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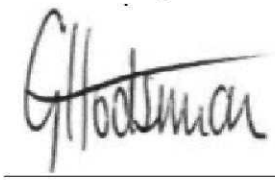
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SPALDING ENERGY EXPANSION

SUPPLEMENTARY FLOOD RISK ASSESSMENT

Revision History

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1 INTRODUCTION

1.1 Intention to Vary Consent under Section 36C of the Electricity Act 1989

1.1.1 In March 2009, Spalding Energy Expansion Limited (SEEL) submitted an application for Consent under Section 36 of the Electricity Act 1989 (the Original Consent Application) to the Secretary of State for Energy and Climate Change (the Secretary of State) via the Department of Energy and Climate Change (DECC) to construct a 900 megawatt (MW) Combined Cycle Gas Turbine (CCGT) generating station to be known as Spalding Energy Expansion (SEE). In addition, a direction that planning permission be deemed to be granted under Section 90 of the Town and Country Planning Act 1990 was also sought.

1.1.2 Amongst other documents / studies, the Original Consent Application was accompanied by an Environmental Statement (ES) (the March 2009 ES), which included (at Appendix 12.1) an Initial Flood Risk Assessment (Document Reference: 64-C13376). Furthermore, in July 2009 SEEL provided additional information on Flood Risk to the Environment Agency (Additional Flood Risk Information).

1.1.3 On 11 November 2010, Consent under Section 36 of the Electricity Act 1989 and deemed planning permission under Section 90 of the Town and Country Planning Act 1990 was granted (the Original Consent) for SEE.

1.1.4 Based on a number of influencing factors since the Original Consent was granted, SEEL is submitting an application under Section 36C of the Electricity Act 1989 to the Secretary of State via DECC for the Original Consent to be varied (the Variation Application).

1.1.5 If the Original Consent is varied as per the Variation Application, SEE will provide up to 945 MW of power generation capacity. In providing up to 945 MW of power generation capacity, the Proposed Development will either comprise:

- Scenario 1: Up to 945 MW of CCGT units; or,
- Scenario 2: Up to 645 MW of CCGT units and less than 300 MW of Open Cycle Gas Turbine (OCGT) units.

1.1.6 In addition, if the Original Consent is varied as per the Variation Application, the commencement of the deadline for the Consent will be 5 years from the date of granting the variation. Similarly, the commencement deadline for the deemed planning permission will be 5 years from the date of granting the variation.

1.2 The Purpose of this Document

1.2.1 To accompany the Variation Application, SEEL is providing the following information to DECC:

- An Environmental Statement Further Information Document (ES FID) (the Variation Application ES FID), which includes (amongst other items):
  - The rationale for proposing that the Original Consent is varied;
  - An assessment of whether the likely significant effects on the environment of the Proposed Development[1] differ from those described in the March 2009 ES; and,
    - Where there is potential for the likely significant effects to differ, an updated impact assessment;
    - Where there is no potential for the likely significant effects to differ, an explanation and / or supporting information.
- A Revised Carbon Capture Readiness (CCR) Feasibility Study;

[1] Being the generating station which SEEL would be authorised to construct under the Original Consent if this is varied as requested in the Variation Application.

- A Revised CHP Assessment; and,
- A Supplementary Flood Risk Assessment.

1.2.2 This Document is the Supplementary Flood Risk Assessment which accompanies the Variation Application. This Document supplements the Initial Flood Risk Assessment and Additional Flood Risk Information, making use of recent data and reiterating the findings of the site-specific modelling previously undertaken.

Key Updates to the Initial Flood Risk Assessment / Additional Flood Risk Information

1.2.3 The key updates that have been made include:

- References to planning guidance;
- Inclusion of recent baseline data (e.g. River Basin Management Plan information and other flood risk assessments); and,
- Consideration of the revised indicative construction schedule.

1.2.4 To prepare this Document, the key sources of information used include:

- The Initial Flood Risk Assessment and the Additional Flood Risk Information;
- National Planning Policy Framework (NPPF) and National Planning Practice Guidance (NPPG) on Flood Risk and Coastal Change;
- Environment Agency (EA) online database of indicative floodplain and hydrogeological maps;
- The South Holland District Council Strategic Flood Risk Assessment (SFRA) from 2002, and also the updated SFRA from 2010; and,
- British Geological Survey (BGS) online database of geological maps and borehole records.

1.2.5 In particular, the Initial Flood Assessment was undertaken in line with Planning Policy Statement 25: Development and Flood Risk Practice Guidance (PPS 25). Since then, the requirements of PPS 25 have been placed by those of the NPPF and the associated NPPG. However, a flood risk assessment undertaken in compliance with PPS 25 would yield the same results as those undertaken in compliance with the NPPF and the associated NPPG. Therefore the Initial Flood Risk Assessment and the Additional Flood Risk Information is considered to be in compliance with the NPPF and the associated NPPG.

1.2.6 Ramboll cannot accept liability for the accuracy or otherwise of any information derived from third party sources.

Scope and Objectives

1.2.7 This Document considers the risks of various sources of flooding to the proposed SEE site and the consequent risk of flooding to downstream receptors (such as: designated sites; habitats; infrastructure; people; and, property) from the Proposed Development as a result of surface water run-off. A comparison is made between the current situation and the likely future situation.

1.2.8 This Supplementary FRA has been carried out in accordance with the NPPF, and provides the following information:

- An assessment of the flood risk to the proposed SEE site based upon flood data and the flood maps provided by the Environment Agency / South Holland District SFRA and generated through hydraulic modelling;
- Proposals to mitigate any flood risk to the Proposed Development (if any);
- An assessment of the impact of the Proposed Development in terms of surface water run-off; and,

- Proposals for measures to mitigate the generation of surface water run-off from the Proposed Development.

Consultation

Previous Consultation

1.2.9 In preparing the March 2009 and Initial Flood Risk Assessment, the Environment Agency was consulted on the scope of the Initial Flood Risk Assessment, the extent of available information on flood risk affecting the proposed SEE site and the likely mechanisms of flooding. The Environment Agency was also further consulted regarding the mitigation measures which would be considered acceptable.

1.2.10 Regarding the extent of available information on flood risk affecting the proposed SEE site, consultation was undertaken with the Environment Agency Flood Risk Mapping and Data Management Team. The details of any historic river, groundwater or sewer flooding on the proposed SEE site or neighbouring areas was requested.

1.2.11 The Welland and Deepings Internal Drainage Board (WDIDB) was consulted regarding flood risk and site drainage issues.

1.2.12 Therefore, the scope of the Initial Flood Risk Assessment and the Additional Flood Risk Information was designed to address the issues raised by the Environment Agency and WDIDB.

Consultation undertaken for the Variation Application

1.2.13 In terms of the Variation Application, a Scoping Opinion was sought from the Secretary of State in November 2014. The request for a Scoping Opinion was accompanied by an Environmental Scoping Report. A Scoping Opinion was received from the Secretary of State on 27 February 2015. Additional responses were also received from other statutory and non-statutory consultees, including the Environment Agency.

1.2.14 In terms of flood risk, the Environment Agency advised that the Initial Flood Risk Assessment and Additional Flood Risk Information be updated. Information on the advised updates, and a reference to where information is provided is this Supplementary Flood Risk Assessment, is provided in Table 1.1.

TABLE 1.1: ADVISED UPDATES FROM THE ENVIRONMENT AGENCY / INFORMATION PROVIDED IN THIS SUPPLEMENTARY FLOOD RISK ASSESSMENT

Advised Updates	***Section of this Document***
"*We consider that an updated Flood Risk Assessment (FRA) will need to be prepared for this proposal, to ensure that it is informed by both the best available information and the most* [recent] *planning guidance*".	Section 2 (Development Description / Site Context) provides details on the Variation Application and site context. In the preparation of this Supplementary Flood Risk Assessment, consideration has been given to the requirements of the NPPF and the NPPG.
"*The FRA should incorporate, and make reference to, the Environment Agency's Coastal Hazard Mapping if it does not already. Our Hazard Mapping shows the consequences to the development site should a breach or overtopping event occur in the raised defences of the River Welland. Should you wish to obtain this information, please request a 'Product 8' from our Customers and Engagement team at LNenquiries@environment-agency.gov.uk*".	Hazard Mapping was not available for the proposed SEE site. See Appendix A. However, it is considered that the Initial Flood Risk Assessment provides a more rigorous and detailed 'site level' assessment due to the high resolution, the variety of scenarios considered and the timescales that were assumed. Therefore, the Initial Flood Risk Assessment is considered to provide the most accurate and up to date evaluation of flood risk to the proposed SEE site.
"*The previous calculations and figures may need to be revised as a result of the variation in the proposed lifetime of the development*".	The Initial Flood Risk Assessment noted that the Proposed Development was due to become operational in 2014, with a site presence of 60 years. However, based on the revised indicative construction schedule, the Proposed Development is now due to become operational in 2019, with an operational lifetime of 35 years to 2054. However, within this Document a conservative approach has been taken and a continued site presence to 2074 has been assumed. Therefore, the eventual decommissioning and demolition dates between the Initial Flood Risk Assessment and this Document are in alignment. Therefore, the calculations contained within the Initial Flood Risk Assessment are considered to remain valid.
"*We note that the* [Environmental Scoping Report] *makes it clear that finished floor levels (FFL) of all critical infrastructure will conform to those previously agreed, and we support this recommendation*".	Site levels have been carefully developed to mitigate flood risk and ensure accessibility standards are met. Under both Scenario 1 and Scenario 2, the design flood level for the Proposed Development (taking account of climate change and freeboard) is 6.5 mAOD. The whole site will be regarded to this level, except where the Proposed Development must tie in with the adjacent land along the boundary of the proposed SEE site. In particular, the substation will be raised to approximately 5.3 mAOD to facilitate interconnection with the existing Spalding CCGT generating station substation which is approximately 4.8 mAOD.
"*The FRA should also confirm that the previously agreed mitigation measures are still to be employed*".	Section 3.4 (Mitigation) discusses the proposed mitigation measures. These mitigation measures are the same as those contained within the Initial Flood Risk Assessment which are considered to remain valid.
"*The updated FRA should also discuss surface water management for the site*".	Section 4.3 (Surface Water Run-Off) discusses the surface water management target / proposed surface water drainage strategy.

2 DEVELOPMENT DESCRIPTION / SITE CONTEXT

2.1 SEE (i.e. The Proposed Development)

2.1.1 If the Original Consent is varied as per the Variation Application, SEE will provide up to 945 MW of power generation capacity. SEE will be capable of operating continuously for up to 35 years.

2.1.2 In providing up to 945 MW of power generation capacity, the Proposed Development will either comprise:

- Scenario 1: Up to 945 MW of CCGT units; or,
- Scenario 2: Up to 645 MW of CCGT units and less than 300 MW of Open Cycle Gas Turbine units.

2.1.3 In addition, if the Original Consent is varied as per the Variation Application, the commencement of the deadline for the Consent will be 5 years from the date of granting the variation. Similarly, the commencement deadline for the deemed planning permission will be 5 years from the date of granting the variation.

Revised Indicative Construction Schedule

2.1.4 For both Scenario 1 and Scenario 2, the following comprises the indicative programme for development for SEE:

- Variation Application submitted: Spring 2015.
- Variation Application determined: Autumn / Winter 2015.
- Removal of the Mound: Summer 2016.
- Main construction works commence: Winter 2016.
- Operation commences: Summer 2019.

2.2 The Proposed SEE Site

2.2.1 The proposed SEE site lies approximately 2 km to the north east of Spalding town centre. The Ordnance Survey (OS) Grid Reference of the centre of the SEE site is approximately 525950, 324950. The proposed SEE site occupies a total area of approximately 14 ha, within which approximately 4.3 ha of land in the south of the proposed SEE site has been set aside by SEEL for the purposes of CCR.

2.2.2 Adjacent to the northern boundary of the proposed SEE site is the existing Spalding CCGT generating station site which covers an area of approximately 10 ha.

2.2.3 The location of the proposed SEE site and the existing Spalding CCGT generating station site is shown in Figure 2.1.

2.2.4 During operation, the preferred primary site access will be via the security-controlled Gate A on West March Road. This is also the main access to the existing Spalding CCGT generating station site. In the event that SEE is operated on a stand-alone basis, an alternative is to have a security-controlled Gate C on West Marsh Road.

2.2.5 The northern boundary of the proposed SEE site comprises made ground in the form of a large flat-topped mound (the Mound) up to 4 m above ground level, occupying an area of approximately 2.4 ha. Along the western boundary of the proposed SEE site is an embankment up to 3 m above ground level. Other than the Mound and the embankment, the proposed SEE site is predominately open and grassy in nature at an elevation of approximately 7.5 mAOD. A topographical survey of the proposed SEE site (undertaken by MSURV Ltd on behalf of Stirling Maynard Construction Consultants) is shown in Figure 2.2.

2.3 Factors influencing Selection of the SEE Site

2.3.1 The proposed SEE site, which utilises brownfield land, was selected as the most appropriate site for the Proposed Development. Indeed, the proposed SEE site offers a number of key benefits including:

- The use of existing infrastructure wherever possible;
- The presence of a skilled workforce at the existing Spalding CCGT generating station, with established operational systems, who will be available for training new employees;
- The availability of technical support (if required) from the existing Spalding CCGT generating station;
- The close proximity of the National Grid Gas National Transmission System;
- The close proximity of the National Grid Electricity National Transmission System, and the allowable use of the existing overhead line;
- The availability of sufficient land for the Proposed Development;
- An appropriate visual context with the adjoining land uses;
- The opportunities to link beneficially adjoining land uses;
- Compatibility with planning policy; and,
- The existing strong relationships with key stakeholders and the local community.

2.4 Geological Setting

2.4.1 The geological setting of the proposed SEE site has not changed since the preparation of the March 2009 ES. Therefore, the summary of the geological setting presented in Section 11 of the March 2009 ES is considered accurate. A summary is presented in this sub-Section.

2.4.2 The published solid geology indicates that the proposed SEE site is underlain by the Jurassic Oxford Clay Formation, described as grey silicate mudstone, with sporadic beds of argillaceous limestone nodules.

2.4.3 Furthermore, the published drift geology indicates that the proposed SEE site is underlain by Quaternary Drift deposits of significant thickness. These comprise:

- Terrington Bed sequences; and
- Barroway Drove Bed sequences.

2.4.4 In terms of soils, the Cranfield University National Soilscapes Survey shows the proposed SEE site is located over loamy and clayey soils of coastal flats with naturally high groundwater. This suggests that the soils will be naturally wet.

2.4.5 Ground investigations carried out at both the proposed SEE site and the existing Spalding CCGT generating station site have shown that deposits present are generally consistent with the published data. In addition, these ground investigations indicated that a variable layer of made ground is present above the Quaternary Drift deposits.

2.4.6 The stratigraphy encountered during ground investigations at the proposed SEE site is summarised in Table 2.1.

TABLE 2.1: GENERALISED STRATIGRAPHY AT PROPOSED SEE SITE

Stratum Encountered	*Description*	*Maximum Thickness (m)*
Made Ground	Brown grey black silty clay with roots and vegetation	Variable
Alluvium	Silty fine-medium sand, occasionally with a little to some gravel and a little to some shell fragments	15.7
Glacial Sand and Gravel	As the alluvial sand; however containing fewer shell fragments	7.2
Glacial Till	Brown / grey stiff to very stiff sandy clay with gravel of chalk and limestone	6.2
Oxford Clay	Stiff to very stiff green grey very silty clay with occasional limestone nodule bands	Not proven

Note: Boreholes completed within the proposed SEE site have not been advanced any deeper than the natural alluvial deposits. Within the existing Spalding CCGT generating station site, boreholes have been advanced to greater depths and have encountered the Glacial Till and Oxford Clay deposits. It is reasonable to assume that this stratigraphy is also present at depth within the proposed SEE site.

2.5 Potential Soil Contamination

2.5.1 The land use of the proposed SEE site has not changed since the preparation of the March 2009 ES. Therefore, the assessment of ground conditions presented in Section 11 of the March 2009 ES is considered accurate.

2.5.2 In summary:

- Leachable metals from materials present in The Mound are not considered likely to result in significant harm to the water environment, and therefore are not considered to represent a significant source of contamination.
- Information from the previous ground investigation identified that ground gas continues to be generated in the southern part of the proposed SEE site, despite the relocation of the majority of this made ground to The Mound. Therefore, it is considered likely that some made ground remains in the southern part of the proposed SEE site. Indeed, the previous ground investigation notes the fill material (i.e. made ground) in the southern part of the proposed SEE site should be identified as low flow gas-generating material. In places this is up to 4 m thick. The composition of the low flow ground gas has been demonstrated to be primarily methane and carbon dioxide, with limited concentrations of carbon monoxide. No petroleum hydrocarbon vapour or ammonia generation has been detected. There is no evidence to suggest that there is an alternative source of made ground other than that originating from the settlement lagoons which previously occupied the proposed SEE site. Mitigation identified in the March 2009 ES will be the removal of the gas-generating material.

2.6 Hydrological Setting

2.6.1 The hydrological setting of the proposed SEE site has not changed since the preparation of the March 2009 ES. Therefore, the summary of the hydrological setting presented in Section 12 of the March 2009 ES is considered accurate. A summary is presented in this sub-Section.

2.6.2 There are two surface watercourses in the immediate vicinity of the proposed SEE site. These are:

- Vernatt's Drain: This forms the western boundary of the proposed SEE site. Vernatt's Drain is owned and maintained by the Welland and Deepings Internal Drainage Board, and comprises a high level embanked watercourse conveying water from the Pode Hole Pumping Station at Pode Hole (TF 213 220) to the Vernatt's Outfall Sluice at Surfleet Seas End (TF 282 220), where it discharges into the River Welland

- River Welland: This lies approximately 30 m to the east of the proposed SEE site beyond West Marsh Road. The River Welland is a tidal river and flows in a northerly direction, discharging into the Wash approximately 15 km north west of the proposed SEE site.

2.6.3 During a site visit in October 2014, waterlogged areas were observed between the storage tents located in the north west corner of the proposed SEE site, adjacent to Vernatt's Drain (NGR: 525719, 324607). Insert 2.1 shows these waterlogged areas. These waterlogged areas are likely to be as a result of rainfall run-off. An additional site visit in February 2015 indicated that waterlogging is likely to be persistent in these areas (based on the flora present). However, this information is considered incidental and does not comprise a comprehensive assessment of the site's current drainage.

INSERT 2.1: WATERLOGGED AREAS ADJACENT TO VERNATT'S DRAIN (TAKEN OCTOBER, 2014)



Vernatt's Drain

2.6.4 Insert 2.2 shows a photograph of Vernatt's Drain.

INSERT 2.2: PHOTOGRAPH SHOWING VERNATT'S DRAIN (TAKEN OCTOBER, 2014)



2.6.5 During flood conditions, discharge from the site is restricted and only pumped discharge from the Pode Hole Pumping Station discharges into the Vernatt's Drain. This serves an area of 16,165 ha and has a capacity of 21.18 m^3/s. As this is a pumped discharge, and therefore controlled, the maximum design water levels within the system are not exceeded.

2.6.6 According to correspondence with WDIDB, the maximum design water level within the Vernatt's Drain is 3.83 mAOD at Pode Hole and 3.66 mAOD at Vernatt's Sluice. In the vicinity of the proposed SEE site, the maximum design water level is approximately 3.75 mAOD. The Initial Flood Risk Assessment noted that normal water levels within the system are 1.35 mAOD.

2.6.7 WDIDB byelaws apply to Vernatt's Drain. Therefore, no fences, structures or landscaping may be placed within 9 m of the landward toe of any flood bank and no surface water runoff may be directed to the watercourse itself.

The River Welland

2.6.8 The River Welland is designated as 'main river' and is tidal downstream of the Fulney Lock. The section of the River Welland downstream of the Fulney Lock is referred to here as the Tidal River Welland.

2.6.9 The Coronation Channel was opened in 1953 and diverts excess water around Spalding. Coronation Channel diverts from the River Welland at Little London and flows to the east of Spalding then has its confluence with the River Welland to the south east of the proposed SEE site. The Coronation Channel is tidal downstream of the Marsh Road Sluice.

2.6.10 These tide gates (Fulney Lock and the Marsh Road Sluice) are at least 700 m upstream of the proposed SEE site. Therefore, fluvial flooding is dominant upstream of the Fulney Lock and Marsh Road Sluice, and tidal flooding is dominant downstream.

Surface Water Abstraction

2.6.11 The existing Spalding CCGT generating station holds a surface water abstraction licence for abstraction of water from Vernatt's Drain which was issued by the Environment Agency (Licence Number: 5/31/14/*S/0014). This abstraction licence was previously used by British Sugar for non-evaporative cooling and was subsequently inherited by SECL on purchase of the existing Spalding CCGT generating station site. Whilst this licence is still current, it is not utilised and the existing Spalding CCGT generating station sources all of its operational water requirements from the mains supply.

2.6.12 There are a further 12 surface water abstractions within 2 km of the proposed SEE site which are mainly used for spray irrigation. Two are used for general domestic purposes.

River Basin Management Plan

2.6.13 The proposed SEE site is within the Anglian River Basin District and the Wellend Management Catchment.

2.6.14 Vernatt's Drain has been recognised as a riverine artificial water body (ID: GB105031050700) within the River Basin Management Plan (RBMP). Its current ecological potential is 'good' and it is considered to be 'at risk'. It has not been assessed for chemical quality, and does not currently have targets for chemical status. The hydro-morphological quality was assessed as 'not high'.

2.6.15 The Welland riverine artificial water body (ID: GB105031050680) is approximately 200 m south east of the proposed SSE site. Its current ecological potential is 'moderate', and its current chemical status is 'good'. The hydro-morphological quality was assessed as 'not high'.

2.7 Hydrogeological Setting

2.7.1 The hydrogeological setting of the proposed SEE site has not changed since the preparation of the March 2009 ES. Therefore, the summary of the hydrogeological

setting presented in Section 12 of the March 2009 ES is considered accurate. A summary is presented in this sub-Section.

2.7.2 The Oxford Clay is a dominantly mudstone unit, which is classified as a Non-Aquifer. However, some fissure flow may take place in the weathered zone of the clay and within limestone bands.

2.7.3 The natural Quaternary Drifty deposits underlying the proposed SEE site are classified by the Environment Agency as a Minor Aquifer, with variable flow mechanisms depending on the character of the deposit. It is considered likely that flow within the Alluvium, which comprises mainly silt and clay, would be limited by the low primary permeability of these deposits. However, they would still retain the ability to store and transmit the flow of groundwater, albeit it at a limited rate.

2.7.4 Underlying the alluvial and sand and gravel deposits is Glacial Till, which is also classified as a Minor Aquifer. However, it is considered unlikely to offer significant groundwater movement or storage potential, as a result of the predominantly clay nature of the deposits.

2.7.5 Similar to the Quaternary Drift deposits, the made ground deposits, which comprise a sandy clay with occasional gravel and ash pockets, are considered to have an ability to store groundwater and transmit groundwater.

2.7.6 It is therefore considered likely that a shallow groundwater body exists within the made ground and Quaternary alluvial and sand and gravel deposits. Indeed, the March 2009 ES also noted that during the previous site investigations, groundwater monitoring wells screening the made ground were found to contain shallow groundwater. It is considered likely that this shallow groundwater would drain locally towards Vernatt's Drain.

2.7.7 In addition, previous site investigations have not identified any ground water contamination, and ground conditions on the proposed SEE site do not provide a contamination source.

2.7.8 In addition to the above, the Environment Agency has defined Source Protection Zones (SPZs) for groundwater sources (such as wells, boreholes and springs) used for public drinking water supply. The proposed SEE site is not situated within a defined SPZ. Furthermore, the Environment Agency also has Safeguard Zones to restrict activities which are carried out on sites which may adversely impact on water abstraction quality. The proposed SEE site is not located within a Safeguard Zone.

Groundwater Abstraction

2.7.9 There are no existing groundwater abstraction licences in the vicinity of the proposed SEE site.

2.8 Existing Flood Risk

2.8.1 The flood risk at the proposed SEE site is not considered to have changed since the preparation of the Initial Flood Risk Assessment. A summary is presented in this sub-Section.

Fluvial and Tidal

2.8.2 The Environment Agency Indicative Floodplain Maps identify areas in England and Wales at risk of flooding by allocating them into various flood risk zones. The flood risk zones are defined in Table 1 of Planning Practice Guidance: Flood Risk and Coast Change[2]. These are:

[2] Available at: http://planningguidance.planningportal.gov.uk/blog/guidance/flood-risk-and-coastal-change/

- Zone 1: Low Probability of Flooding

  According to the NPPF, land in this zone is considered to have less than 1 in 1000 annual probability of river or sea flooding in any year (<0.1% probability of flooding in any year).

- Zone 2: Medium Probability of Flooding

  According to the NPPF, land in this zone is considered to have between a 1 in 1000 and 1 in 100 annual probability of river flooding in any year (between 0.1% to 1% probability of flooding in any year) or between a 1 in 1000 and a 1 in 200annual probability of sea flooding in any year (between 0.1% to 0.5% probability of flooding in any year).

- Zone 3a: High Probability of Flooding

  According to the NPPF, land in this zone is considered to have greater than a 1 in 100 annual probability of river flooding in any year (>1% probability of flooding in any year) or greater than a 1 in 200 annual probability of flooding from the sea in any year (>0.5% probability of flooding in any year).

- Zone 3b: The Functional Floodplain

  According to the NPPF, land in this zone is used for water flow or storage in times of flood. This flood zone should be identified by a SFRA. I t is considered to have greater than a 1 in 20 chance of river flooding in any year (>5% probability of flooding in any year). However, other probabilities can also be agreed between the Environment Agency and the relevant local planning authority.

2.8.3 Figure 2.3 presents an indicative flood map for the proposed SEE site and the surrounding area which has been produced from the Environment Agency Indicative Floodplain Maps. This shows that the proposed SEE site lies in Flood Zone 3a, i.e. an area with a high probability of flooding, yet outside the functional floodplain. However, it is important that the Environment Agency Indicative Floodplain Maps do not take into account the effect of flood defences along Vernatt's Drain and the River Welland.

Historic Flooding

2.8.4 The Environment Agency has stated that they do not hold any records of flooding in this area. However, it is possible that flooding may have occurred that the Environment Agency have no records for.

2.8.5 Indeed, the South Holland District SFRA from 2002 provides details of flooding post-1953 (i.e. after the Coronation Channel was opened and after remedial works to the tidal defences was completed following a 1953 tidal flood event). These details note a January 1978 tidal flood event. This involved a breach in The Wash primary sea defence. The tide reached near to the 1 in 200 year level and was accompanied by strong winds and wave action. This caused a breach on the right bank of the entrance channel to Fulney Lock, with the flooding contained north of Holbeach Road, on the opposite bank of the River Welland from the proposed SEE site.

2.8.6 An updated SFRA from 2010 is now available which includes more detailed mapping and analysis for the area. However, both the South Holland District SFRA from 2002 and updated SFRA from 2010 did not reveal any other records of flooding, other than those due to inadequacy of local surface water drainage provisions.

Flooding Mechanisms

2.8.7 The principle risk of flooding to the proposed SEE site is from the River Welland. There is no risk of flooding from Vernatt's Drain. Further assessment of flooding mechanisms is provided in Section 3.

Tidal and Fluvial Flood Risk and Associated Flood Levels

2.8.8 Environment Agency modelled tidal and fluvial flood levels for the River Welland and crest levels of flood defences along the River Welland adjacent to the site were requested for the Initial Flood Risk Assessment.

2.8.9 The modelled extreme tide flood levels were based on a 2006 tidal analysis and were taken from the 2008 Northern Area Tidal Model. The maximum 200 year tide flood level is 5.98 mAOD at the Marsh Road Sluice.

2.8.10 Further to this modelled flood levels, contingency allowances for net sea level rise were applied. In the Initial Flood Risk Assessment, these contingency allowances were applied based on the completion of construction in 2014 and an estimated lifetime presence on site of 60 years. As a result, an additional 559 mm was added to the maximum 200 year tide flood level. The climate change adjusted maximum 200 year tide flood level was 6.54 mAOD at the Marsh Road Sluice.

2.8.11 The modelled fluvial flood levels were based on the 2007 Welland Catchment Model, and the climate change adjusted maximum 100 year fluvial flood level was 4.68 mAOD.

2.8.12 In terms of updated flood levels, whilst hazard maps were requested from the Environment Agency in February 2015, data for the proposed SEE site was not available (see Appendix A). An updated SFRA from 2010 is now available which includes more detailed mapping and analysis for the area. However, it is considered that the Initial Flood Risk Assessment provides a more rigorous and detailed 'site level' assessment than the updated SFRA from 2010 due to the high resolution, the variety of scenarios considered and the timescales that were assumed. Therefore, the Initial Flood Risk Assessment is considered to provide the most accurate and up to date evaluation of flood risk to the proposed SEE site.

2.8.13 In this regard, the Initial Flood Risk Assessment noted that the Proposed Development was due to become operational in 2014, with a site presence of 60 years. However, based on the revised indicative construction schedule, the Proposed Development is now due to become operational in 2019, with an operational lifetime of 35 years to 2054. However, within this Document a conservative approach has been taken and a continued site presence to 2074 has been assumed. Therefore, the eventual decommissioning and demolition dates between the Initial Flood Risk Assessment and this Document are in alignment and the calculations contained within the Initial Flood Risk Assessment are considered to remain valid.

Hydraulic Structures to Mitigate Tidal and Fluvial Flood Risk

Vernatt's Drain

2.8.14 The earth embankments containing Vernatt's Drain provide approximately 600 mm of freeboard to the design water level.

2.8.15 The WDIDB maintains the channel vegetation on an annual basis using weedboats and weedbaskets fitted to hydraulic excavators. Cleansing or de-silting is undertaken as and when necessary, approximately every 10 to 15 years.

2.8.16 Since the improvements of the Vernatt's Drain in the 1960s, minor settlement has occurred along the lengths of embankment. A scheme in the early 2000s restored crest levels and widths to design standards.

River Welland

2.8.17 The tidal defences protecting the proposed SEE site from the Tidal River Welland consist of earth embankments, which are in a good condition. The Environment Agency has stated that the defences provide protection against an event with a 1% probability of flooding in any year. These defences are inspected regularly to ensure that any defects are identified and rectified.

2.8.18 For these tidal defences, the Environment Agency has provided three crest heights adjacent to the proposed SEE site. These are at 6.97 mAOD, 6.99 mAOD and

7.42 mAOD. Based on the climate change adjusted maximum 200 year tide flood level of 6.54 mAOD, these crest heights suggest that the proposed SEE site is protected with a freeboard of at least 0.43 m.

2.8.19 Additional tidal defences are provided by the Fulney Lock and Marsh Road Sluice. These gates close as the tide rises to prevent floodwater ingress, but open during low tide periods to facilitate fluvial discharge from rivers and drains. All tidal gates of relevance were assessed in the updated SFRA from 2010 as being secure against a climate change adjusted maximum 200 year tide flood level up to 2055.

2.8.20 The fluvial defences upstream of the tidal defences are provided by earth embankments. These have crest levels which vary between 5.3 mAOD and 6.79 mAOD. Based on the climate change adjusted maximum 100 year fluvial flood level of 4.68 mAOD, these crest levels suggest that the proposed SEE site is protected with a freeboard of at least 0.62 m.

Surface Water and Sewer Drainage Risk

2.8.21 High risk of surface water flooding is typically experienced by sites which are low lying, poorly infiltrating and have shallow gradients.

2.8.22 The Environment Agency Surface Water Flood map identifies that the majority of the proposed SEE site is at very low risk of surface water flooding. However, small and localised areas may be at high risk of surface water flooding. Indeed, during site visits, waterlogged areas were observed between the storage tents located in the north west corner of the proposed SEE site.

2.8.23 On this basis, the risk of surface water flooding at the proposed SEE site is considered medium.

3 ASSESSMENT OF FLOOD RISK TO PROPOSED DEVELOPMENT

3.1 Flood Risk Vulnerability

3.1.1 The NPPF seeks to direct development into areas at low risk of flooding. Different classes of development are considered by the NPPF to have varying levels of flood risk vulnerability. Depending on their flood risk vulnerability classification, an assessment can then be made as to which class of development may or may not be appropriate in different flood risk zones.

3.1.2 Flood risk vulnerabilities are defined in Table 2 of Planning Practice Guidance: Flood Risk and Coast Change[3]. From Table 2, the Proposed Development is classed as 'Essential Infrastructure' which includes "*essential utility infrastructure which has to be located in a flood risk area for operational reasons, including electricity generating power stations and grid and primary substations".*

Sequential Test

3.1.3 The Sequential Test is a simple logical test applied to all proposed developments to decide whether they are situated in a sufficiently low risk location, based on the land use proposed and the flood risk zone.

3.1.4 The proposed SSE site is within Flood Zone 3a. Flood risk vulnerability and flood zone compatibility are defined in Table 3 of Planning Practice Guidance: Flood Risk and Coast Change[4]. Table 3 indicates that 'Essential Infrastructure' developments require the Exception Test to be applied, and that infrastructure must be designed and constructed to remain operational and safe in times of flood.

3.1.5 Therefore, the Sequential Test is passed for the Proposed Development provided the Exception Test can be satisfied.

Exception Test

3.1.6 The Exception Test is a method to demonstrate and help ensure that flood risk to people and property will be managed satisfactorily.

Demonstrate the Wider Sustainability Benefits

3.1.7 The first part of the Exception Test is a requirement to "*demonstrate that the wider sustainability benefits to the community outweigh the flood risk*".

3.1.8 The rationale for the development of SEE is provided in full in Section 2 (Rationale for Development) of the Variation Application ES FID.

3.1.9 In summary, current national policy for energy infrastructure (including the construction / extension of a generating station with a generating capacity of more than 50 MW) is provided in the Overarching National Policy Statement (NPS) for Energy (EN-1) (NPS EN-1), and the technology-specific NPSs. In particular, NPS EN-1 states (at paragraph 2.1.2) that: "*Energy is vital to economic prosperity and social well-being and so it is important to ensure that the UK has secure and affordable energy. Producing the energy the UK requires and getting it to where it is needed necessitates a significant amount of infrastructure, both large and small scale*".

3.1.10 Furthermore, NPS EN-1 states (at paragraphs 3.1.1 to 3.1.4) that:

"*The UK needs all the types of energy infrastructure covered by this NPS in order to achieve energy security at the same time as dramatically reducing greenhouse gas emissions.*

[3] Available at: http://planningguidance.planningportal.gov.uk/blog/guidance/flood-risk-and-coastal-change/
[4] Available at: http://planningguidance.planningportal.gov.uk/blog/guidance/flood-risk-and-coastal-change/

It is for industry to propose new energy infrastructure projects within the strategic framework set by Government. The Government does not consider it appropriate for planning policy to set targets for or limits on different technologies.

The [relevant authority] *should therefore assess all applications for* […] *consent for the types of infrastructure covered by the energy NPSs on the basis that the Government has demonstrated that there is a need for those types of infrastructure and that the scale and urgency of that need is as described for each of them in this Part.*

The [relevant authority] *should give substantial weight to the contribution which projects would make towards satisfying this need when considering applications for* […] *consent*".

3.1.11 Furthermore, the letter accompanying the Original Consent stated the Secretary of State's view that: "*gas fired-power stations play a vital role in providing reliable electricity supplies; they can be operated flexibly in response to changes in supply and demand, and provide diversity in our energy mix. They will continue to play an important role in the energy mix as the UK makes the transition to a low carbon economy, and they must be constructed in line with climate change goals*".

3.1.12 Therefore, it is clear that fossil-fuelled power plants will play a key role in providing reliable and flexible capacity to provide back-up and maintain the safety margin[5]. The development of SEE is therefore an appropriate candidate to contribute to the need for new energy infrastructure.

3.1.13 In addition, the need for the proposed SEE has been confirmed through the award of the Original Consent.

3.1.14 Therefore it is considered that the first part of the Exception Test is satisfied.

Demonstrate the Proposed Development will be Safe

3.1.15 The second part of the Exception Test is a requirement to "*demonstrate that the development will be safe*".

3.1.16 As part of the preparation of the Initial Flood Risk Assessment, the Environment Agency were consulted on the appropriateness of the proposed mitigation measures and commitments.

3.1.17 As part of these mitigation measures and commitments, finished floor levels of all critical infrastructure were agreed. Within this Document, the finished floor levels of all critical infrastructure will conform to those previously agreed. The Environment Agency has stated that it supports this approach[6].

3.1.18 Furthermore, other mitigation measures and commitments in relation to flood risk will conform to those previously agreed. These are discussed further in this Section.

3.1.19 Therefore it is considered that the second part of the Exception Test is satisfied.

3.2 Flooding Mechanisms and Modelled Flood Scenarios

Flooding Mechanisms

3.2.1 The principle risk of flooding to the proposed SEE site is from the River Welland. There is no risk of flooding from Vernatt's Drain as, during flood conditions, discharge to Vernatt's Drain is restricted. As noted previously, this is a pumped discharge, and is therefore controlled. As such, the maximum design water levels within the system are not exceeded.

[5] The safety margin is an amount of spare capacity which is able to accommodate unexpectedly high demand and mitigate risks (such as unexpected power plant closures or extreme weather events). The larger the difference between available electricity generating capacity and electricity demand (i.e. the larger the safety margin), the more resilient the system will be.

[6] Environment Agency response to the Environmental Scoping Report. Ref: AN/2015/120938/01-L01

3.2.2 In terms of flooding from the Tidal River Welland, it was previously noted that the climate change adjusted maximum 200 year tide flood level was 6.54 mAOD at the Marsh Road Sluice. The tidal defences protecting the proposed SEE site from the Tidal River Welland consist of earth embankments, which are in a good condition. Based on the crest heights for these tidal defences (6.97 mAOD, 6.99 mAOD and 7.42 mAOD), this suggests that, for the climate change adjusted maximum 200 year tide flood, the proposed SEE site is protected with a freeboard of at least 0.43 m.

3.2.3 In terms of flooding from the fluvial River Welland, it was previously noted that the climate change adjusted maximum 100 year fluvial flood level as 4.68 mAOD. The fluvial flood defences protecting the proposed SEE site also consist of earth embankments. Based on the crest heights for these fluvial defences (between 5.3 mAOD and 6.79 mAOD), this suggests that, for the climate change adjusted maximum 100 year fluvial flood, the proposed SEE site is protected with a freeboard of at least 0.62 m.

3.2.4 Therefore, potential flooding of the proposed SEE site has been determined to only occur if there is a breach of the defences. Due to the location of the proposed SEE site, and the differences in freeboard, a breach of the tidal defences is considered to represent the 'worst case'.

3.2.5 Tidal flooding due to an excess of the climate change adjusted maximum 200 year tide flood level / fluvial flooding due to an excess of the climate change adjusted maximum 100 year fluvial flood level is considered to be extremely unlikely and is therefore not considered further.

Modelled Flood Scenarios

3.2.6 The Initial Flood Risk Assessment modelled three flood scenarios. These are described in Table 3.1

TABLE 3.1: MODELLED FLOOD SCENARIOS

Scenario	***Description***
Scenario A	Uses existing site levels (i.e. current site levels, see paragraph 2.2.5). The breach of the tidal defences occurs adjacent to the proposed SEE site.
Scenario B	Uses proposed future site levels (i.e. design flood level for the Proposed Development (taking account of climate change and freeboard), see paragraph 3.4.1). The breach of the tidal defences occurs adjacent to the proposed SEE site.
Scenario C	Uses proposed future site levels (i.e. design flood level for the Proposed Development (taking account of climate change and freeboard), see paragraph 3.4.1). The breach of the tidal defences occurs to the south east of the proposed SEE site.

3.2.7 The modelled breach location are shown in Figure 3.1 A summary of the hydraulic modelling undertaken for the Initial Flood Risk Assessment is provided in Appendix B.

Results for Scenario A

3.2.8 The results of the hydraulic modelling are shown in Figure 3.2. Under Scenario A, the existing Spalding CCGT generating station site and substation would be flooded but the proposed SEE site is largely unaffected. The only area flooded in this event is the area covered by the former British Sugar Sports and Social Club (BSSSC), including the associated bowling green.

3.2.9 This extent is less than, but comparable to, the hazard maps contained within the updated SFRA from 2010. These hazard maps for 2115 show, for a 1% probability of fluvial flooding / 0.5% probability of tidal flooding, that the existing Spalding CCGT generating station site and substation would be flooded but that the majority of the

proposed SEE site is unaffected. The only area flooded in this event is the area covered by the former BSSSC bowling green and a ditch to the south.

Results for Scenario B

3.2.10 The results of the hydraulic modelling are shown in Figure 3.3. Under Scenario B, the existing Spalding CCGT generating station site and substation would be flooded. Except for the area covered by the proposed substation, the proposed SEE site is unaffected. During the breach, flooding adjacent to the site begins immediately.

Results for Scenario C

3.2.11 The results of the hydraulic modelling are shown in Figure 3.4. Under Scenario C, both the existing Spalding CCGT generating station site and the proposed SEE site are largely unaffected.

3.3 Flood Hazards for the Modelled Flood Scenarios

3.3.1 The damage to assets and danger to people as a result of a flood event is assessed via a measure of flood hazard. Flood hazard is calculated a combination of flood depth and velocity. According the danger to people is categorised via the following flood hazard classifications:

- Danger for None – intrinsically safe for all;
- Danger for Some – includes children / elderly or infirm adults;
- Danger for Most – includes the general public; and,
- Danger for All – includes emergency services.

3.3.2 In terms of the above, no children / elderly or infirm adults will be permitted on-site during normal operation. The site will be operated by trained members of staff. Visitors at any time would be infrequent and accompanied by trained members of staff.

Flood Hazards Mapped for Scenario B

3.3.3 Table 3.2 shows the progression of flood hazards for Scenario B along West Marsh Road. Corresponding results are shown in Figure 3.5.

TABLE 3.2: PROGRESSION OF FLOOD HAZARDS FOR SCENARIO B

Time after Breach (minutes)	*Along West Marsh Road*		
	Depth (m)	*Velocity (m/s)*	*Flood Hazard*
0	0.40	1.43	Danger for Most
15	0.71	1.53	Danger for All
30	0.88	2.03	Danger for All
45	0.95	2.21	Danger for All
60	0.88	1.91	Danger for All

3.3.4 The breach simulation ended approximately 7 hrs 15 mins after the breach event. At the end of the breach simulation the flood water will remain a 'Danger for All' along West Marsh Road.

Flood Hazards Mapped for Scenario C

3.3.5 Table 3.3 shows the progression of flood hazards for Scenario C along West Marsh Road. Corresponding results are shown in Figure 3.6.

TABLE 3.3: PROGRESSION OF FLOOD HAZARDS FOR SCENARIO C

Time after Breach (minutes)	*Along West Marsh Road*		
	Depth (m)	*Velocity (m/s)*	*Flood Hazard*
0	-	-	Danger for None
15	0.70	1.37	Danger for Most
30	0.92	2.30	Danger for All
45	0.98	2.80	Danger for All
60	0.94	2.70	Danger for All

3.3.6 The breach simulation ended approximately 7 hrs 15 mins after the breach event. At the end of the breach simulation the flood water will be a 'Danger for None' along West Marsh Road.

3.4 Mitigation

Floor / Site Levels

3.4.1 Site levels have been carefully developed to mitigate flood risk and ensure accessibility standards are met. Under both Scenario 1 and Scenario 2, the design flood level for the Proposed Development (taking account of climate change and freeboard) is 6.5 mAOD.

3.4.2 The whole site will be regarded to this level, except where the Proposed Development must tie in with the adjacent land along the boundary of the proposed SEE site. In particular, the substation will be raised to approximately 5.3 mAOD to facilitate interconnection with the existing Spalding CCGT generating station substation which is approximately 4.8 mAOD.

3.4.3 A cross sectional diagram of the proposed site levels is shown in Figure 3.7.

Refuge Points

3.4.4 As the proposed SEE site itself will not be impacted by flooding (based on Scenario B and Scenario C), during a flood event the proposed SEE will be entirely safe for people to remain in situ until the flood waters recede when the tide falls.

However, due to the residual risk of an extremely unlikely event occurring, internal muster points are recommended to be located within the main area of the proposed SEE at an elevation above 6.5 mAOD.

Access and Egress

Evacuation Routes

3.4.5 As noted previously, during operation, the preferred primary site access will be via the security-controlled Gate A on West March Road. This is also the main access to the existing Spalding CCGT generating station site. An alternative access will be a security-controlled Gate C on West Marsh Road.

3.4.6 Under Scenario B, the preferred access (Gate A) is flooded, and safe access and egress cannot be ensured. However, the alternative access (Gate C) remains free from flooding. Safe access and egress can therefore be maintained via this route.

3.4.7 Under Scenario C, the preferred access (Gate A) remains free from flooding. Safe access and egress can therefore be maintained via this route.

3.4.8 Safe access and egress can therefore be maintained onto West Marsh Road. Depending on whether a breach occurs adjacent to the site or to the south of the site, access / egress should take place along a safe, dry route to the north or south along West Marsh Road accordingly. Access / egress routes are shown in Figure 3.7.

Evacuation Actions

3.4.9 In the event that a full or partial evacuation of the site is required, specific actions to be taken are as follows:

- Records of all staff, contractors and visitors present on-site at the time will be obtained;
- An assessment of those who can and those who should or should not evacuate the site will be made (the assessment will consider the ability of the individuals to make a safe evacuation. If assistance is required, this will be provided by duly appointed individuals);
- Records of those who will be evacuating the site will be made and contact details for each person will be logged (e.g. mobile phone numbers);
- Each person evacuating the site will be made aware of the proposed evacuation route and procedures to be undertaken in the event that the evacuation route becomes unusable, taking into consideration the issues identified above;
- Each person leaving the site will take a note of the site's contact details and call to inform any staff, contractors and visitors remaining on-site of any relevant information with respect to the evacuation route (e.g. hazards, blocked roads, traffic congestion); and,
- If the evacuation is taking place within hours of darkness, portable lighting equipment will be provided to those being evacuated where possible.

4 ASSESSMENT OF THE IMPACT OF THE PROPOSED DEVELOPMENT

4.1 Obstruction to Flood Flows

4.1.1 Figures 3.2 and 3.3 show the flood extent for the same breach event for both the existing and proposed future site levels within the SEE site.

4.1.2 Although the flood extent and depth within the proposed substation changes as a result of the proposed SEE, no significant changes are observed in other areas, including the existing Spalding CCGT generating station site and the land between West Marsh Road and the River Welland.

4.1.3 Therefore, the Proposed Development does not obstruct flood flows in the event of the breach.

4.2 Fluvial Geomorphology

4.2.1 The proposed SEE may discharge surface water runoff into the River Welland. This would be undertaken under a 'Consent to Discharge' from the Environment Agency and would be carried out in a controlled manner. Other than this the proposed SEE will not require any direct works to watercourses.

4.2.2 Therefore, the Proposed Development will not have an impact on fluvial geomorphology or an impact on the likely longer-term stability and sustainability of any watercourses.

4.3 Surface Water Run-off

4.3.1 As far as is practicable, surface water flows arising from a developed site should be managed to mimic the surface water flows representative of the pre-developed site and, where appropriate, reduce the flood risk to downstream receptors.

4.3.2 In this regard, the Environment Agency has advised that the surface water runoff rates post-development must not be greater than the existing surface water runoff rates.

Calculation of Surface Water Run-Off

4.3.3 Within the Initial Flood Risk Assessment, overall surface water run-off rates were calculated using the Modified Rational Method as described by the Wallingford Procedure[7]. Supporting information was provided by the Flood Estimation Handbook (FEH) modelling software which was used to generate statistical data on rainfall events for any specified return period.

4.3.4 Therefore, in the calculation of surface water run-off:

- The FEH modelling was used to establish rainfall depths for a range of return periods;
- The FEH was used to determine catchment descriptors (e.g. annual average rainfall);
- The Wallingford Procedure was used to determine values for soil index (SOIL) and urban catchment wetness index (UCWI)[8];
- The Modified Rational Method was used to calculate storm run-off volumes for each return period. In calculating storm run-off volumes:
    - The percentage existing impermeable hard standing area was estimated to be 21 per cent which, using the Wallingford Procedure, equates to a percentage run-off value of 7.8; and,

[7] 'Design and Analysis of Urban Storm Drainage: The Wallingford Procedure'. Volume 1 - Principles, Methods and Practice. National Water Council Standing Technical Committee Report 28. Department of the Environment, 1981.
[8] For the proposed SEE site, a SOIL value of 0.3 and a UCWI value of 49.5 were used.

- The percentage proposed impermeable hard standing area was conservatively estimated to be 70 per cent which, using the Wallingford Procedure, equates to a percentage run-off value of 48.4.

- Peak discharges for a 30 minute storm were determined from storm volumes using the standard hydrograph approach. The critical storm duration was determined to be lower than 30 minutes but the FEH modelling should not be used for durations lower than 30 minutes.

4.3.5 This approach was considered appropriate by the Environment Agency for catchment specific data.

Climate Change

4.3.6 In addition, surface water drainage measures need to account for predicted increases in surface water runoff as a result of the effects of climate change. Therefore, peak rainfall rates for the proposed SEE were increased by 20 per cent.

Calculation of Existing and Proposed Future Surface Water Run-Off Rates

Existing Surface Water Run-Off Rates

4.3.7 It is assumed that there is no management of existing surface water runoff for the proposed SEE site. Therefore, surface water run-off from the existing impermeable hard standing areas discharge onto the surrounding grass areas where infiltration occurs. The extent of existing impermeable hard standing area is considered to be 21 per cent. Using the above calculation methodology, Table 4.1 presents the existing surface water run-off rates.

TABLE 4.1: EXISTING SURFACE WATER RUN-OFF RATES

Return Period Modified	*Rational Method Calculations (years)*		
	30 Minute Rainfall (mm)	*Storm Volume (m^3)*	*Peak Flow (l/s)*
2	10.7	79.7	44.3
5	15.4	114.7	63.8
10	19.6	146.0	81.2
30	28.1	209.3	116.4
50	33.2	247.3	137.5
100	41.5	309.1	171.9

Proposed Future Surface Water Run-Off Rates

4.3.8 The extent of the proposed impermeable hard standing area is conservatively considered to be 70 per cent. Using the above calculation methodology, Table 4.2 presents the proposed future surface water run-off rates.

TABLE 4.2: PROPOSED FUTURE SURFACE WATER RUN-OFF RATES

Return Period Modified	*Rational Method Calculations (years)*		
	30 Minute Rainfall (mm)	*Storm Volume (m^3)*	*Peak Flow (l/s)*
2	10.7	496.5	276.1
5	15.4	714.6	397.3
10	19.6	909.5	505.7
30	28.1	1304.6	725.0
50	33.2	1925.8	856.6
100	41.5	2311.0	1070.7
100 (+20 per cent)	49.8	2311.0	1284.8

Surface Water Drainage Management Target

4.3.9 Based on the use of Table 4.2, the future (post-development) surface water drainage management target is an estimated 'worst case' climate change corrected peak flow of 1,284.8 l/s during storm with a 100-year return period and with a 30 minute duration. This is equivalent to a climate change corrected storm volume of 2,311 m^3.

4.3.10 Whilst the River Welland is tidal in this area (and therefore surface water runoff can be discharged into the river at greater rates than would be accepted into a fluvial river), it has been assumed that some attenuation of surface water run-off will be required on the proposed SEE site in order to offer hydrological and water quality treatment benefits. In addition, given the potential for aspects of the proposed SEE to generate ground contaminants, it would be advisable that all surface water runoff generated by the proposed SEE is attenuated and treated on site before discharge into the Tidal River Welland.

4.3.11 Therefore, for the 'worst case' climate change corrected storm with a 100-year return period, approximately 2,311 m^3 of attenuation must be provided on the proposed SEE site.

Sustainable Drainage Systems (SUDS)

4.3.12 To reduce meet the surface water drainage management target, a range of Sustainable Drainage System (SUDS) techniques can be utilised. SUDS techniques can be adopted to reduce peak flows and storm volumes and also to improve water quality. For the Proposed Development, any proposed SUDS technique(s) would need to be contained within the proposed SEE site as there is insufficient space within the existing Spalding CCGT generating station site for additional SUDS techniques.

4.3.13 Most often, SUDS are physical structures and fall into three broad groups:

- Source Control Techniques

  Source control techniques are concerned with capturing surface water at or near the point where the rain falls, and aim to reduce the quantity of surface water runoff at source. These techniques work best when dealing with small quantities of water and are most effective when distributed throughout a catchment.

  Source control techniques include: green roofs; infiltration areas; infiltration basins / swales; infiltration trenches; and, permeable or impermeable paved areas.

- Permeable Conveyance Techniques (Site Control)

  These techniques provide attenuation or treatment for a group of buildings, moving surface water run-off towards a receiving watercourse but allowing for storage / filtering / some loss (e.g. through evaporation and infiltration) before the discharge point.

  Site control techniques include: filter drains; and, non-infiltration swales.

- Passive Treatment Techniques (Regional Control):

  These are end-of-pipe techniques which usually involve the storage of water in constructed ponds / detention basins / wetlands where natural purification processes can be encouraged and a large degree of attenuation can be achieved before discharge into a storm sewer or watercourse. Such measures may also have the additional advantage of providing wildlife or landscape benefits.

  Regional control techniques include: balancing ponds.

4.3.14 The use of SUDS techniques provide a significant contribution towards more sustainable development as they:

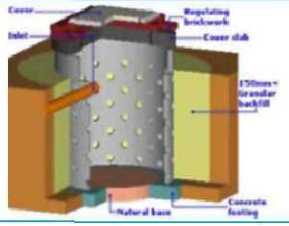
- Address environmental impacts at source, rather than downstream;
- Attenuate surface run-off, reducing the impact of development on flooding;

- Protect and / or enhance water quality;
- Can be engineered to be sympathetic to the environmental setting and the needs of the local community;
- Provide opportunities for ecological habitat creation; and,
- Can encourage natural groundwater recharge.

Feasibility of SUDS Techniques within the Proposed Development

4.3.15 Table 4.3 provides an overview of the feasibility of a range of SUDS techniques in order to identify which may be suitable for the proposed SEE site. Further details are then given regarding the feasible techniques.

TABLE 4.3: MATRIX EXAMINING THE FEASIBILTIY OF SUDS TECHNIQUES

Technique	*Image*	*Physical Constraints*	*Feasibility*
Green Roofs		Requires flat or minimal slope roofs. Limited value for run-off attenuation in comparison with other techniques. Requires specialist maintenance.	**Feasible** Green roofs may be feasible in certain areas. Green roofs only offer limited attenuation benefit and, therefore, other SUDS techniques will be required.
Shallow Landscaped Infiltration Areas		Primarily used to remove pollutants from run-off. Due to their shallow nature are not as effective at run-off attenuation as other SUDS techniques.	**Not Feasible** There is insufficient space for these features within the proposed SEE site.
Infiltration Basins / Swales		Are widely applicable for attenuation and treatment of surface run-off by infiltration into the ground. Require slope of no more than 4 to 10% and can act as a substitute for soakaways where groundwater is shallow.	**Not Feasible** Direct infiltration will be avoided on operational aspects of the site in order to mitigate against creating potential ground contamination pathways.
Infiltration Trenches		Require infiltration rates of 1 x 10^{-6} m/s or greater. Shallow soakaways or infiltration trenches would be required where groundwater is shallow (i.e. less than 2.0 mbgl).	**Not Feasible** Direct infiltration will be avoided on operational aspects of the site in order to mitigate against creating potential ground contamination pathways.

Technique	*Image*	*Physical Constraints*	*Feasibility*
Underground Storage beneath Permeable or Impermeable Paved Areas		Ideally requires a level site and favourable underlying ground conditions. Function by either allowing rainfall to pass between paving blocks into a sub-base or by transferring runoff from other areas into the sub-base. The sub-base is used for temporary storage before infiltration where ground conditions allow or before discharge to sewers at a reduced rate. Engineered sub-base to a car park or paved area can take many forms e.g. porous block paving or conventional drainage connected to impermeable membrane liner; geotextiles; crushed stone.	**Feasible** Permeable paving could be applied to some areas of the site. Roof runoff from other areas of the site could also be transferred into the underground storage. Direct infiltration will be avoided on operational aspects of the site in order to mitigate against potential ground contamination. The porous sub-base would therefore need to be lined to prevent infiltration. This technique could offer storage of surface water runoff in some areas of the site and offer the first stage of treatment
Filter Drains		These are normally used adjacent to areas of car parking or roads and convey run-off via flow through an engineered substrate.	**Feasible** These could be applied in some areas of the proposed SEE site. Although infiltration is to be avoided, filter drains could be used as conveyance of surface water towards the River Welland whilst offering some water quality treatment.
Non-Infiltration Swales		Used in the same concept as carrier ditches or storage bunds.	**Feasible** There may be sufficient space for use of these features within some areas of the proposed SEE site. Swales would offer conveyance of surface water towards the River Welland whilst offering some water quality treatment.
Balancing Ponds (Retention or Detention Ponds)		These are permanent ponds that provide storage above the resting water level in the pond. Are appropriate for most sites but require suitable space. Require impermeable soils, or can be lined.	**Feasible** There may be sufficient space for these features within some areas of the proposed SEE site. Whilst there may not be sufficient space for a Balancing Pond to be designed to hold the whole volume of surface water runoff generated on site, a Balancing Pond in combination with other SUDS techniques would offer significant water quality treatment.

4.3.16 Therefore, based on the use of Table4.3, the SUDS techniques which could feasibly be included in the proposed SEE include:

- Green roofs;
- Permeable paving;
- Filter drains;
- Non-infiltration swales; and,
- Balancing pond(s).

Permeable Paving (Source Control)

4.3.17 It may be feasible to construct some areas of hard standing using permeable paving techniques with a porous sub-base.

4.3.18 Permeable paving is now becoming common-place in the UK. The sub-base normally comprises granular material of specific size grading. The depth of construction is designed to provide structural support as well as provide surface water storage. The granular fill is normally around 350 mm deep, although depths can be designed to be greater or less than this value.

4.3.19 Water quality treatment from permeable pavements is normally very good with minimal sediment load and low pollutant concentrations, especially if a geotextile is used below the bedding layer for the blocks. Water quality treatment is not significant for plastic, high voids units.

4.3.20 Permeable paving techniques have good hydraulic properties with high levels of attenuation when granular fill is used. Runoff volume reduction is very high for small events in dry periods though not particularly good for large events and in very wet periods.

4.3.21 The design for permeable paving should specifically cater for future maintenance requirements. In addition, there is some concern over their design lives and therefore designs should take a precautionary approach to maximised performance and ease of maintenance.

4.3.22 As, at the proposed SEE site, surface water should not be allow to infiltrate the ground, the porous substrate beneath the hard standing areas will be lined to prevent downward migration of contaminants. The proposed permeable paved areas will offer attenuation of surface water before discharge to the next stage within the drainage strategy.

Filter Drains (Source Control)

4.3.23 It may also be possible to include filter drains within the proposed SEE site's drainage strategy.

4.3.24 These are below ground SUDS techniques which are essentially a perforated or porous pipe in a trench surrounded with a suitable filter material or lightweight aggregate fill (e.g. gravel). The fill may be exposed at ground surface or could be covered with turf, topsoil or suitable capping. All filter drains should contain a sediment sump at the inlet.

4.3.25 Filter drains allow some treatment of water and attenuation as well as conveyance before discharge into a suitable discharge outlet. As filter drains are below ground features which can be capped, they are often applied in areas where there are pressures on land availability.

Non-Infiltration Swales (Site Control)

4.3.26 It may be feasible to offer non-infiltration swales to attenuate surface water runoff from some areas of the proposed SEE site. These swales will offer some treatment of water and attenuation before discharge to the next stage of the surface water drainage strategy.

4.3.27 The term 'swale' covers a range of different drainage designs, though they all have in common the dual feature of storage and conveyance. Furthermore, swales can vary in size and include:

- Large conveyance swales which are shallow vegetated channels of around 400 mm deep and, up to 5 m wide at ground level and 1 m wide at the base; and,
- Smaller swales which are around 100 mm deep and are around 1 m wide.

4.3.28 The hydraulic performance of swales is good for smaller events. The importance of swales in improving water quality and addressing volumes of runoff for small events makes these components very desirable in terms of protecting the receiving environment.

Balancing Pond (Regional Control)

4.3.29 The proposed SEE will include a balancing pond or ponds which will offer water quality treatment and attenuation before discharge into the Tidal River Welland.

4.3.30 There are two categories of balancing pond. These are referred to as detention ponds and retention ponds, with the difference being the duration that surface water runoff is retained. In summary:

- A detention pond is a wet pond where runoff is retained for some days to allow settlement and biological treatment of some pollutants, as well as providing attenuation of storm water flows; and,
- Retention ponds has a permanent pool depth and are provided where a higher level of water quality treatment provision is needed and where there is a perceived enhanced risk of accidental spillage of pollutants in the catchment.

4.3.31 Balancing ponds provide very little volume reduction, but some losses will occur through evaporation. Their main benefit is their facility for limiting discharge flow rates.

4.3.32 In addition, the water quality treatment efficiency of balancing ponds is high assuming they are well designed to prevent short-circuiting. Long narrow ponds or ponds in a series provide better water quality, more wildlife diversity and higher levels of attenuation than a single pond of the same volume.

4.3.33 However, the land take of balancing ponds is significant and they can require large areas of open space, sometimes up to 5 per cent of a site's area.

Proposed Surface Water Drainage Strategy

4.3.34 In order to attenuate the surface water runoff generated from the proposed SEE site during the 'worst case' climate change corrected storm, approximately 2,311 m^3 of attenuation will need to be provided.

4.3.35 This attenuation will be provided by the use of a balancing pond(s) supplemented by the use of additional SUDS techniques including: permeable paving with a porous sub-base; filter drains; and, non-infiltration swales. In utilising this approach, the balancing pond(s) will not need to be sized for the full required 2,311 m^3 of attenuation.

4.3.36 It is likely that any water which exceeds the estimated attenuation volume, either as a result of failure or as a result of an extreme event, will be contained in surface water ponding within the site boundary.

4.3.37 The final determination of the attenuation volume offered by the balancing pond(s) and the additional SUDS techniques will be made as part of the detailed drainage design. This will be undertaken post-application, and will be submitted to and agreed with the Environment Agency and South Holland District Council.

4.3.38 Furthermore, the final location of the balancing pond(s) / additional SUDS techniques will also be determined as part of the detailed drainage design. However, at this time it is considered likely that:

- The balancing pond(s) will be located within either the green or the blue area shown in Figure 4.1;
- Filter drains and swales may also be located within the green area shown in Figure 4.1 to accept surface water runoff from the main built elements of the proposed SEE; and,
- Filter drains and permeable paving techniques could be used within the yellow are shown in Figure 4.1 as part of the construction of hard standing areas. This is subject to the final structural design and will be explored as part of the detailed drainage design.

4.3.39 The net effect of these proposed SUDS techniques would be to ensure that surface water runoff from the proposed SEE site would be stored on site for the 'worst case' climate change corrected storm. Therefore, no increase in flood risk would occur to the proposed SEE site, existing Spalding CCGT generating station site or to downstream areas as a consequence of the development.

4.3.40 Through the implementation of this strategy, the proposed surface water drainage system will offer betterment as it will manage the surface water run-off in a controlled manner.

5 CONCLUSIONS AND RECOMMENDATIONS

5.1.1 SEEL is submitting an application to the Secretary of State for the Original Consent to be varied (the Variation Application). If the Original Consent is varied as per the Variation Application, SEE will provide up to 945 MW of power generation capacity. In providing up to 945 MW of power generation capacity, the Proposed Development will either comprise:

- Scenario 1: Up to 945 MW of CCGT units; or,
- Scenario 2: Up to 645 MW of CCGT units and less than 300 MW of Open Cycle Gas Turbine (OCGT) units.

5.1.2 In addition, if the Original Consent is varied as per the Variation Application, the commencement of the deadline for the Consent will be 5 years from the date of granting the variation. Similarly, the commencement deadline for the deemed planning permission will be 5 years from the date of granting the variation.

5.1.3 To accompany the Variation Application, SEEL is providing the following information to DECC:

- An ES FID (the Variation Application ES FID), which includes (amongst other items):
  - The rationale for proposing that the Original Consent is varied;
  - An assessment of whether the likely significant effects on the environment of the Proposed Development differ from those described in the March 2009 ES; and,
    - Where there is potential for the likely significant effects to differ, an updated impact assessment;
    - Where there is no potential for the likely significant effects to differ, an explanation and / or supporting information.
- A Revised CCR Feasibility Study;
- A Revised CHP Assessment; and,
- A Supplementary Flood Risk Assessment.

5.1.4 This Document is the Supplementary Flood Risk Assessment which accompanies the Variation Application. This Supplementary Flood Risk Assessment has shown:

- The Proposed Development passes both the Sequential Test and the Exception Test.
- The principle risk of flooding to the proposed SEE site is from the River Welland. There is no risk of flooding from Vernatt's Drain as, during flood conditions, discharge to Vernatt's Drain is restricted.
- In terms of the Tidal River Welland:
  - The climate change adjusted maximum 200 year tide flood level is 6.54 mAOD at the Marsh Road Sluice.
  - At this location, the tidal defences protecting the proposed SEE site from the Tidal River Welland consist of earth banks which are in a good condition. Furthermore, the Environment Agency has provided crest heights for these tidal defences (6.97 mAOD, 6.99 mAOD and 7.42 mAOD) which suggests that, for the climate change adjusted maximum 200 year tide flood, the proposed SEE site is protected with a freeboard of at least 0.43 m.
  - Additional tidal defences are provided by the Fulney Lock and Marsh Road Sluice. These gates close as the tide rises to prevent floodwater ingress, but open during low tide periods to facilitate fluvial discharge from rivers and drains. All tidal gates of relevance were assessed in the updated SFRA from

2010 as being secure against a climate change adjusted maximum 200 year tide flood level up to 2055.

- In terms of the fluvial River Welland:
  - The modelled fluvial flood levels were based on the 2007 Welland Catchment Model, and the climate change adjusted maximum 100 year fluvial flood level was 4.68 mAOD.
  - At this location, the fluvial defences are provided by earth embankments. The Environment Agency has provided crest heights for these fluvial defences (between 5.3 mAOD and 6.79 mAOD) which suggests that, for the climate change adjusted maximum 100 year fluvial flood, the proposed SEE site is protected with a freeboard of at least 0.62 m.
- Potential flooding of the proposed SEE site has been determined to only occur if there is a breach of the defences. Due to the location of the proposed SEE site, and the differences in freeboard, a breach of the tidal defences is considered to represent the 'worst case'.
- Tidal flooding due to an excess of the climate change adjusted maximum 200 year tide flood level / fluvial flooding due to an excess of the climate change adjusted maximum 100 year fluvial flood level is considered to be extremely unlikely and is therefore not considered further.
- Tidal flooding at the proposed SEE site has been considered for three flood scenarios. In terms of the proposed future site levels:
  - For Scenario B (breach adjacent to the proposed SEE site), except for the area covered by the proposed substation, the proposed SEE site is unaffected.
  - For Scenario C (breach to the south east of the proposed SEE site), the proposed SEE site is largely unaffected.
  - Therefore, a breach in the tidal defences has an insignificant impact on the proposed SEE site and safe access / egress can be maintained at all times.
- The Proposed Development does not obstruct flood flows in the event of the breach.
- The Proposed Development will not have an impact on fluvial geomorphology or an impact on the likely longer-term stability and sustainability of any watercourses.
- In order to attenuate the surface water runoff generated from the proposed SEE site during the 'worst case' climate change corrected storm, approximately 2,311 m^3 of attenuation will need to be provided. This attenuation will be provided by the use of a balancing pond(s) supplemented by the use of additional SUDS techniques including: permeable paving with a porous sub-base; filter drains; and, non-infiltration swales. In utilising this approach, the balancing pond(s) will not need to be sized for the full required 2,311 m^3 of attenuation. The net effect of these proposed SUDS techniques would be to ensure that surface water runoff from the proposed SEE site would be stored on site for the 'worst case' climate change corrected storm. Therefore, no increase in flood risk would occur to the proposed SEE site, existing Spalding CCGT generating station site or to downstream areas as a consequence of the development.

5.1.5 Site levels have been carefully developed to mitigate flood risk and ensure accessibility standards are met. Under both Scenario 1 and Scenario 2, the design flood level for the Proposed Development (taking account of climate change and freeboard) is 6.5 mAOD. The whole site will be regarded to this level, except where the Proposed Development must tie in with the adjacent land along the boundary of the proposed SEE site. In particular, the substation will be raised to approximately 5.3 mAOD to facilitate

interconnection with the existing Spalding CCGT generating station substation which is approximately 4.8 mAOD.

5.1.6 Therefore, this Supplementary Flood Risk Assessment has shown the flood risk to the proposed SEE site is acceptable, and the proposed SEE will not increase flood risks elsewhere.

FIGURES

FIGURE 2.1: SITE LOCATION PLAN

Taken from the March 2009 ES

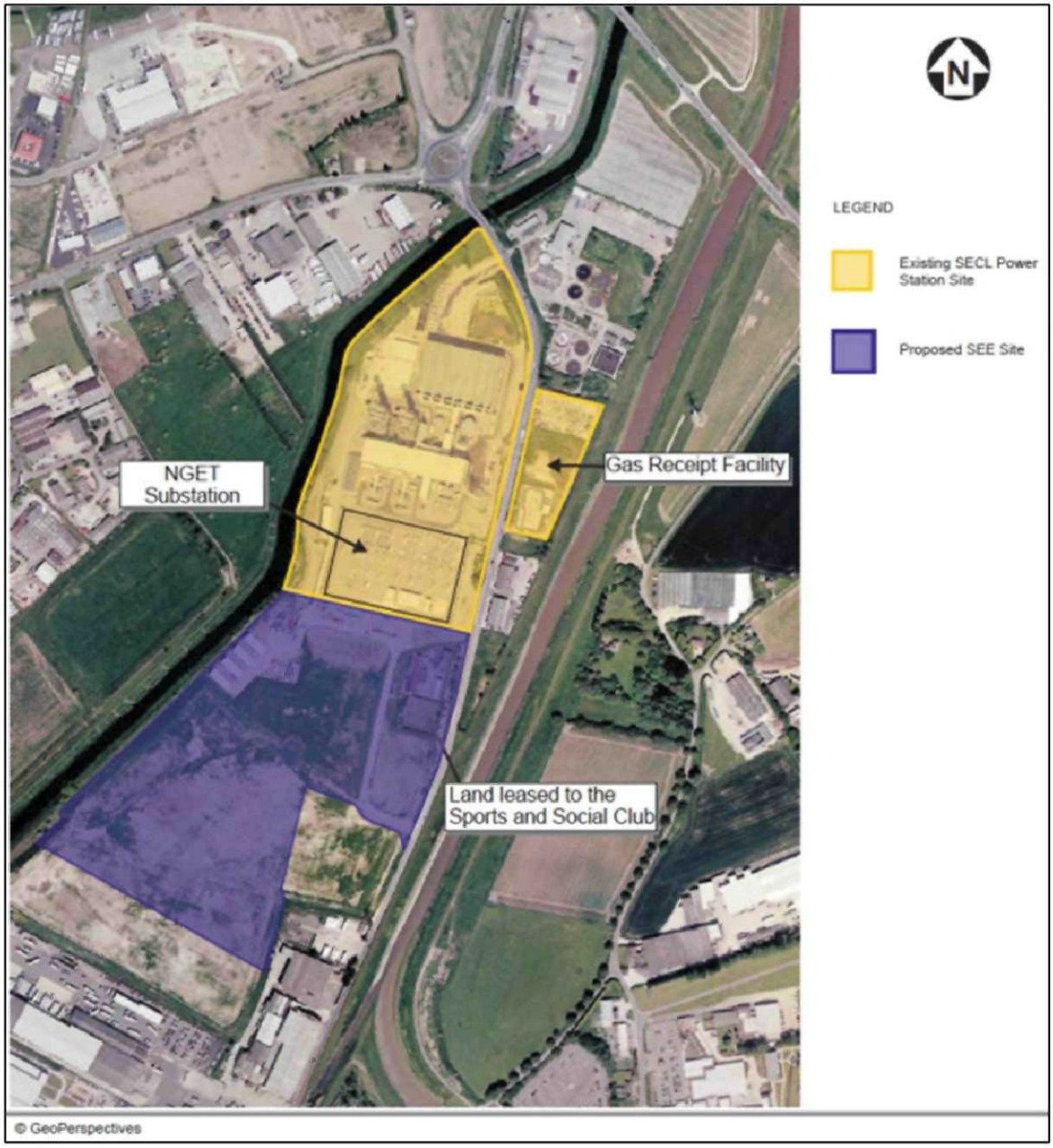


FIGURE 2.2: TOPOGRAPHICAL SURVEY

Taken from the Initial Flood Risk Assessment

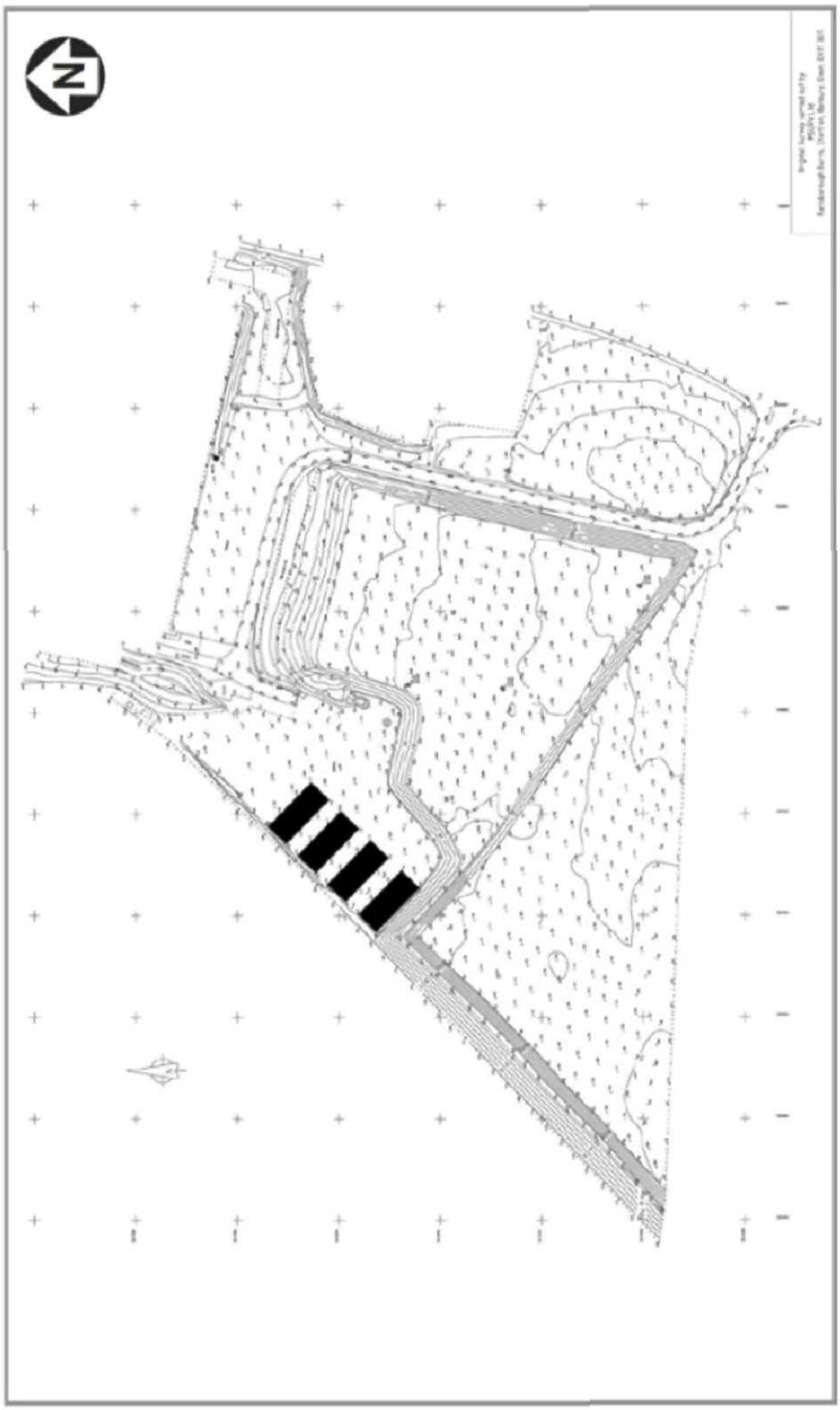


FIGURE 2.3: INDICATIVE FLOOD MAP FOR THE PROPOSED SEE SITE

Copyright Environment Agency 2014

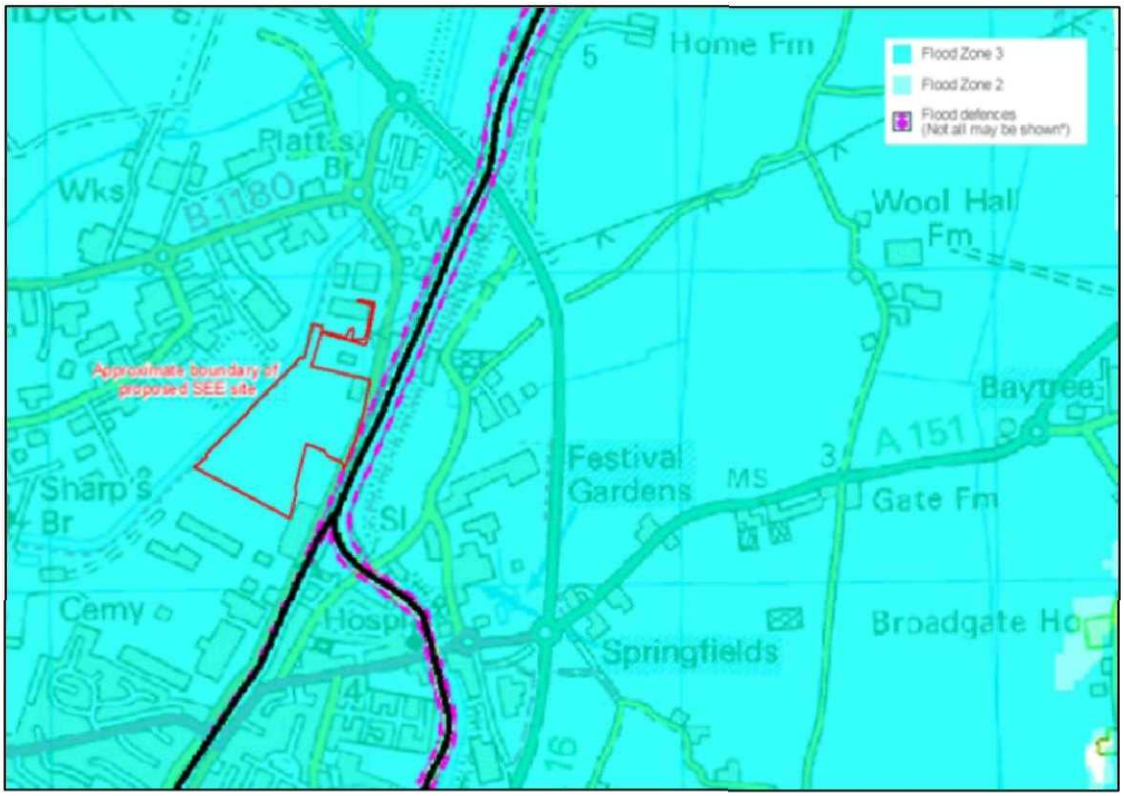


FIGURE 3.1: AERIAL PHOTO TUFLOW BREACH LOCATIONS

Taken from the Initial Flood Risk Assessment / Copyright GeoPerspectives

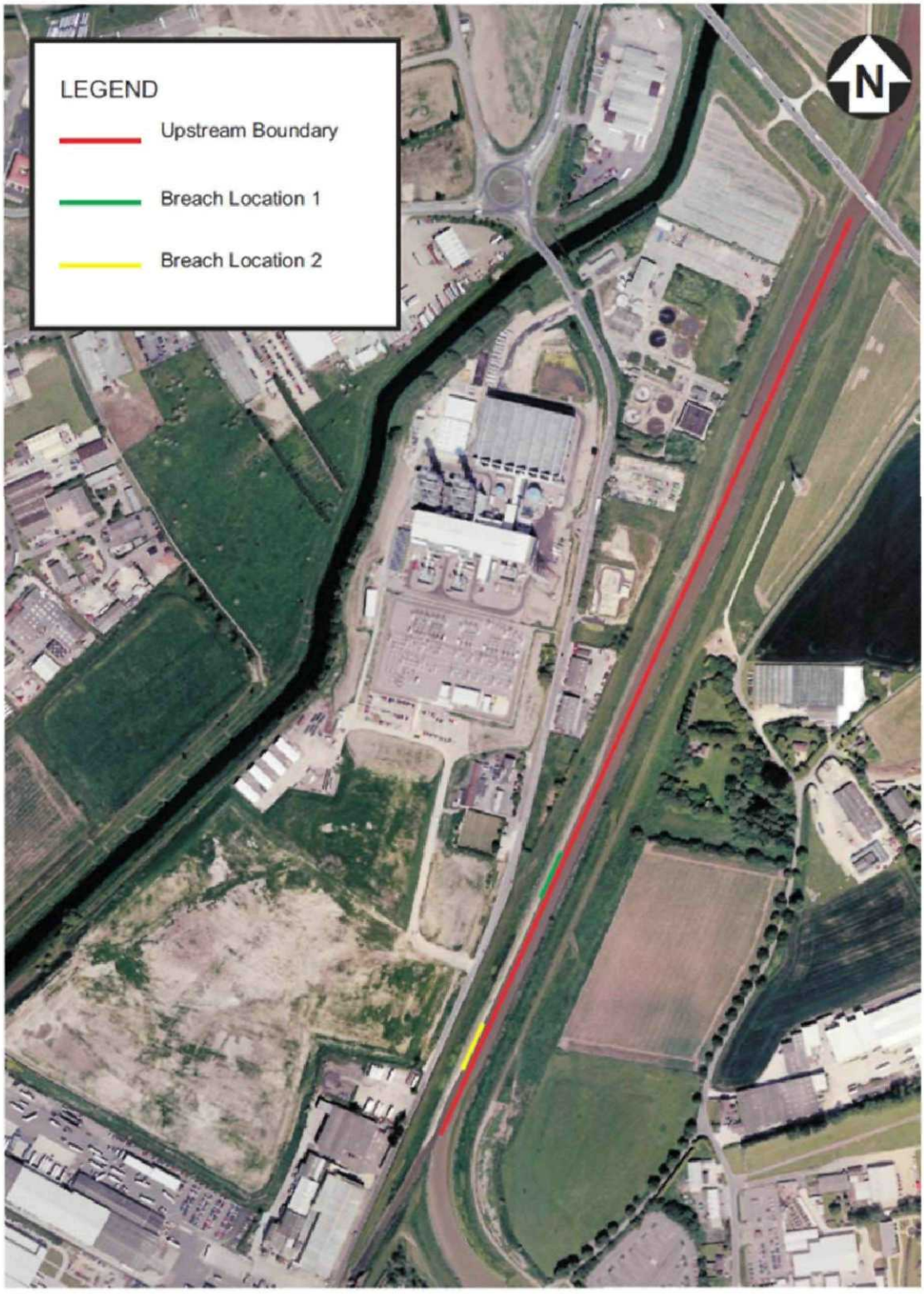


FIGURE 3.2: FLOOD EXTENT FOR SCENARIO A

Taken from the Initial Flood Risk Assessment / Copyright GeoPerspectives

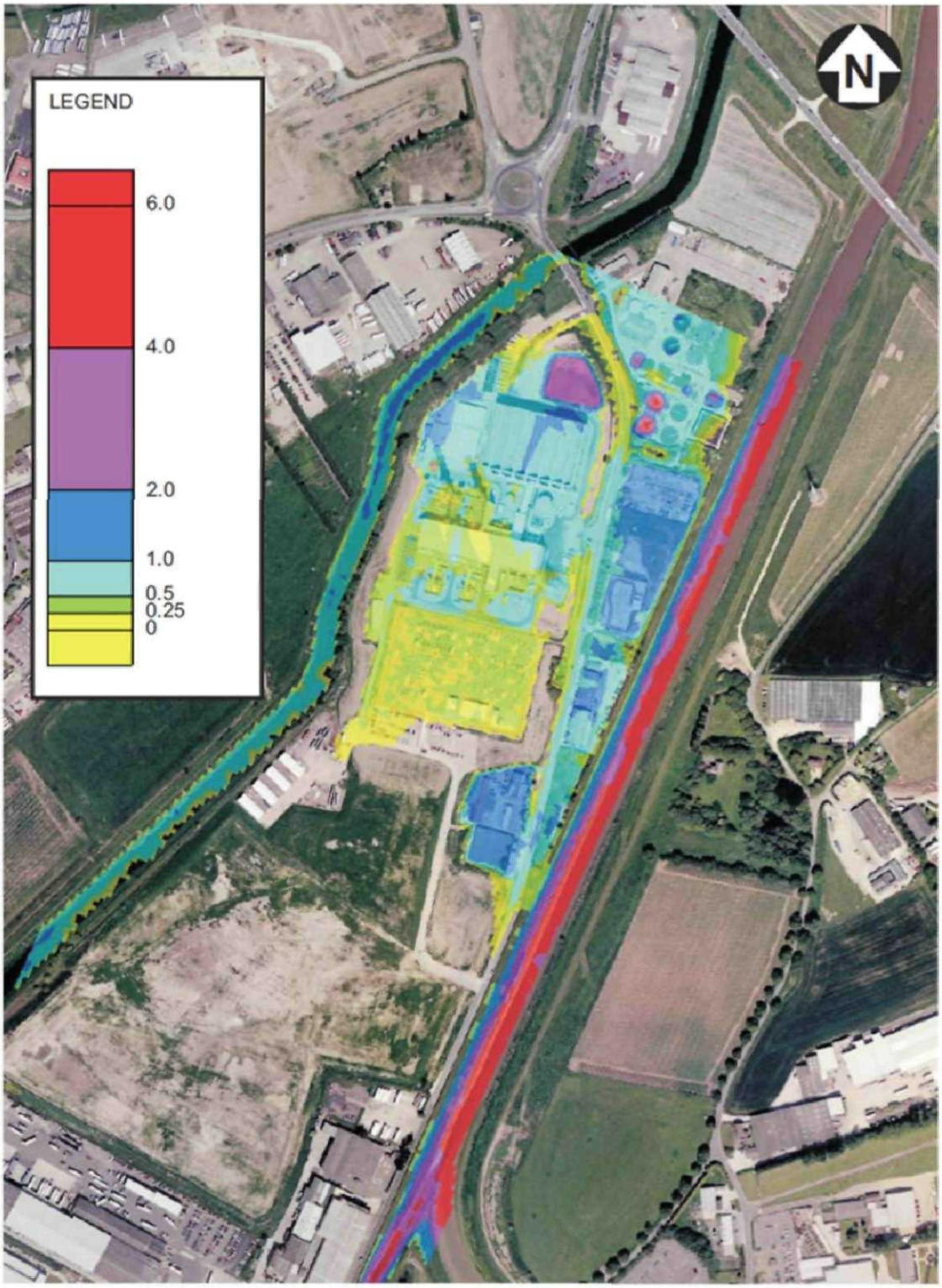


FIGURE 3.3: FLOOD EXTENT FOR SCENARIO B

Taken from the Initial Flood Risk Assessment / Copyright GeoPerspectives

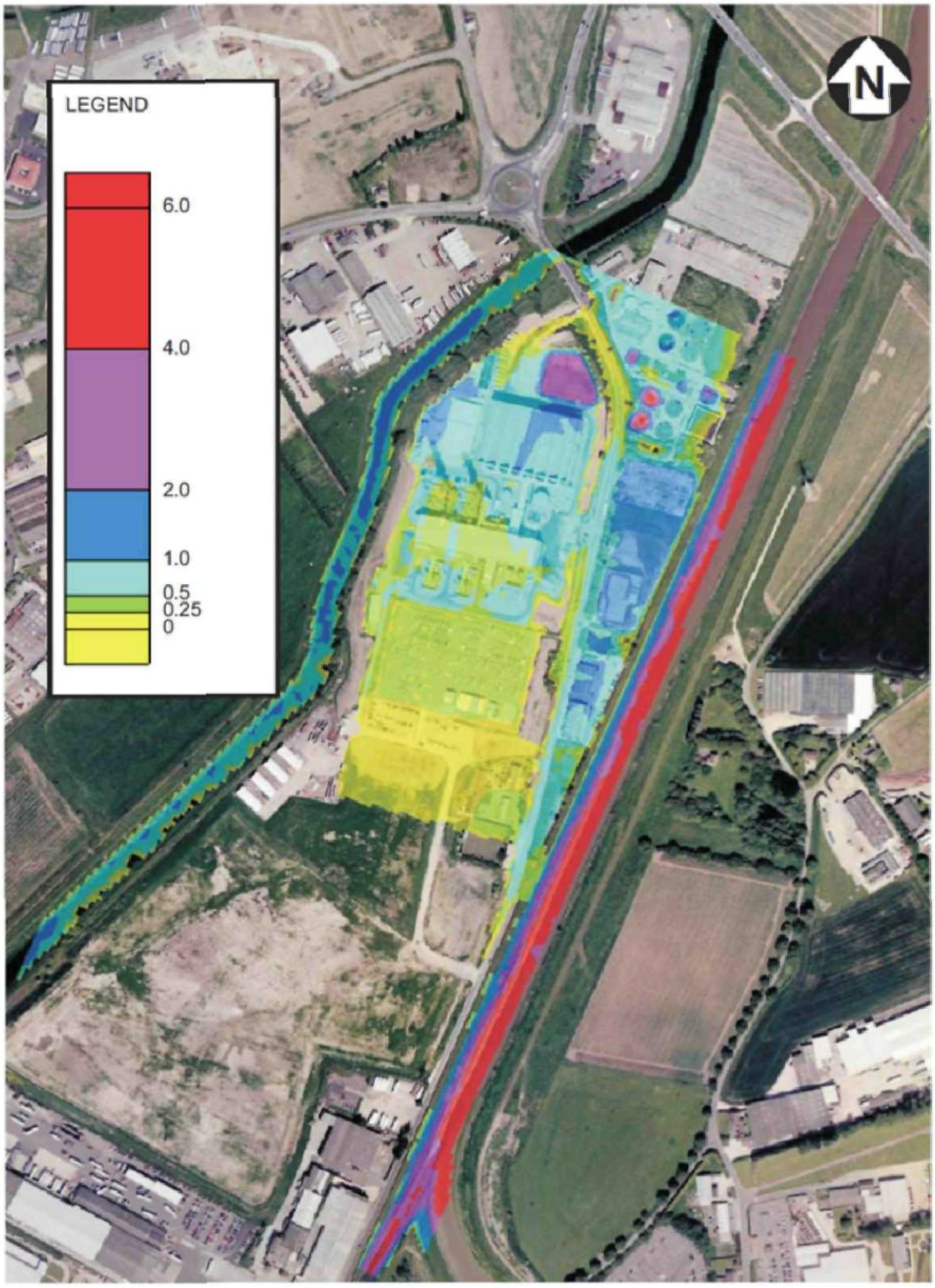


FIGURE 3.4: FLOOD EXTENT FOR SCENARIO C

Taken from the Initial Flood Risk Assessment / Copyright GeoPerspectives

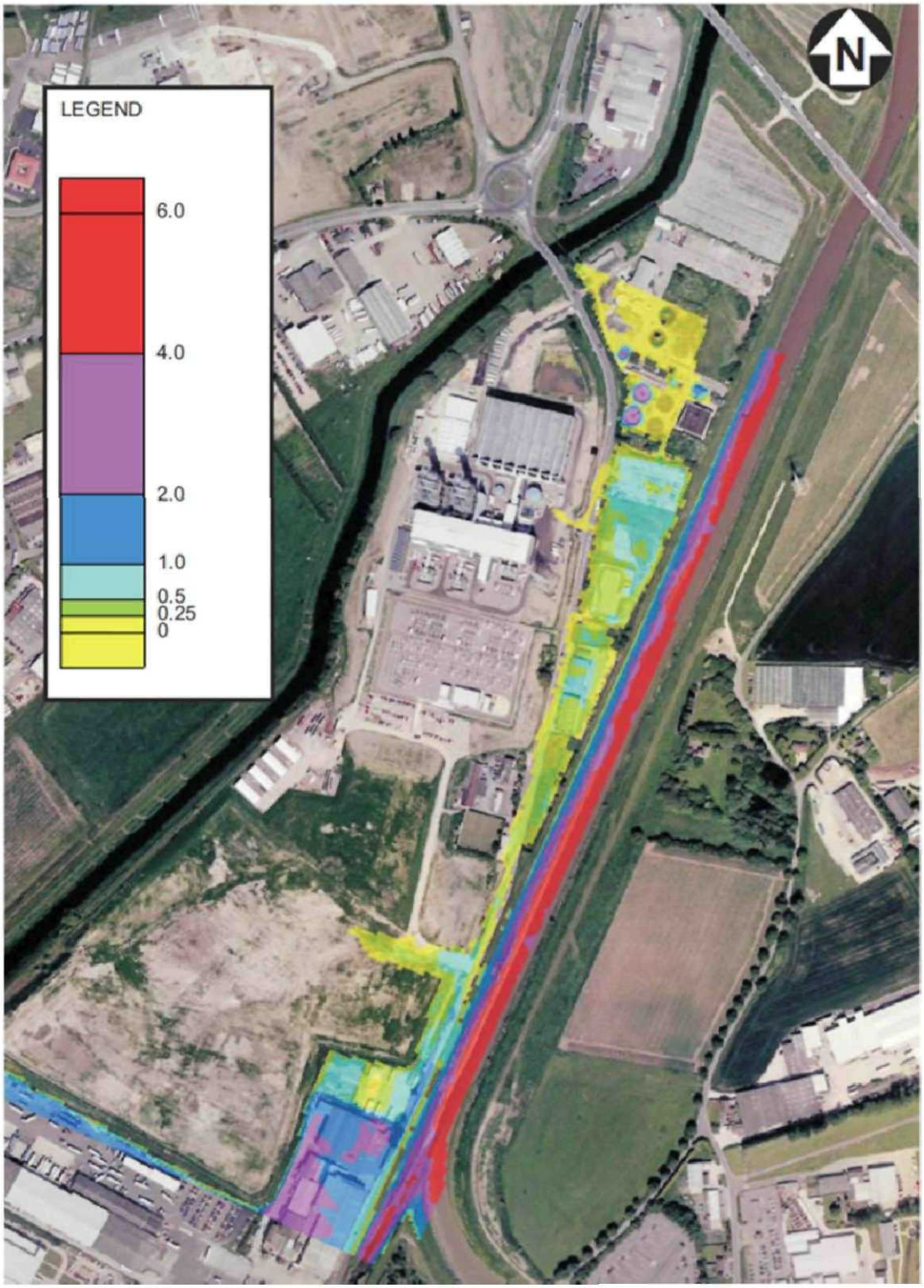


FIGURE 3.5: FLOOD HAZARDS FOR SCENARIO B

Taken from the Additional Flood Risk Information



FIGURE 3.6: FLOOD HAZARDS FOR SCENARIO C

Taken from the Additional Flood Risk Information

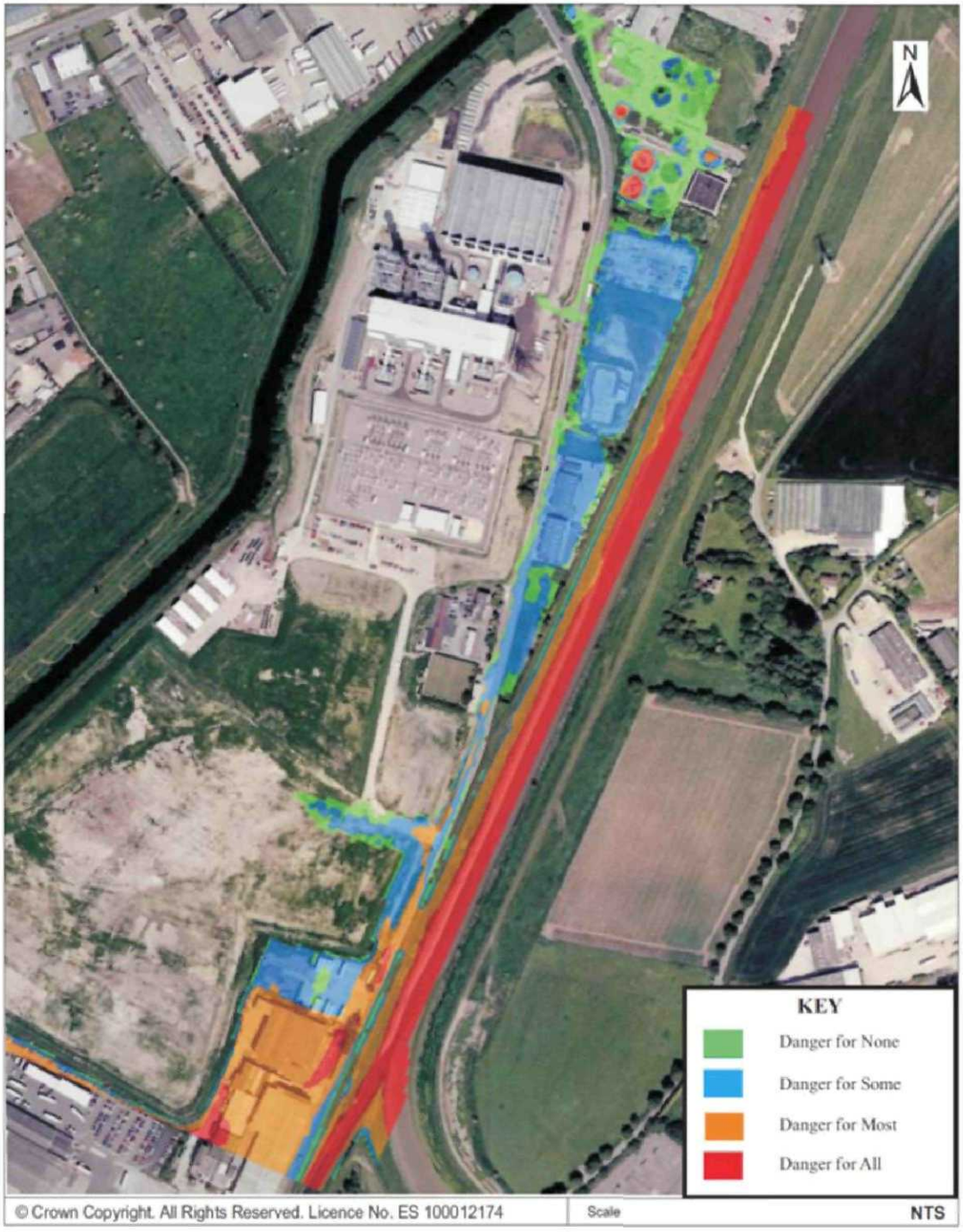


FIGURE 3.7: CROSS SECTION DIAGRAM OF THE PROPOSED SITE LEVELS

Taken from the Initial Flood Risk Assessment

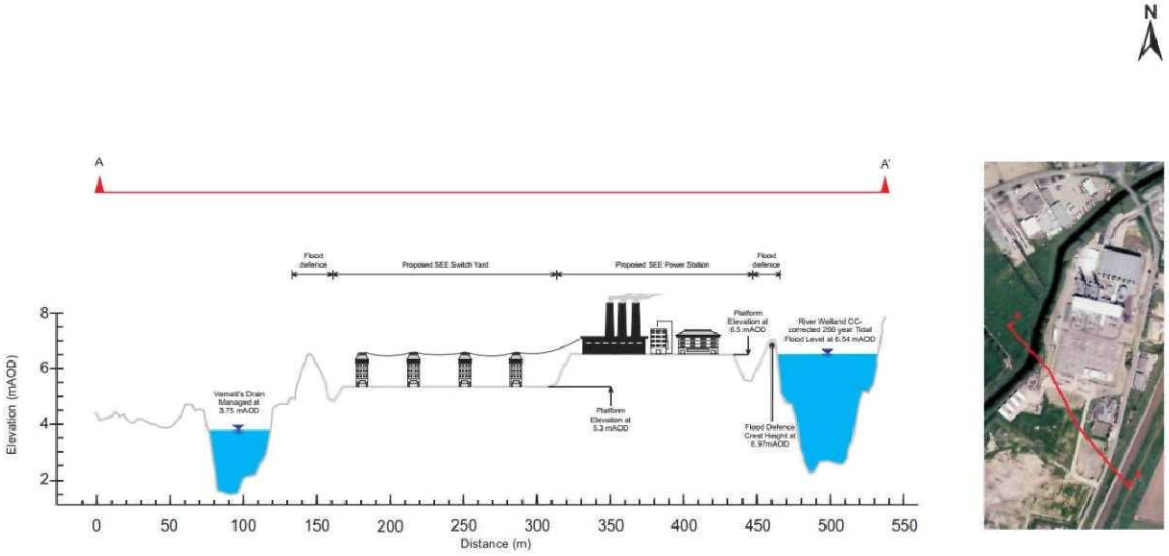


FIGURE 3.8: ACCESS AND EGRESS POINTS / EVACUATION ROUTES

Taken from the Additional Flood Risk Information

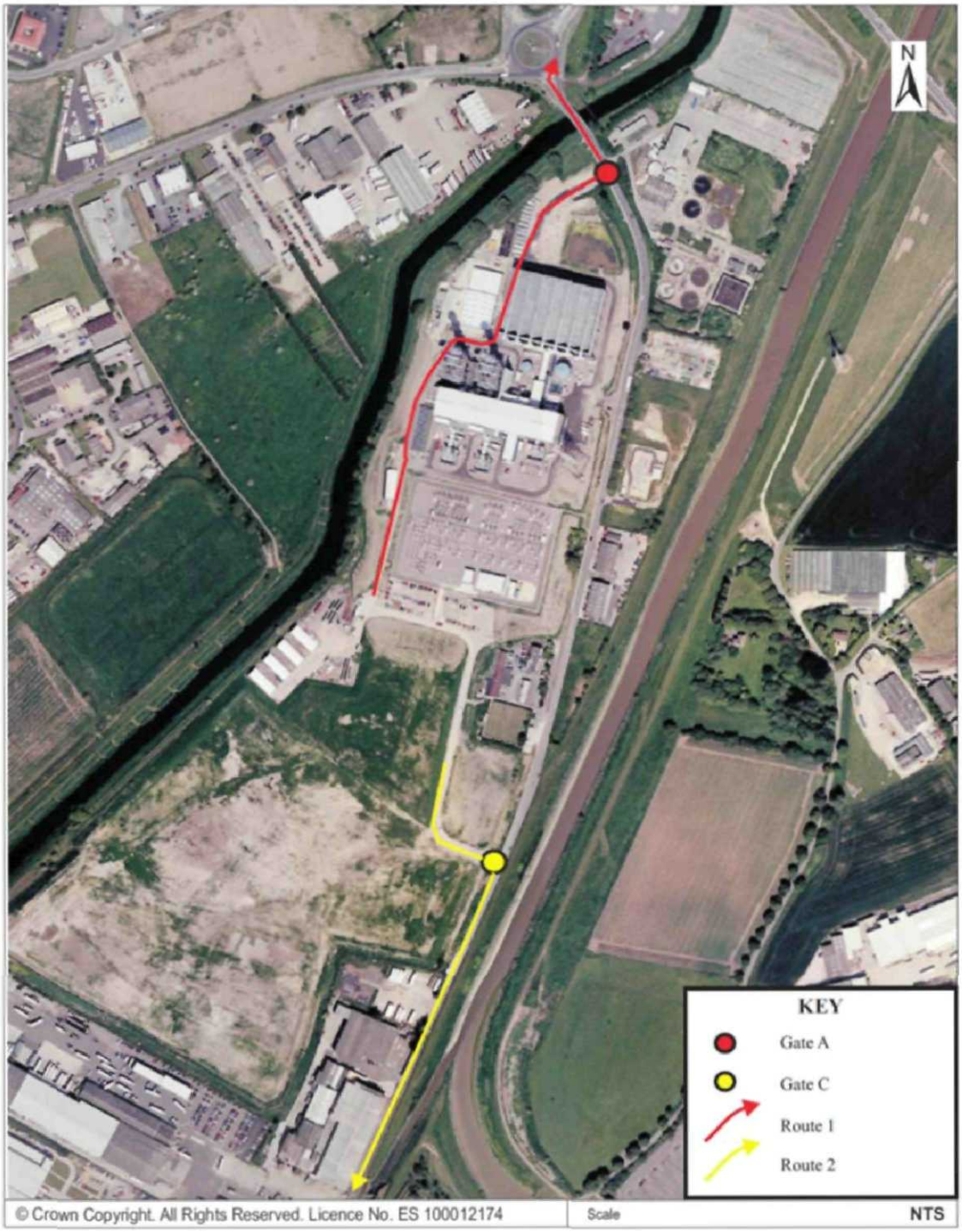


FIGURE 4.1: DRAINAGE PARAMETERS PLAN

Adapted from the March 2009 ES



APPENDICES

APPENDIX A
ENVIRONMENT AGENCY HAZARD MAP CORRESPONDANCE

Emily McVean

From: Lincs & Northants, Customer Enquiries <LNenquiries@environment-agency.gov.uk>
Sent: 25 February 2015 12:21
To: Emily McVean
Subject: [Pending]RE: Product 8 CCN/2015/38799

Dear Emily,

Enquiry regarding information for Product 8 Hazard Mapping

Thank you for your enquiry and sending through the plan.

We do not have the data you require however, Hazard Maps are available within the South Holland SFRA. I have added the link here:
http://www.sholland.gov.uk/environment/plandev/localplan/background/lfraupdatefinal2010.htm

I hope this helps,

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

Deb Bluck
Customers & Engagement Officer

Environment Agency
Lincolnshire and Northamptonshire Area
Waterside House, Waterside North, Lincoln, LN2 5HA
[redacted]
[redacted] (internal)
[redacted]
www.gov.uk/environment-agency

Awarded to Lincolnshire and Northamptonshire Area

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We constantly strive to provide a first-class service to our customers. Our customers give us feedback about what we have got right and wrong. If you would like to see the results of your feedback and what we have done to improve, please let me know.

APPENDIX B
SUMMARY OF HYDRAULIC MODELLING UNDERTAKEN FOR THE INITIAL FLOOD RISK ASSESSMENT

Introduction

The following section provides detail on the site-specific modelling undertaken for the Initial Flood Risk Assessment, and has been adapted from the Initial Flood Risk Assessment.

The parameters required to inform the modelling (e.g. topography of defences, site) are considered to be applicable to present conditions. The assessment of surface roughness of the site and surrounds was based on 2008 aerial photography and comparison of historical photography indicates that there has been little change in the features of the site. Therefore, the previous assessment of surface roughness is considered to be an accurate representation of the present conditions.

Objective and Selection of Model

Flood risk behind defences is related to the probability of flooding and the magnitude of the consequence:

Risk = Probability x Consequence

The probability of the flood is dependent on the following:

- The defence(s) being overtopped; and
- The defence(s) failing by breaching, which is itself dependent on:
  - Height of defence;
  - Structure of defence;
  - Condition of defence; and
  - Length of time water will be at a high level.

The tidal defences protecting the proposed SEE site from the Tidal River Welland are of a sufficient height to ensure that overtopping is avoided. The Environment Agency have also stated that these defences are inspected regularly to ensure that any defects are identified and rectified. However, the risk of a breach of the tidal defences cannot be entirely discounted.

The consequence of flooding represents the damage to assets and danger to people, and is assessed via a measure of flood hazard. Flood hazard is calculated a combination of flood depth and velocity.

Objective

Therefore, the objective of hydraulic modelling was to provide an estimate of flood levels within the proposed SEE site as a result of a breach of the tidal flood defences along the River Welland.

Selection of Model

For the hydraulic modelling, one-dimensional (1D) techniques such as HEC-RAS or ISIS software were discounted due to the complexity of interactions between the channel and floodplain storage in the area. In addition, 1D techniques could not accurately simulate the presence of flood embankments and the lower elevations beyond.

Therefore, two-dimensional (2D) techniques were used to allow more detailed analyses of flood depths and velocities across the proposed SEE site. The package used was the industry-standard TUFLOW (2D) river modelling software. The hydraulic models constructed for this study were all run stable throughout each simulation.

Description of Model Package

TUFLOW is a modelling package for simulating depth-averaged 2D free-surface flows and was developed as a joint research and development project by WBM Oceanics Australia and the

University of Queensland from 1990. For the Initial Flood Risk Assessment, the most up-to-date version of TUFLOW was used (2007-07-BF).

TUFLOW model construction was undertaken in a GIS environment using SMS (outside of the TUFLOW programme), enabling direct geo-referenced visualisation of all model elements. This facilitated the identification of model elements as well as visual inspection of model schematisation.

The basic steps to building a TUFLOW flood model are:

- Collate all available ground level data (lidar, topographic surveys) into a Digital Terrain Model (DTM);
- Collate all available GIS data (Landline, aerial photos etc);
- Determine the extent of the area of interest;
- Determine the extent of the 2D domain;
- Identify locations for boundary conditions;
- Identify areas of 2D domain that can be made 'inactive' (e.g. high ground);
- Select appropriate grid orientation and cell size;
- Create the grid and base elevations (e.g. embankments, buildings and other features not contained in the base DTM);
- Review the 2D 'mesh' created by TUFLOW;
- Assign appropriate Manning's roughness values; and,
- Determine the time-step required for the simulation.

Data Collection

Topographic Data

Topographic datasets were derived from site specific topographic surveys, aerial survey (LiDAR) and from Environment Agency information on crest heights. Table B.1 details which datasets were used for which components of the 2D modelling.

TABLE B.1: DATASETS USED IN THE 2D MODELLING

2D Model Component	*Topographic Data*
Proposed SEE Site Elevations	Site Specific Topographic Survey
Flood Defence Elevations	Environment Agency Data
Surrounding Land Elevations	Aerial Survey / LiDAR Data

Manning Roughness Coefficients

The various land uses within the modelled domain were derived from site observations (at the time of a site visit on 14th November 2008) and from aerial photography. Land uses were converted into roughness coefficients (i.e. Manning's 'n' values) using standard values and procedures as detailed in Chow[9]. A check on the roughness coefficients used was carried out by calculating roughness using the Conveyance Estimation System (CES).

Table B.2 presents the Manning roughness coefficients used in the 2D modelling.

[9] Chow, V.T. Open Channel Hydraulics (1959)

TABLE B.2: MANNINGS ROUGHNESS COEFFICIENTS

Land Use	*Manning's 'N'*
Buildings	0.032
Hard standing and roads	0.032
River channel	0.024
Grass	0.045
Shrubs	0.063
Open water	0.044

Tide Curve

The modelled extreme tide flood levels were based on a 2006 tidal analysis and were taken from the 2008 Northern Area Tidal Model. The maximum 200 year tide flood level is 5.98 mAOD at the Marsh Road Sluice.

Further to this modelled flood levels, contingency allowances for net sea level rise were applied. In the Initial Flood Risk Assessment, these contingency allowances were applied based on the completion of construction in 2014 and an estimated lifetime presence on site of 60 years. As a result, an additional 559 mm was added to the maximum 200 year tide flood level. The climate change adjusted maximum 200 year tide flood level was 6.54 mAOD at the Marsh Road Sluice.

In order to model this event in TUFLOW, a tide curve must be generated for this event.

In order to generate the tide curve, the Environment Agency provided tide data for the telemetry station downstream of the Marsh Road Sluice. The data covered two years, at 15 minute intervals.

The peak tide level from this data was 5.192 mAOD, recorded at 20:15 on 19 April 2007. The tide data covering this peak tide curve and the immediately preceding and following tide curves were extracted from the whole date set. This data was adjusted by a factor of 1.259 so that the peak tide level coincided with the climate change adjusted maximum 200 year tide flood level of 6.54 mAOD.

Model Development

Extents

The extent of the TUFLOW 2D domain covers the left bank of the River Welland adjacent to the proposed SEE site with sufficient area to allow flooding of the proposed SEE site, the existing Spalding CCGT generation station site and surrounding land.

All areas within the 2D domain for which there is no topographic data were set by default to an elevation of 25 mAOD so that they would be effectively inactive.

Grid orientation was angled in line with the predominant flow direction of the River Welland in this area. This not only allows accurate flow patterns in the direction of flow for the 2D domain but also for flows over the flood embankments which would generally be perpendicular to channel direction.

Boundary Conditions

The upstream boundary to the 2D model was set up as a TUFLOW z-line longitudinally along the centre of the river channel. This z-line was set up as a time dependent head boundary condition (BC) which represents the water surface elevation versus time based on climate change adjusted maximum 200 year tide curve. The BC was set up with positive flow towards the left bank of the river and towards the site. No negative flow towards the right bank was allowed. This ensured that the full tide height was experienced at the breach location.

No downstream boundary condition was required as the model is set up to observe the behaviour of flood waters outside of the normal river channel.

Grid Size

The 2D domain was initially set up using a 10 m grid size. The final model runs used a finer grid size (5 m) in order to provide maximum detail of flood routes within the 2Dm domain to be simulated.

Flood Embankments and Buildings

Once the model had been set up and tested using the above detail, refinements to the model DTM were made by incorporating specific height data to allow more detailed modelling of the earth flood embankments along the left bank of the River Welland. These were added to the model by means of TUFLOW z-lines.

Breach

A breach width of 50 m has used in the model. This was based on Environment Agency recommended breach widths. These are presented in Table B.3.

TABLE B.3: ENVIRONMENT AGENCY RECOMMENDED BREACH WIDTHS

Location Type	*Defence Type*	*Breach Width*
Open Coast	Earth Bank	200
	Dunes	100
	Hard	50
	Sluice	Sluice Width
Estuary	Earth Bank	50
	Hard	20
Tidal River	Earth Bank	50
	Hard	20
Fluvial River	Earth Bank	40
	Hard	20

There is no guidance on breach depths, but a 1 m deep breach below the peak of the embankments has been assumed at a level of 5.97 mAOD.

Calibration ad Validation

In the absence of gauging data and / or evidence of historical flooding in the local area, the model has been left uncalibrated. Due to the lack of calibration / validation, a conservative approach has been taken at each stage of the modelling process.