	14.7	3040.0	O K
960 min Summer	1.396	0.646	14.7	3204.4	O K
1440 min Summer	1.432	0.682	14.7	3402.0	O K
2160 min Summer	1.455	0.705	14.7	3526.5	O K
2880 min Summer	1.462	0.712	14.7	3567.8	O K
4320 min Summer	1.398	0.648	14.7	3213.4	O K
5760 min Summer	1.343	0.593	14.7	2914.9	O K
7200 min Summer	1.293	0.543	14.7	2648.7	O K
8640 min Summer	1.247	0.497	14.7	2406.1	O K
10080 min Summer	1.205	0.455	14.7	2186.2	O K
15 min Winter	1.231	0.481	14.7	2324.2	O K
30 min Winter	1.276	0.526	14.7	2557.2	O K

Storm Event	Rain (mm/hr)	Flooded Volume (m³)	Discharge Volume (m³)	Time-Peak (mins)
15 min Summer	263.696	0.0	1240.2	27
30 min Summer	145.425	0.0	1245.6	42
60 min Summer	80.200	0.0	2089.7	72
120 min Summer	44.229	0.0	2250.9	130
180 min Summer	31.226	0.0	2326.7	190
240 min Summer	24.392	0.0	2363.3	250
360 min Summer	17.221	0.0	2374.6	368
480 min Summer	13.452	0.0	2347.2	488
600 min Summer	11.106	0.0	2313.8	606
720 min Summer	9.497	0.0	2279.7	726
960 min Summer	7.754	0.0	2197.9	964
1440 min Summer	5.827	0.0	2038.9	1442
2160 min Summer	4.379	0.0	4236.4	2100
2880 min Summer	3.576	0.0	4126.9	2424
4320 min Summer	2.499	0.0	3840.4	3072
5760 min Summer	1.938	0.0	5553.7	3816
7200 min Summer	1.591	0.0	5685.7	4616
8640 min Summer	1.355	0.0	5786.0	5368
10080 min Summer	1.182	0.0	5843.4	6152
15 min Winter	263.696	0.0	1251.3	27
30 min Winter	145.425	0.0	1241.4	41

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	1.323	0.573	14.7	2805.7	O K
120 min Winter	1.371	0.621	14.7	3064.0	O K
180 min Winter	1.398	0.648	14.7	3214.4	O K
240 min Winter	1.417	0.667	14.7	3317.3	O K
360 min Winter	1.441	0.691	14.7	3451.6	O K
480 min Winter	1.456	0.706	14.7	3533.9	O K
600 min Winter	1.466	0.716	14.7	3586.0	O K
720 min Winter	1.471	0.721	14.7	3618.3	O K
960 min Winter	1.509	0.759	14.7	3831.3	O K
1440 min Winter	1.555	0.805	14.7	4091.0	O K
2160 min Winter	1.586	0.836	14.7	4268.8	O K
2880 min Winter	1.594	0.844	14.7	4318.2	O K
4320 min Winter	1.521	0.771	14.7	3897.6	O K
5760 min Winter	1.450	0.700	14.7	3499.5	O K
7200 min Winter	1.374	0.624	14.7	3084.2	O K
8640 min Winter	1.305	0.555	14.7	2711.6	O K
10080 min Winter	1.241	0.491	14.7	2373.9	O K

Storm Event	Rain (mm/hr)	Flooded Volume (m³)	Discharge Volume (m³)	Time-Peak (mins)
60 min Winter	80.200	0.0	2343.6	70
120 min Winter	44.229	0.0	2427.7	128
180 min Winter	31.226	0.0	2418.9	188
240 min Winter	24.392	0.0	2394.8	246
360 min Winter	17.221	0.0	2343.9	364
480 min Winter	13.452	0.0	2295.7	480
600 min Winter	11.106	0.0	2253.0	598
720 min Winter	9.497	0.0	2214.6	714
960 min Winter	7.754	0.0	2125.8	946
1440 min Winter	5.827	0.0	2008.6	1404
2160 min Winter	4.379	0.0	4334.4	2076
2880 min Winter	3.576	0.0	4171.8	2712
4320 min Winter	2.499	0.0	3832.0	3372
5760 min Winter	1.938	0.0	6468.1	4280
7200 min Winter	1.591	0.0	6620.9	5112
8640 min Winter	1.355	0.0	6732.3	5888
10080 min Winter	1.182	0.0	6801.1	6664

Rainfall Details

Rainfall Model	FEH
Return Period (years)	100
FEH Rainfall Version	1999
Site Location	GB 566350 176250 TQ 66350 76250
C (1km)	-0.026
D1 (1km)	0.261
D2 (1km)	0.415
D3 (1km)	0.236
E (1km)	0.320
F (1km)	2.576
Summer Storms	Yes
Winter Storms	Yes
Cv (Summer)	0.729
Cv (Winter)	0.851
Shortest Storm (mins)	15
Longest Storm (mins)	10080
Climate Change %	+40

Time Area Diagram

Total Area (ha) 4.170

Time From:	**(mins) To:**	**Area (ha)**	**Time From:**	**(mins) To:**	**Area (ha)**	**Time From:**	**(mins) To:**	**Area (ha)**
0	4	1.390	4	8	1.390	8	12	1.390

Model Details

Storage is Online Cover Level (m) 1.750

Tank or Pond Structure

Invert Level (m) 0.750

Depth (m)	Area (m²)	Depth (m)	Area (m²)
0.000	4468.0	1.000	6050.0

Hydro-Brake® Optimum Outflow Control

Unit Reference	MD-SHE-0173-1470-1000-1470
Design Head (m)	1.000
Design Flow (l/s)	14.7
Flush-Flo™	Calculated
Objective	Minimise upstream storage
Application	Surface
Sump Available	Yes
Diameter (mm)	173
Invert Level (m)	0.750
Minimum Outlet Pipe Diameter (mm)	225
Suggested Manhole Diameter (mm)	1200

Control Points	Head (m)	Flow (l/s)
Design Point (Calculated)	1.000	14.7
Flush-Flo™	0.322	14.7
Kick-Flo®	0.702	12.4
Mean Flow over Head Range	-	12.5

The hydrological calculations have been based on the Head/Discharge relationship for the Hydro-Brake® Optimum as specified. Should another type of control device other than a Hydro-Brake Optimum® be utilised then these storage routing calculations will be invalidated

Depth (m)	Flow (l/s)	Depth (m)	Flow (l/s)	Depth (m)	Flow (l/s)	Depth (m)	Flow (l/s)
0.100	6.1	1.200	16.0	3.000	24.8	7.000	37.3
0.200	14.2	1.400	17.2	3.500	26.7	7.500	38.6
0.300	14.7	1.600	18.4	4.000	28.5	8.000	39.8
0.400	14.6	1.800	19.4	4.500	30.2	8.500	41.0
0.500	14.3	2.000	20.4	5.000	31.7	9.000	42.2
0.600	13.8	2.200	21.4	5.500	33.2	9.500	43.3
0.800	13.2	2.400	22.3	6.000	34.6		
1.000	14.7	2.600	23.2	6.500	36.0		