Tillbridge Solar

Tillbridge Solar Project
EN010142

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Environmental Statement
Appendix 10-3: Flood Risk Assessment
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Executive Summary

The Tillbridge Solar Project (the Scheme) will comprise the construction, operation (including maintenance), and decommissioning of ground-mounted solar photovoltaic (PV) arrays. The Scheme will also include associated development to support the solar PV arrays.

The Scheme is made up of the Principal Site, the Cable Route Corridor and works to the existing National Grid Cottam Substation. The Principal Site comprises the solar PV arrays, electrical substations, grid balancing infrastructure, cabling and areas for landscaping and ecological enhancement.

The associated development element of the Scheme includes but is not limited to access provision; a Battery Energy Storage System (BESS), to support the operation of the ground mounted solar PV arrays; the development of on-site substations; underground cabling between the different areas of solar PV arrays; and areas of landscaping and biodiversity enhancement.

The Scheme also includes a 400kV underground Cable Route Corridor of approximately 18.5km in length connecting the Principal Site to the National Electricity Transmission System (NETS) at the existing National Grid Cottam Substation. The Scheme will export and import electricity to the NETS.

A full description of the Scheme is included in **Chapter 3: Scheme Description** of the Environmental Statement **[EN010142/APP/6.1]**. An overview of the Scheme and its environmental impacts is provided in the Environmental Statement **Non-Technical Summary [EN010142/APP/6.4]**.

AECOM has been commissioned to prepare a Flood Risk Assessment (FRA), as an Appendix (**Appendix 10-3**) of **Chapter 10: Water Environment** of this Environmental Statement (ES) **[EN010142/APP/6.2]** in relation to the Development Consent Order (DCO) Application for the Scheme.

The operational phase of the Scheme is 60 years and decommissioning is expected to commence thereafter.

The Order limits of the Scheme are predominately located within Lincolnshire County Council, within West Lindsey District Council (WLDC), approximately centred on National Grid Reference (NGR); SK 90503 88862. The area within and surrounding the Order limits is a primarily rural setting, comprising open agricultural fields with sparse areas of woodland and villages.

The Order limits have two sections:

- ‘the Principal Site’, which is the location where ground mounted solar photovoltaic (PV) panels, electrical sub-stations and energy storage facilities will be installed; and
- ‘the Cable Route Corridor’, which will comprise the underground electrical infrastructure required to connect the Principal Site to the national transmission system.

This FRA primarily relates to the Principal Site during the operational phase of the Scheme, as works within the Cable Route Corridor are underground and therefore not anticipated to have any impact on long term flood risk (i.e. there will be no permanent above ground built development within the Cable Route Corridor). The underground cabling is inherently flood protected. Flood risk during the construction of the Scheme is to be managed by the on-site contractors through the Construction Environmental Management Plan (**Framework CEMP [EN010142/APP/7.8]**).

The Scheme will consist of the following infrastructure:

- Solar PV infrastructure consisting of solar PV panels and mounting structures (also known as solar modules);
- Solar Stations (invertor, transformer and switchgear);
- Battery Energy Storage System (BESS);
- Battery Direct Current (DC)/DC convertors;
- On-site cabling;
- On-site sub-stations;
- Solar farm control centre;
- Equipment storage;
- Fencing, security and lighting;
- Site access and access tracks;
- Surface water drainage; and
- Electricity connection to National Grid via Cable Route Corridor. The Tillbridge circuit will be connected to an existing free bay at Cottam substation.

The physical infrastructure within the Scheme is described in further detail in **Chapter 3: Scheme Description** of this ES **[EN010142/APP/6.1]**.

This FRA has been prepared in accordance with the requirements of the Overarching National Policy Statement (NPS) for Energy (EN-1) (Ref. 1),the NPS for Renewable Energy Infrastructure (EN-3)(Ref. 2), the NPS Electricity Networks Infrastructure (EN-5)(Ref. 3), and the National Planning Policy Framework (NPPF)(Ref. 4). The proposed use of the Scheme would be classed as 'Essential Infrastructure' in accordance with Annex 3 of the NPPF(Ref. 04).

The vast majority of the Principal Site lies within Flood Zone 1. Small areas of Flood Zone 2 and 3 associated with Ordinary Watercourses (surface water ditches along field boundaries) are present in areas near the boundary of the Principal Site.

An identified area where the extents of Flood Zone 2 and 3 overlap with proposed Solar PV Panel locations has been identified within this FRA and is referred to as an "interaction zone" within this report. This is discussed in more detail in Chapter 4 of this report. Other than solar PV Panels, no other above ground permanent built development (such as on-substations or BESS) will be located within Flood Zones 2 or 3, except for a section of the 2.4m high open mesh Principal Site security fence along Field 56 in the north of the Principal Site, which will allow flood flows to pass through.

A Fluvial Flood Level Technical Note included in Annex C of this report provides an analysis and subsequent findings to predict the estimated flood levels within the interaction zone and provides an assessment to demonstrate that there will be no increased risk from fluvial flooding to the solar PV panel infrastructure, or elsewhere, as a result of the Scheme. The methodology and approach used to assess the estimated flood level across the interaction zone has been discussed in consultation with the Environment Agency, Internal Drainage Boards and Lead Local Flood Authority. Record of the correspondence is located in **Appendix 10-5: Water Environment Stakeholder Meeting Minutes** of this ES **[EN010142/APP/6.2]**. All parties have considered the approach to be reasonable in lieu of a lack of available hydraulic model data for the watercourse.

The River Trent and River Till, both Environment Agency designated main rivers, pass through part of the Cable Route Corridor. Large expanses of Flood Zone 2 and 3 are present associated with these main rivers and other ordinary watercourses. However, as discussed, there is no proposed permanent aboveground built infrastructure within the Cable Route Corridor.

The flood risk summary table below provides the overall flood risk across the Scheme. This FRA assesses the Scheme in more detail relative to each flood risk area.

Table 0-1: Flood Risk Summary

Flood Risk Source	Pre-Scheme Flood Risk Level	Post-Scheme Flood Risk Level	Comments
Fluvial	Low (majority of Principal Site and majority of Cable Route Corridor) – Medium to high (area of Cable Route Corridor where crossing the River Trent)	Low (Principal Site and majority of Cable Route Corridor) – Medium to High (area of Cable Route Corridor where crossing the River Trent)	Discharge from impermeable areas detailed in the Outline Drainage Strategy (**Appendix 10-4** of this ES **[EN010142/APP/6.2]**) is to be restricted to Greenfield rates, mitigating increases to peak river flow rates. Solar PV Panel infrastructure within the Flood Zones 2 and 3 “interaction zone” is not envisaged to alter the existing flood extent topography and is proposed to be installed with sufficient freeboard of 300mm during the worst-case flooding scenarios. No change to flood risk level.
Tidal	Low (majority of Order limits) – High (areas associated	Low (majority of Order limits) – High (areas associated with watercourses)	No change to flood risk level.

Flood Risk Source	Pre-Scheme Flood Risk Level	Post-Scheme Flood Risk Level	Comments
	with watercourses)		
Pluvial (surface water)	Low	Low	Increased surface water runoff is proposed to be managed on-site to mimic the pre-Scheme conditions for up to and including the 1 in 100 + 40% climate change (CC) event. No change to flood risk level.
Groundwater	Low	Low	The **Outline Drainage Strategy** (**Appendix 10-4** of this ES **[EN010142/APP/6.2]**) does not propose to utilise infiltration techniques to discharge increased surface water runoff. No change to flood risk level.
Sewers	Low	Low	No proposed connection to public foul or surface water sewers. No change to flood risk level.
Artificial sources	Low (Principal Site and majority of Cable Route Corridor) – Medium (small area of Cable Route Corridor where crossing the River Trent)	Low (Principal Site and majority of Cable Route Corridor) – Medium (small area of Cable Route Corridor where crossing the River Trent)	No change to flood risk level.

When considered within the context of national, regional and local planning policy in respect of development and flood risk, this FRA concludes that the area of the Scheme remains safe from flood risk, does not increase flood risk elsewhere and fulfils the Government's wider criteria for sustainable development.

1. Introduction

1.1 Background

1.2 The Tillbridge Solar Project (the Scheme) will comprise the construction, operation (including maintenance), and decommissioning of ground-mounted solar photovoltaic (PV) arrays. The Scheme will also include associated development to support the solar PV arrays.

1.3 The Scheme is made up of the Principal Site, the Cable Route Corridor and works to the existing National Grid Cottam Substation. The Principal Site comprises the solar PV arrays, electrical substations, grid balancing infrastructure, cabling and areas for landscaping and ecological enhancement.

1.4 The associated development element of the Scheme includes but is not limited to access provision; a Battery Energy Storage System (BESS), to support the operation of the ground mounted solar PV arrays; the development of on-site substations; underground cabling between the different areas of solar PV arrays; and areas of landscaping and biodiversity enhancement.

1.5 The Scheme also includes a 400kV underground Cable Route Corridor of approximately 18.5km in length connecting the Principal Site to the National Electricity Transmission System (NETS) at the existing National Grid Cottam Substation. The Scheme will export and import electricity to the NETS.

1.6 A full description of the Scheme is included in **Chapter 3: Scheme Description** of the Environmental Statement **[EN010142/APP/6.1]**. An overview of the Scheme and its environmental impacts is provided in the Environmental Statement Non**-Technical Summary [EN010142/APP/6.4]**.

1.6.1 AECOM has been commissioned to undertake a FRA for the Scheme located at approximate grid reference centre SK 90503 88862 and approximate postcode DN21 5XB.

1.6.2 The Order limits are made up of two sections:

a. ‘the Principal Site’, covering approximately 1,350 ha which is the location where ground mounted solar photovoltaic (PV) panels, electrical sub-stations and energy storage facilities will be installed; and

b. ‘the Cable Route Corridor’, which will comprise the underground electrical infrastructure required to connect the Principal Site to national transmission system.

1.6.3 The area within and surrounding the Order limits is a primarily rural setting, comprising open agricultural fields with sparse areas of woodland and villages. The Scheme location is described in more detail in **Chapter 2: Scheme Location** of this ES **[EN010142/APP/6.1]**.

1.6.4 This FRA primarily relates to the Principal Site during the operational phase of the Scheme, as permanent works associated with the Cable Route

Corridor will all be underground with no permanent above ground built development. The Cable Route Corridor is therefore considered to not have an impact on long term flood risk during the operation of the Scheme as there will be no increase in impermeable area within this area of the Scheme during the operational phase.

1.6.5 Flood risk during construction and decommissioning of the Scheme across the Principal Site and Cable Route Corridor is to be managed in-situ for the duration of works via flood risk and pollution management mitigation measures documented within the CEMP and Decommissioning Environmental Management Plan (DEMP). A **Framework CEMP [EN010142/APP/7.8]** and **Framework DEMP [EN010142/APP/7.10]** have been submitted with the DCO application.

1.7 FRA Objectives

1.7.1 The minimum requirements for FRAs, as outlined in the National Policy Statement (NPS) EN-1(Ref. 1) (paragraph 5.8.15). are to:

a. "*be proportionate to the risk and appropriate to the scale, nature, and location of the project;*

b. *consider the risk of flooding arising from the project in addition to the risk of flooding to the project;*

c. *take the impacts of climate change into account, across a range of climate scenarios, clearly stating the development lifetime over which the assessment has been made;*

d. *be undertaken by competent people, as early as possible in the process of preparing the proposal;*

e. *consider both the potential adverse and beneficial effects of flood risk management infrastructure, including raised defences, flow channels, flood storage areas and other artificial features, together with the consequences of their failure and exceedance;*

f. *consider the vulnerability of those using the site, including arrangements for safe access and escape;*

g. *consider and quantify the different types of flooding (whether from natural and human sources and including joint and cumulative effects) and include information on flood likelihood, speed-of-onset, depth, velocity, hazard and duration;*

h. *identify and secure opportunities to reduce the causes and impacts of flooding overall, making as much use as possible of natural flood management techniques as part of an integrated approach to flood risk management;*

i. *consider the effects of a range of flooding events including extreme events on people, property, the natural and historic environment and river and coastal processes;*

j. *include the assessment of the remaining (known as 'residual') risk after risk reduction measures have been taken into account and demonstrate* *that these risks can be safely managed, ensuring people will not be exposed to hazardous flooding;*

k. *consider how the ability of water to soak into the ground may change with development, along with how the proposed layout of the project may affect drainage systems. Information should include*;

  i. Describe the existing surface water drainage arrangements for the site
  ii. Set out (approximately) the existing rates and volumes of surface water run-off generated by the site. Detail the proposals for restricting discharge rates
  iii. Set out proposals for managing and discharging surface water from the site using sustainable drainage systems and accounting for the predicted impacts of climate change. If sustainable drainage systems have been rejected, present clear evidence of why their inclusion would be inappropriate
  iv. Demonstrate how the hierarchy of drainage options has been followed
  v. Explain and justify why the types of SuDS and method of discharge have been selected and why they are considered appropriate.
  vi. Explain how sustainable drainage systems have been integrated with other aspects of the development such as open space or green infrastructure, so as to ensure an efficient use of the site
  vii. Describe the multifunctional benefits the sustainable drainage system will provide
  viii. Set out which opportunities to reduce the causes and impacts of flooding have been identified and included as part of the proposed sustainable drainage system
  ix. Explain how run-off from the completed development will be prevented from causing an impact elsewhere
  x. Explain how the sustainable drainage system been designed to facilitate maintenance and, where relevant, adoption. Set out plans for ensuring an acceptable standard of operation and maintenance throughout the lifetime of the development

l. detail those measures that will be included to ensure the development will be safe and remain operational during a flooding event throughout the development's lifetime without increasing flood risk elsewhere;

m. identify and secure opportunities to reduce the causes and impacts of flooding overall during the period of construction; and

n. *be supported by appropriate data and information, including historical information on previous events*."

1.7.2 The principal objectives of the FRA, taking into account the above, are to:

a. Identify potential forms of flooding, including rivers, watercourses, surface water flooding, groundwater flooding, flooding from sewer systems and other forms of flooding, relevant to the Scheme;

b. Establish the risk of flooding in relation to the Scheme;

c. Determine the effects of the Scheme on flooding elsewhere either through displacement of floodwaters or increased runoff; and

d. Suggest appropriate flood mitigation measures for the Scheme, including a strategy for disposal of surface water run-off following the principles of SuDS.

1.7.3 The robust and comprehensive detail assessed and included in the FRA and the accompanying **Outline Drainage Strategy** (refer to **Appendix 10-4** of this ES **[EN010142/APP/6.2]**) are sufficient to support the DCO application for the Scheme.

1.8 Scope of Work

1.8.1 In preparing this FRA, the following work has been completed:

a. Relevant data and information from statutory and other authorities has been obtained;

b. The potential sources of flooding have been considered;

c. The risk of flooding to the Scheme has been assessed;

d. The impact of the Scheme on off-site flooding (displaced water) on third parties has been assessed;

e. The impact of climate change has been assessed; and

f. Likely mitigation requirements and any residual risk has been defined.

1.9 Scheme Description

1.9.1 The Scheme is for the construction, operation (including maintenance) and decommissioning of ground mounted solar PV panel arrays to generate solar electricity and store this within a BESS for export to the national electricity transmission network.

1.9.2 **Chapter 3: Scheme Description** of the ES **[EN010142/APP/6.1]** provides further details of the proposed key activities and programme for site preparation, construction, and decommissioning works.

1.10 Scheme Extent

1.10.1 The Scheme is made up of two sections, the “Principal Site” and the “Cable Route Corridor”.

1.10.2 The Principal Site is located to the south of Harpswell Lane (A631), to the west of Middle Street (B1398) and largely to the north of Kexby Road and to the east of Springthorpe. The Principal Site covers an area of approximately 1,350ha and is located entirely within the administrative area of WLDC.

1.10.3 The Principal Site comprises numerous field parcels used for arable farming. The fields are large with limited hedgerows and trees. Where there are hedgerows, these generally form the boundaries of fields as they adjoin roads. There are also some small scattered areas of woodland located within the Principal Site, as well as some rural dwellings and agricultural buildings dispersed across the area.

1.10.4 The Scheme will deliver power to National Grid Cottam Substation located approximately 18.5km to the south-west of the Principal Site at the decommissioned Cottam Power Station in Cottam on the Nottinghamshire border.

1.10.5 The electrical connection between the Principal Site and the National Grid Cottam Substation will comprise underground cables within the Cable Route Corridor.

1.10.6 **Chapter 2: Scheme Location** of the ES **[EN010142/APP/6.1]** provides a description of the existing conditions of the land within and surrounding the Scheme.

1.11 Existing Land Use

1.11.1 The Principal Site consists mostly of greenfield agricultural land, with some rural dwellings as well as agricultural buildings dispersed across the area.

1.11.2 The Cable Route Corridor consists of similar land use to the Principal Site, with the addition of crossings under the River Till and River Trent as well as various existing roads. Further details of the Principal Site and Cable Route Corridor are provided within **Chapter 2: Scheme Location** of the ES **[EN010142/APP/6.1]**.

1.11.3 The Principal Site within the Order limits has been set to only occupy natural landscape, avoiding existing developments and buildings. It is estimated to cover less than 1% impermeable area. Therefore, land within the Principal Site Order limits is considered 100% permeable (0% impermeable) for the purposes of this assessment. This represents a worst case approach to the existing catchment surface water greenfield runoff rates.

1.11.4 As mentioned above; it is not anticipated that there will be a change to existing permeable/impermeable areas following installation of the Cable Route Corridor as there would be no permanent aboveground built development. Therefore, only the Principal Site has been assessed in detail to ensure the Scheme remains safe from future flood risk, does not increase flood risk elsewhere, and fulfils the Government’s wider criteria for sustainable development.

1.11.5 **Table 1-1** below provides the existing site permeable and impermeable areas of the Principal Site:

Table 1-1: Contributing Areas of the Existing Principal Site

	Permeable Area (ha)	Impermeable Area (ha)	Percentage Impermeable
Principal Site	Approximately 1,350	0	0

1.12 Scheme Proposals

1.12.1 The Scheme is for the construction, operation (including maintenance) and decommissioning of ground mounted solar PV panels to generate solar electricity and store this within a BESS for export to the national electricity transmission network.

1.12.2 The Scheme will consist of the following infrastructure:

a. Solar PV infrastructure consisting of solar PV panels and mounting structures (also known as solar modules);
b. Solar stations (invertor, transformer and switchgear);
c. Battery Energy Storage System;
d. Battery Direct Current (DC)/DC convertors;
e. On-site cabling;
f. On-site sub-stations;
g. Solar farm control centre;
h. Equipment storage;
i. Fencing, security and lighting;
j. Site access and access tracks;
k. Surface water drainage; and
l. Electricity connection to National Grid via Cable Route Corridor. The Tillbridge circuit will be connected to an existing free bay at National Grid Cottam Substation.

1.12.3 **ES Chapter 3 Scheme Description [EN010142/APP/6.1]** provides further details of the components of the Scheme.

1.12.4 Annex B includes the Site Layout Plan, **Figure 3-1**: Indicative Principal Site Layout Plan of the ES **[EN010142/APP/6.3]**.

1.13 Consultees

1.13.1 The following stakeholders have been consulted to inform the FRA prior to DCO submission:

a. Lead Local Flood Authority (LLFA) – Lincolnshire County Council;
b. LLFA – Nottinghamshire County Council
c. The Environment Agency;
d. Scunthorpe & Gainsborough Water Management Board;

e. Upper Witham Internal Drainage Board and

f. Trent Valley Internal Drainage Board (now part of the newly formed Water Management Consortium (WMC)).

2. Legislation and Planning Policy

2.1.1 Legislation, planning policy, and guidance relating to flood risk and pertinent to the Scheme is set out in the following sections. Further information is also provided within **Appendix 10-1: Water Environment Legislation, Policy and Guidance** of the ES **[EN010142/APP/6.2]**.

2.1.2 This FRA considers the in force NPS documents published in November 2023, which came into effect in January 2024, as follows:

a. NPS EN-1(Ref. 1);

b. NPS EN-3(Ref. 2); and

c. NPS EN-5(Ref. 3).

2.2 National Planning Policy

Overarching NPS for Energy (EN-1)

2.2.1 NPS EN-1(Ref. 1) sets out the Government's policy for the development of nationally significant infrastructure projects which must be authorised by a DCO.

2.2.2 The objectives of this FRA are in line with paragraph 5.8.15 of NPS EN-1 (Ref. 1).

2.2.3 Paragraph 5.8.18 of NPS EN-1 (Ref. 1) recommends that applicants should arrange:

"*pre-application discussions before the official pre-application stage of the NSIP process with the EA or NRW, and, where relevant, other bodies such as Lead Local Flood Authorities, Internal Drainage Boards, sewerage undertakers, navigation authorities, highways authorities and reservoir owners and operators*".

2.2.4 Paragraph 5.8.36 states that, in determining an application for development consent, the Secretary of State should be satisfied that where relevant:

a. "the application is supported by an appropriate FRA;

b. the Sequential Test has been applied and satisfied as part of site selection;

c. a sequential approach has been applied at the site level to minimise risk by directing the most vulnerable uses to areas of lowest flood risk; and

d. The proposal is in line with any relevant national and local flood risk management strategy."

2.2.5 For the Sequential Test, NPS EN-1 (Ref. 1) states at paragraph 5.8.29 states the following:

"The sequential approach should be applied to the layout and design of the project. Vulnerable aspects of the development should be located on parts of the site at lower risk and residual risk of flooding. Applicants should seek opportunities to use open space for multiple purposes such as amenity, wildlife habitat and flood storage uses. Opportunities should be taken to lower flood risk by reducing the built footprint of previously developed sites and using SuDS".

2.2.6 For the Exception Test, NPS EN-1 (Ref. 1) states at paragraph 5.8.10 states the following:

"The Exception Test is only appropriate for use where the Sequential Test alone cannot deliver an acceptable site. It would only be appropriate to move onto the Exception Test when the Sequential Test has identified reasonably available, lower risk sites appropriate for the proposed development where, accounting for wider sustainable development objectives, application of relevant policies would provide a clear reason for refusing development in any alternative locations identified. Examples could include alternative site(s) that are subject to national designations such as landscape, heritage and nature conservation designations, for example Areas of Outstanding Natural Beauty (AONBs), SSSIs and World Heritage Sites (WHS) which would not usually be considered appropriate".

2.2.7 Paragraph 5.8.11 states that both elements of the Exception Test, set out below, will have to be satisfied for development to be consented:

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

2.2.8 Paragraph 5.8.42 states that "*exceptionally, where an increase in flood risk elsewhere cannot be avoided or wholly mitigated, the Secretary of State may grant consent if they are satisfied that the increase in present and future flood risk can be mitigated to an acceptable and safe level and taking account of the benefits of, including the need for, nationally significant energy infrastructure as set out in Part 3 above. In any such case the Secretary of State should make clear how, in reaching their decision, they have weighed up the increased flood risk against the benefits of the project, taking account of the nature and degree of the risk, the future impacts on climate change, and advice provided by the EA or NRW and other relevant bodies"*.

2.2.9 Paragraph 5.8.41 states "*energy projects should not normally be consented within Flood Zone 3b, Zone C2 in Wales, or on land expected to fall within these zones within its predicted lifetime. This may also apply where land is subject to other sources of flooding (for example surface water). However, where essential energy infrastructure has to be located in such areas, for operational reasons, they should only be consented if the development will not result in a net loss of floodplain storage, and will not impede water flows"*.

2.2.10 Paragraph 5.8.27 states the "*surface water drainage arrangements for any project should, accounting for the predicted impacts of climate change* *throughout the development's lifetime, be such that the volumes and peak flow rates of surface water leaving the site are no greater than the rates prior to the proposed project, unless specific off-site arrangements are made and result in the same net effect*".

2.2.11 Paragraph 5.8.28 also states that it "*may be necessary to provide surface water storage and infiltration to limit and reduce both the peak rate of discharge from the site and the total volume discharged from the site. There may be circumstances where it is appropriate for infiltration facilities or attenuation storage to be provided outside the project site, if necessary through the use of a planning obligation*".

National Policy Statement for Renewable Energy NPS EN-3

2.2.12 NPS EN-3 (Ref. 2) notes, in paragraph 2.10.84 that "*where a Flood Risk Assessment has been carried out this must be submitted alongside the applicant's ES. This will need to consider the impact of drainage. As solar PV panels will drain to the existing ground, the impact will not, in general, be significant*".

2.2.13 This FRA is compliant with paragraph 2.10.84 NPS EN-3 (Ref. 2), as it considers drainage for the Scheme.

2.2.14 The Scheme proposes, as a design principal, to utilise existing water crossing locations to avoid the need for new culverts; this principle accords with the aspirations of paragraph 2.10.87 and 2.10.88. Should a new crossing, requiring a culvert to be proposed, it is expected that the least impacting design be utilised, (e.g. arch rather than box or pipes) to mitigate impact to flood risk levels.

National Policy Statement for Electricity Networks Infrastructure (EN-5)

2.2.15 National Policy Statement for Electricity Networks Infrastructure (EN-5) (NPS EN-5 (Ref. 3) is principally concerned with high voltage transmission systems and distribution systems in addition to associated infrastructure.

2.2.16 Paragraph 2.3.2 of NPS EN-5 (Ref. 3) explains that as "*climate change is likely to increase risks to the resilience of some of this infrastructure, from flooding for example, or in situations where it is located near the coast or an estuary or is underground, applicants should in particular set out to what extent the proposed development is expected to be vulnerable, and, as appropriate, how it has been designed to be resilient to*:

a. flooding, particularly for substations that are vital to the network; and especially in light of changes to groundwater levels resulting from climate change;

b. the effects of wind and storms on overhead lines;

c. higher average temperatures leading to increased transmission losses;

d. earth movement or subsidence caused by flooding or drought (for underground cables); and

e. coastal erosion – for the landfall of offshore transmission cables and their associated substations in the inshore and coastal locations respectively."

2.2.17 NPS EN-5(Ref. 3), paragraph 2.3.3 reiterates the requirements set out in NPS EN-1(Ref. 1).

2.2.18 All on-site substations and BESS areas are located in Flood Zone 1; therefore, the Scheme is compliant with NPS EN-5 (Ref. 3) for flood risk to electrical infrastructure. PV panels located in Flood Zone 2 and 3 will be raised above predicted flood levels with an allowance for freeboard to ensure they remain operational in times of flood (flood risk to PV panels is discussed in **Section 4**).

National Planning Policy Framework (NPPF)

2.2.19 The NPPF (Ref. 4) was first published in March 2012, superseding previous national planning policy statements and guidance. The NPPF (Ref. 4) was subsequently revised in July 2021 and September 2023 with the current version published in December 2023. This FRA complies with the current version of the NPPF (Ref. 4) updated in December 2023. Flood Risk and Coastal Change Planning Practice Guidance (PPG) (Ref. 5) was published in 2014 to support the implementation of the NPPF. The flood risk and coastal change section of the PPG was last updated in August 2022; this FRA complies with this and all other current national and local policy.

2.2.20 Section 14 of the NPPF (Ref. 4), entitled Meeting the Challenge of Climate Change, Flooding and Coastal Change (paragraphs. 157-179), sets out the requirements to assess flood risk and climate change for developments. Paragraph 175 expects, "*major developments to incorporate sustainable drainage systems unless there is clear evidence that this would be inappropriate.".*

2.2.21 The assessment of flood risk is based on the definitions in **Table 2-1** as extracted from the PPG.

Table 2-1: Flood Zones – Table 1 of the PPG 2022

Flood Zone	Definition
Zone 1 Low Probability	Land having a less than 1 in 1,000 annual probability of river or sea flooding. (Shown as 'clear' on the Flood Map – all land outside Zones 2 and 3).
Zone 2 Medium Probability	Land having between a 1 in 100 and 1 in 1,000 annual probability of river flooding; or land having between a 1 in 200 and 1 in 1,000 annual probability of sea flooding. (Land shown in light blue on the Flood Map).
Zone 3a High Probability	Land having a 1 in 100 or greater annual probability of river flooding; or Land having a 1 in 200 or greater annual probability of sea flooding. (Land shown in dark blue on the Flood Map).
Zone 3b The Functional Floodplain	This zone comprises land where water has to flow or be stored in times of flood. Local planning authorities should identify in their Strategic FRAs areas of functional floodplain and its boundaries accordingly, in agreement

Flood Zone	Definition
	with the Environment Agency. (Not separately distinguished from Zone 3a on the Flood Map).

2.2.22 Annex 3: Flood risk vulnerability classification of the NPPF (Ref. 4), classifies the Flood Risk Vulnerability of various land uses in **Table 2-2** below. The More Vulnerable classification encompasses usages such as hospitals and buildings used for dwellings. Less Vulnerable applies to buildings used for general industry, storage and distribution.

Table 2-2: Development Type and Vulnerability Classification – Reproduced from Annex 3 of the NPPF

Development Type	**Definition**
Essential Infrastructure	• Essential transport infrastructure (including mass evacuation routes) which has to cross the area at risk. • 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; and water treatment works that need to remain operational in times of flood. • Wind turbines. • Solar farms.
Highly Vulnerable	• Police and ambulance stations; fire stations and command centres; telecommunications installations required to be operational during flooding. • Emergency dispersal points. • Basement dwellings. • Caravans, mobile homes and park homes intended for permanent residential use. • Installations requiring hazardous substances consent (Where there is a demonstrable need to locate such installations for bulk storage of materials with port or other similar facilities, or such installations with energy infrastructure or carbon capture and storage installations, that require coastal or water-side locations, or need to be located in other high flood risk areas, in these instances the facilities should be classified as “essential infrastructure”).
More Vulnerable	• Hospitals.

Development Type	**Definition**
	• Residential institutions such as residential care homes, children's homes, social services homes, prisons and hostels. • Buildings used for dwelling houses, student halls of residence, drinking establishments, nightclubs and hotels. • Non–residential uses for health services, nurseries and educational establishments. • Landfill and sites used for waste management facilities for hazardous waste. • Sites used for holiday or short-let caravans and camping, subject to a specific warning and evacuation plan.
Less Vulnerable	• Police, ambulance and fire stations which are not required to be operational during flooding. • Buildings used for shops, financial, professional and other services, restaurants and cafes, hot food takeaways, offices, general industry, storage and distribution, non–residential institutions not included in "more vulnerable", and assembly and leisure. • Land and buildings used for agriculture and forestry. • Waste treatment (except landfill and hazardous waste facilities). • Minerals working and processing (except for sand and gravel working). • Water treatment works which do not need to remain operational during times of flood. • Sewage treatment works (if adequate measures to control pollution and manage sewage during flooding events are in place). • Car Parks.
Water-compatible Development	• Flood control infrastructure. • Water transmission infrastructure and pumping stations. • Sewage transmission infrastructure and pumping stations. • Sand and gravel working. • Docks, marinas and wharves. • Navigation facilities. • Ministry of Defence installations.

Development Type	**Definition**
	• Ship building, repairing and dismantling, dockside fish processing and refrigeration and compatible activities requiring a waterside location. • Water-based recreation (excluding sleeping accommodation). • Lifeguard and coastguard stations. • Amenity open space, nature conservation and biodiversity, outdoor sports and recreation and essential facilities such as changing rooms. • Essential ancillary sleeping or residential accommodation for staff required by uses in this category, subject to a specific warning and evacuation plan.

2.2.23 The Scheme falls within the definition of ‘Essential Infrastructure’. The overall aim of the sequential approach is to steer new development to areas of lowest flood risk, i.e., Flood Zone 1 and low surface water flood risk (Sequential Test). Where there are no reasonable sites available outside areas at risk of flooding, Flood Zones 2 and 3 may be considered, subject to passing the Exception Test, as required and set out in **Table 2-3** below.

2.2.24 Surface water flood risk has been reviewed alongside the Environment Agency (Gov.uk) published Updated Flood Map for Surface Water (EA uFMfSW) (Ref. 6).

2.2.25 The EA uFMfSW (Ref. 6) shows where areas could be potentially susceptible to surface water flooding in an extreme rainfall event.

2.2.26 The latest surface water mapping assesses flooding resulting from severe rainfall events based on the following three scenarios:

a. High Risk:1 in 30 year (0.33%) annual probability event;

b. Medium Risk: 1 in 100 year (1%) annual probability event; and

c. Low Risk: 1 in 1000 year (0.1%) annual probability event.

2.2.27 Land at lower than 1 in 1000 (0.1%) annual probability of flooding is considered to be a “Very Low” risk.

The Sequential Test and Exception Test

2.2.28 NPS EN-1(Ref. 1) and the NPPF(Ref. 4) set out the requirements of the Sequential Test, which is a risk-based test that should be applied at all stages of development.

2.2.29 All plans should apply a sequential, risk-based approach to the location of development – taking into account all sources of flood risk and the current and future impacts of climate change – so as to avoid, where possible, flood risk to people and property. They should do this, and manage any residual risk, by applying the sequential test and then, if necessary, the exception test as set out below:

a. Safeguarding land from development that is required, or likely to be required, for current or future flood management;

b. Using opportunities provided by new development and improvements in green and other infrastructure to reduce the causes and impacts of flooding, (making as much use as possible of natural flood management techniques); and

c. Where climate change is expected to increase flood risk so that some existing development may not be sustainable in the long-term, seeking opportunities to relocate development, including housing, to more sustainable locations.

2.2.30 The aim of the Sequential Test is to steer new development to areas with the lowest risk of flooding from any source. Development should not be allocated or permitted if there are reasonably available sites appropriate for the development in areas with a lower risk of flooding. A Strategic FRA will provide the basis for applying this test. The sequential test approach should be used in areas known to be at risk now or in the future from any forms of flooding.

2.2.31 If it is not possible for development to be located in areas with a lower risk of flooding (taking into account wider sustainable development objectives), the Exception Test may have to be applied. The need for the Exception Test will depend on the potential vulnerability of the site and of the development proposed, in line with the Flood Risk Vulnerability Classification set out in Annex 3). **Table 2-3** below reproduces the flood risk vulnerability and flood zone compatibility, as set out in Table 2 of the PPG(Ref. 5).

Table 2-3: Flood Risk Vulnerability and Flood Zone Compatibility – Table 2 of the PPG 2022

Flood Zone	Essential Infrastructure	Highly Vulnerable	More Vulnerable	Less Vulnerable	Water compatible
Zone 1	✓	✓	✓	✓	✓
Zone 2	✓	Exception Test Required	✓	✓	✓
Zone 3a	Exception Test Required	×	Exception Test Required	✓	✓
Zone 3b (functional floodplain)	Exception Test Required	×	×	×	✓
✓	Exception test is not required				
×	Development should not be permitted				

Flood Zone	Essential Infrastructure	Highly Vulnerable	More Vulnerable	Less Vulnerable	Water compatible
	Flood Zones that the Scheme sits within				

2.2.32 The NPPF(Ref. 4) states in paragraph 170 that, for the Exception Test to be passed, it should be demonstrated that:

a. The development would provide wider sustainability benefits to the community that outweigh the flood risk; and

b. The development will be safe for its lifetime taking account of the vulnerability of its users, without increasing flood risk elsewhere, and, where possible, will reduce flood risk overall.

2.2.33 Both elements of the Exception Test should be satisfied for development to be allocated or permitted.

2.2.34 Paragraph 5.8.11 of NPS EN-1(Ref. 1) echoes the wording for the requirements of the Exception Test as set out within the NPPF.

2.3 Local Planning Policy

2.3.1 The Order limits are primarily located within the administrative areas of Lincolnshire County Council and West Lindsey District Council. A portion of the Cable Route Corridor, west of the River Trent where National Grid Cottam Substation is located, is within Nottinghamshire County Council and Bassetlaw District Council administrative areas.

2.3.2 Lincolnshire County Council will consider the FRA (through consultation with the Environment Agency as necessary) as the Order limits are predominantly located in Flood Zone 1.

2.3.3 The following key planning documents and salient policies have been considered to inform this FRA:

a. Lincolnshire County Council;
   i. Preliminary FRA (2011) (Ref. 7)
   ii. Second Cycle Preliminary FRA for Lincolnshire (2017) (Ref. 8
   iii. Central Lincolnshire Local Plan (2023) (Ref. 9)
   iv. Joint Flood Risk and Water Management Strategy 2019-2050 (Ref. 10)

b. West Lindsey District Council:
   i. Strategic FRA (2009) (Ref. 11)

c. Bassetlaw District Council:
   i. Bassetlaw Local Plan 2020-2038 (Ref. 12)
   ii. Strategic FRA (2019) (Ref. 13)
   iii. Adopted Bassetlaw District Core Strategy and Development Management Policies Development Plan Documents (2011) (Ref. 14)

2.4 Internal Drainage Boards and Water Management Boards

2.4.1 Internal Drainage Boards (IDB) and Water Management Boards (WMB) are local public authorities that manage water levels within areas of special drainage need (Internal Drainage Districts) in England and Wales. Works relating to watercourses within these designated areas of the Order limits must seek consent from the relevant IDB/WMB.

2.4.2 The Order limits are located across two IDBs and one WMB.

2.4.3 The Cable Route Corridor adjacent to the Cottam Power Station is wholly within Trent Valley IDB, whilst watercourse catchments in the remainder of the Order limits are located within Upper Witham IDB and Scunthorpe and Gainsborough WMB.

2.4.4 The following documents have been considered to inform this FRA:

a. Scunthorpe and Gainsborough Water Management Board:

   i. Policy Statement on Flood Protection and Water Level Management (Ref. 15)
   ii. Application for works in Drainage District, Guidance notes (Ref. 16)
   iii. Land Drainage Byelaws (Ref. 17)

b. Upper Witham Internal Drainage Board:
   i. Policy Statement on Water Level and Flood Risk Management (Ref. 18)
   ii. Upper Witham Internal Drainage Board Byelaws (Ref. 19)

3. Supporting Information

3.1 Contributing Areas

3.1.1 Within hydrology, it is generally understood that permeable surfaces absorb rainfall whilst impermeable surfaces repel rainfall leading to surface water runoff. For a site, the total impermeable area is often referred to as the site's Contributing Area. The Contributing Area is used as part of the calculation to determine the volume of surface water runoff generated within the site. Developing greenfield sites (typically entirely permeable land) often increases the site's Contributing Area as existing natural permeable surfaces are sealed by impermeable surfaces.

3.1.2 For the Scheme, some existing permeable surfaces will be replaced by proposed impermeable surfaces across the Principal Site.

3.1.3 The proposed solar PV panel are assumed to not contribute to the total post-Scheme impermeable area as intercepted runoff drains directly to ground and the mounting structures holding the solar PV panels are usually supported by galvanised steel poles driven into the ground, therefore mitigating the need for concrete footings resulting in the ground beneath the solar PV panels remaining permeable.

3.1.4 It is expected that interception of rainfall by the solar PV panels will impose negligible impact on the with-Scheme scenario surface water runoff rates as the ground below and surrounding the solar PV panels is proposed to consist of native grassland and wildflower mix, which will provide permeable surface area for rainfall to drain directly to.

3.1.5 A comparison of the proposed and existing Principal Site has been undertaken to demonstrate how the with-Scheme scenario Contributing Area will be affected compared to the pre-Scheme scenario.

3.1.6 **Table 3-1** below presents this overall comparison (refer to **Appendix 10-4: Outline Drainage Strategy** of the ES **[EN010142/APP/6.2]** for detailed breakdowns of impermeable areas within the Scheme areas):

Table 3-1: Contributing Areas of the Developed Principal Site

	Total Area (ha)	Pre-Scheme Contributing Area (ha)	Post-Scheme Contributing Area (ha)	Pre-Scheme PIMP*	Post-Scheme PIMP
Extent of Principal Site	Approximately 1,350	0	27.56	0%	2.0%**

*- Percentage Impermeable Area (PIMP) – percentage of an area that is impermeable

**- Assumed operational buildings/compound areas are 100% PIMP. Photovoltaic (PV) panel areas assumed to have effective 0% PIMP

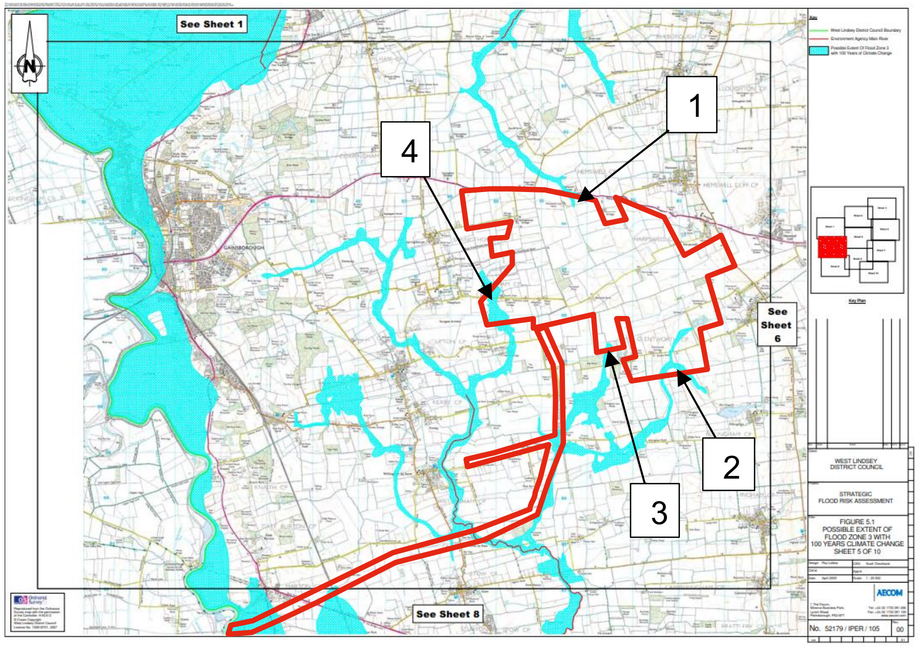
3.2 Existing Drainage

3.2.1 The area within the Principal Site is largely greenfield. Full topographical surveys of the Principal Site are included in Annex A of this report. It is unknown if formal piped drainage systems are present across the Principal Site. It is assumed that for low intensity rainfall events, rainfall is collected within the catchments and naturally drains to ordinary watercourses (surface water ditches) located along the field boundaries identified by the topographical surveys and LiDAR data downloaded from the Department for Environment Food and Affairs' (DEFRA) online service. For rainfall events where rainfall exceeds the maximum discharge rates of the ordinary watercourses, it is assumed that any excess runoff would flow overland and pond in low lying areas surrounding the ordinary watercourses before naturally draining after the event has occurred.

3.3 Existing Flood Risk from All Sources

3.3.1 **Table 3-2** summarises the pre-Scheme flood risk across the Order limits. Note the Order limits have been marked indicatively in **Table 3-2** maps, to represent the perspective of the Principal Site and Cable Route Corridor and surroundings in the context of the West Lindsey District Council's SFRA (Ref. 11) mapping. Refer to **Figure 2-1** of the ES **[EN010142/APP/6.3]** for the precise extent of the Order limits):

Table 3-2: Pre-Scheme Flood Risk Mapping

Flood Risk Source	Flood Risk Level	Comments
Fluvial	Low (majority of Principal Site and Cable Route Corridor) - High (two very small areas in Principal Site and area surrounding Cottam sub-station associated with River Trent within Cable Route Corridor)	 **Plate 3-1 – WLDC SFRA – Fluvial Flood Risk Map (Flood Zone 3 with cllimate change)** *Principal Site* WLDC's Strategic Flood Risk Mapping indicates the majority of the Principal Site is located within Flood Zone 1, with 4 small areas of Flood Zone 2 and 3 extents located near the Principal Site Order limits (Labelled 1 – 4 on **Plate 3-1**). Only one of these Flood Zone extent areas identified in **Plate 3-1** (labelled as "1" located at the northern boundary of the Principal Site) overlap with PV panel infrastructure proposed development areas. This overlap covers approximately 0.35 ha within field no. 56. The remaining Flood Zone extent areas shown on **Plate 3-1** (labelled, "2", "3" and "4") overlap with fields where no above ground infrastructure is proposed, for example to be used as opportunities for ecological enhancements.

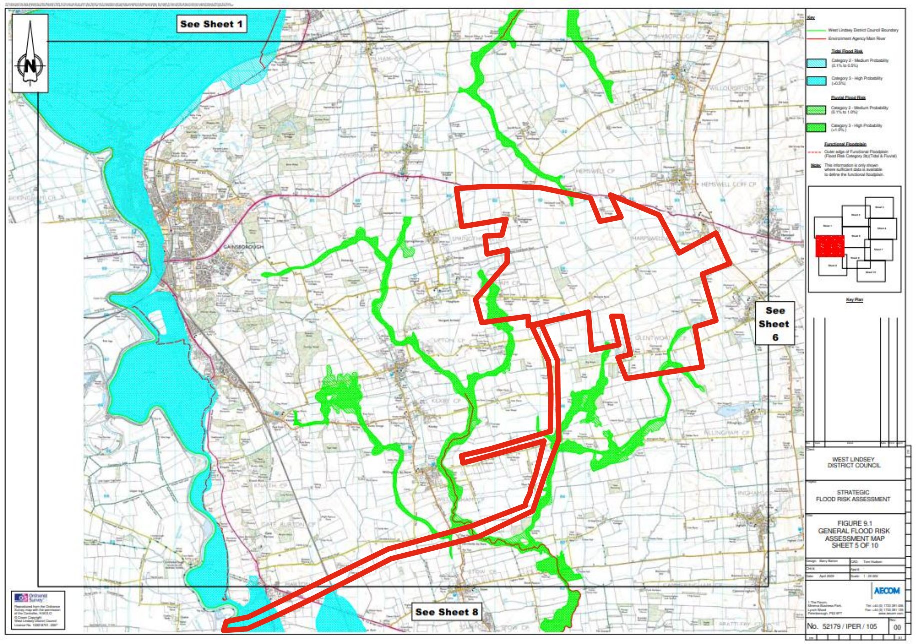
<table>
<tr><th>Flood Risk Source</th><th>Flood Risk Level</th><th>Comments</th></tr>
<tr><td></td><td></td><td>Cable Route Corridor
The majority of the Cable Route Corridor is located within Flood Zone 1 with small areas of Flood Zone 2 and 3 associated with watercourses. The area of the Cable Route Corridor located west of the River Trent, surrounding Cottam sub-station sits within Flood Zone 3.</td></tr>
<tr><td>Tidal</td><td>Low (Principal Site and majority of Cable Route Corridor) – Medium (small area of Cable Route Corridor where crossing the River Trent)</td><td>


Plate 3-2 – WLDC SFRA – Tidal Flood Risk Map (blue hatch)
The WLDC SFRA mapping indicates tidal flood risk only exists along the tidal estuary of the River Trent where flood defences are in place. The Principal Site is not in close proximity to this risk area.</td></tr>
</table>

Flood Risk Source	Flood Risk Level	Comments

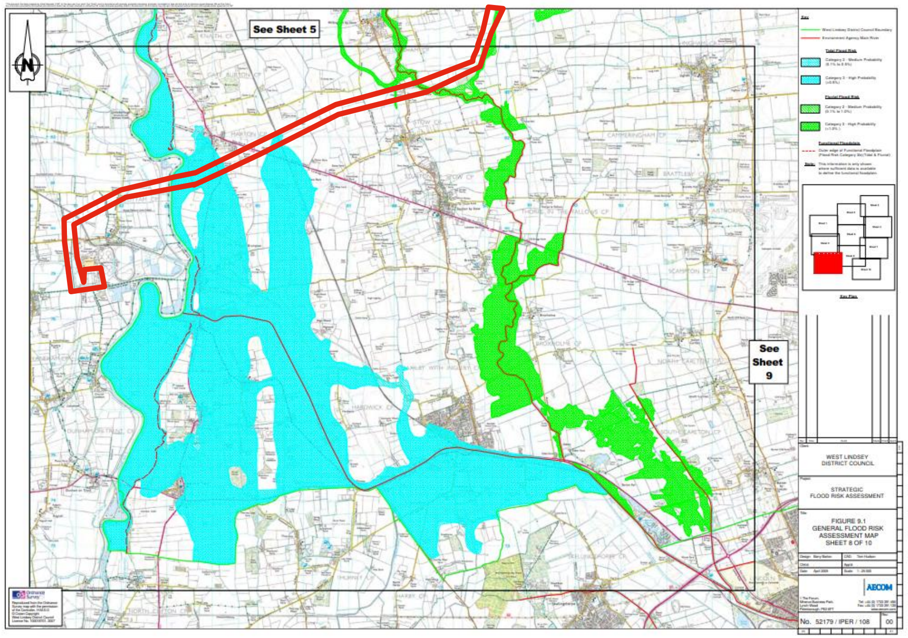
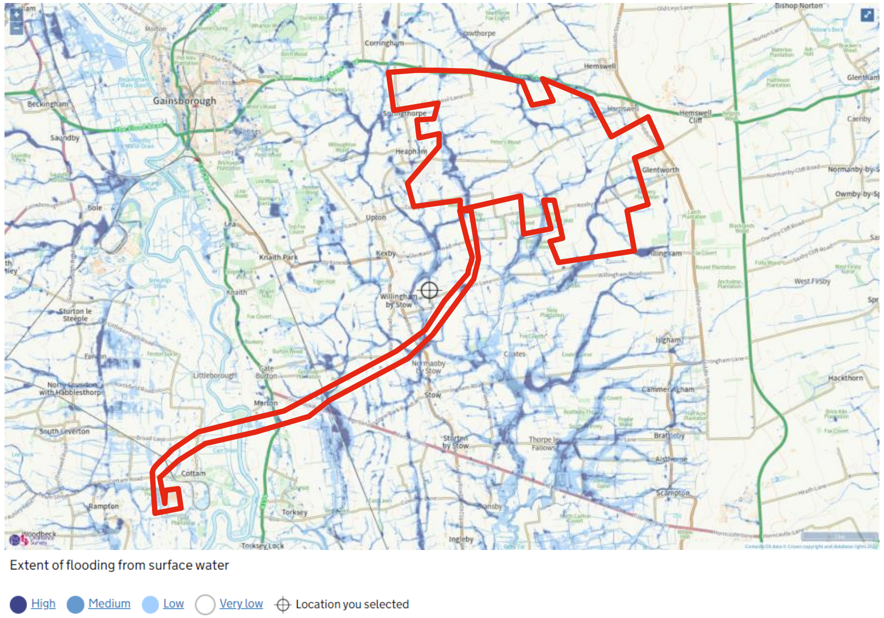
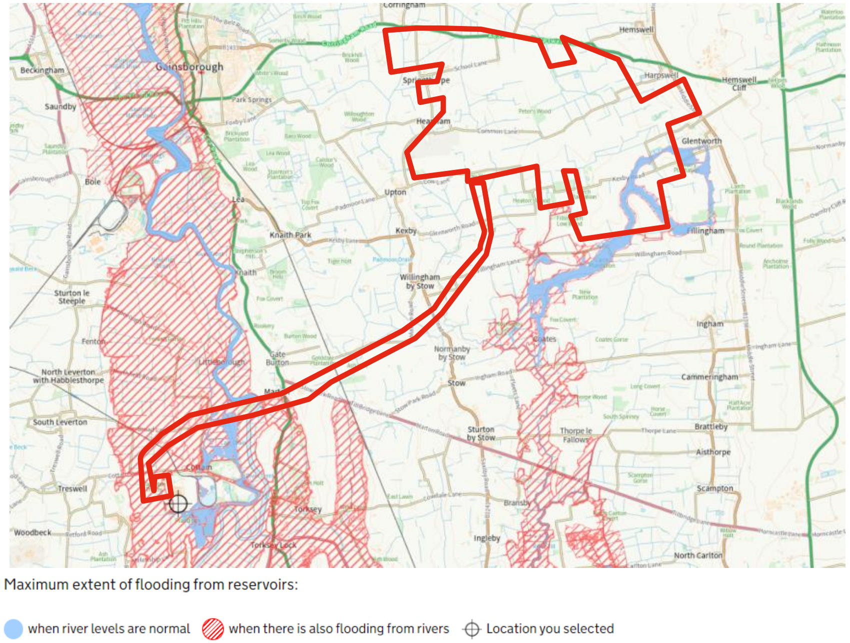


Plate 3-3 – WLDC SFRA – Tidal Flood Risk Map (Blue Hatch)

The Cable Route Corridor passes through an area of High risk, associated with the River Trent as it is subject to tidal influence within this area.

Flood Risk Source	Flood Risk Level	Comments
Pluvial (surface water)	Very Low (majority of Order limits) – High (areas associated with watercourses)	 **Plate 3-4 – Gov.uk – Flood Map for Surface Water (accessed January 2023)** Gov.uk Online Flood Maps (Ref. 30) indicate the majority of the Order limits lie in areas of Very Low risk from surface water flooding. There are small areas ranging from low to high risk associated with watercourses. The area of the Cable Route Corridor crossing the River Trent is shown to be generally low risk.
Groundwater	Low (Principal Site and majority of Cable Route Corridor) – High (Cable Route Corridor within	Majority of boreholes are confidential, with restricted access across the Principal Site. LCC PFRA (Ref. 7) notes groundwater flooding in the region of Louth, far east of the Order limits (~20km); this area is not impacted by the Scheme. No other groundwater flooding has been identified within the Principal Site or Cable Route Corridor within the boundary of Lincolnshire County Council. The Principal Site and majority of the Cable Route Corridor lies atop mudstones and clays, with little ability

Flood Risk Source	Flood Risk Level	Comments
	Bassetlaw District Council Boundary)	to store water. Given the Principals Site’s high elevation and at the top of river catchments, groundwater risk is considered Low. Mapping available via the Bassetlaw District Council SFRA (Ref. 13) shows the proportion of each 1km grid square, where geological and hydrogeological (underground water) conditions indicate that groundwater might emerge. Within the Order limits, the SFRA mapping indicates the Cable Route Corridor within the floodplain of the River Trent has a greater than 75% chance of groundwater emergence during a flood event. The Bassetlaw District Council SFRA notes that the mapping does not show the likelihood of groundwater flooding occurring. There are no recorded historic groundwater flooding events within the vicinity of the Cable Route Corridor located within the Bassetlaw District Council Boundary. Residual groundwater flood risk is considered to be High. The risk of flooding from groundwater sources during the construction and decommissioning phases is to be managed via the **Framework CEMP [EN010142/APP/7.8]** and **Framework DEMP [EN010142/APP/7.10]** respectively.
Sewers	Low	The WLDC SFRA (Ref. 11) indicates the risk of sewer surcharging resulting in flooding events is limited to urbanised areas of the District. The Principal Site’s rural location means that the risk of flooding from sewers exceeding their hydraulic capacity is low. The Cable Route Corridor passes through various roads including the A156. Risk of flooding from sewers located within these roads during the construction and decommissioning phases is to be managed via the **Framework CEMP [EN010142/APP/7.8]** and **Framework DEMP [EN010142/APP/7.10]** respectively.

Flood Risk Source	Flood Risk Level	Comments
Artificial sources	Low	 **Plate 3-5 – Gov.uk – Reservoir Flood Risk Mapping (accessed January 2023)** *Principal Site* Online Flood Maps (Ref. 30) show the maximum extent of flooding from reservoirs extends into a small area within the Principal Site boundary towards the south-east near Kexby Road and extends into areas of the Principal Site where no above ground infrastructure is proposed. This is associated with the unnamed ordinary watercourse which acts as a tributary to the canalised downstream end of the River Till (Fossdyke Canal). The WLDC SFRA (Ref. 11) indicates the Canal is infrequently full and can be considered a minor flood risk source. An anaerobic digestion pit is located adjacent to Field 59. The pit is approximately 100m x 100m in size and up to 2.0m deep above existing ground level. A pit of this size will fall within environmental

Flood Risk Source	Flood Risk Level	Comments
		permitting regulations and is considered to be in good working order and any embankments are monitored and maintained in good condition, to comply with the regulations (Ref. 29). *Cable Route Corridor* The online flood mapping (Ref. 30) also shows areas of the Cable Route Corridor lying over the flood extents "*when river levels are normal"* and "*when there is also river flooding*", i.e. the flood extents of reservoir flooding are greater (higher risk) during flood events where the rivers are at capacity and utilising floodplain storage.

3.4 Watercourses

3.4.1 Watercourses are designated as Main Rivers or ordinary watercourses. Main Rivers are identified on the Statutory Main River Map (Ref. 20) and are maintained by the Environment Agency, whereas ordinary watercourses are maintained by the Lead Local Flood Authority.

3.4.2 The following watercourses lie within the Order limits:

a. Main Rivers:
   i. There are no main rivers present within the Principal Site.
   ii. The River Till runs passes through the Cable Route Corridor flowing in a southerly direction from Kexby to Stow.
   iii. The River Trent passes through the Cable Route Corridor southwest of Marton flowing towards Torksey.

b. Ordinary Watercourses:
   i. Yewthorpe Beck is the only identified ordinary watercourse present within the Principal Site Order limits with associated Flood Zone 2 and 3 extents overlapping fields where Solar PV infrastructure is proposed. It is located on the northern boundary of the Principal Site crossing under Harpswell Lane northwards towards Yewthorpe, labelled as “1” in **Plate 3-4**.
   ii. Various other unnamed watercourses are present within the Order limits, consisting of tributaries to main rivers and surface water ditches along field boundaries; however, these have no material long term flood risk impact to or from the Scheme.

3.5 Geology and Hydrology

3.5.1 A desktop assessment has been completed to determine bedrock and superficial geology within the Order limits. British Geological Society (BGS) Online (Ref. 28) maps indicate the Order limits sit across various bedrock formations, including Marlstone Rock Formation, Scunthorpe Mudstone Formation, Charmouth Mudstone Formation, Penarth Group, and Mercia Mudstone Group. The mapping indicates the Order limits lie within various superficial deposit types, including Till, Mid Pleistocene (Diamicton), Alluvium (clay, silt, sand and gravel), and Glaciofluvial Deposits, Mid Pleistocene (sand and gravel).

3.5.2 The Environment Agency’s Online Interactive Maps for Groundwater (Ref. 21) shows that the Principal Site has a Medium groundwater vulnerability. The Maps also show the Cable Route Corridor generally follows the medium risk areas before reaching the River Trent and continuing to Cottam, where the vulnerability increased to Medium-High.

4. Assessment of Flood Risk (Principal Site)

4.1 Flood risk from all sources

4.1.1 The following section assesses the flood risk from the following sources against the Site Layout Plan, shown on **Figure 3-1: Indicative Principal Site Layout Plan [EN010142/APP/6.3],** included within Annex B, for the with-Scheme scenario:

a. Fluvial (Rivers and the Sea);

b. Surface Water;

c. Sewers;

d. Groundwater; and

e. Artificial waterbodies.

4.1.2 The methodology used to assess the flood risk is detailed below:

a. **Low**: where little risk is identified or any theoretical risk identified is classified as low within Local Authority SFRAs and/or EA flood risk mapping extents, with low probability of flooding occurring.

b. **Medium:** where risk is identified within Local Authority SFRA and/or EA flood risk mapping extents indicating a medium probability, but manageable flood risk with little to no mitigation required; and

c. **High:** where modelled levels within Local Authority SFRA and/or EA flood risk mapping extents show risk to the Scheme as a high probability of flood risk and where mitigation needs to be considered and residual risks controlled.

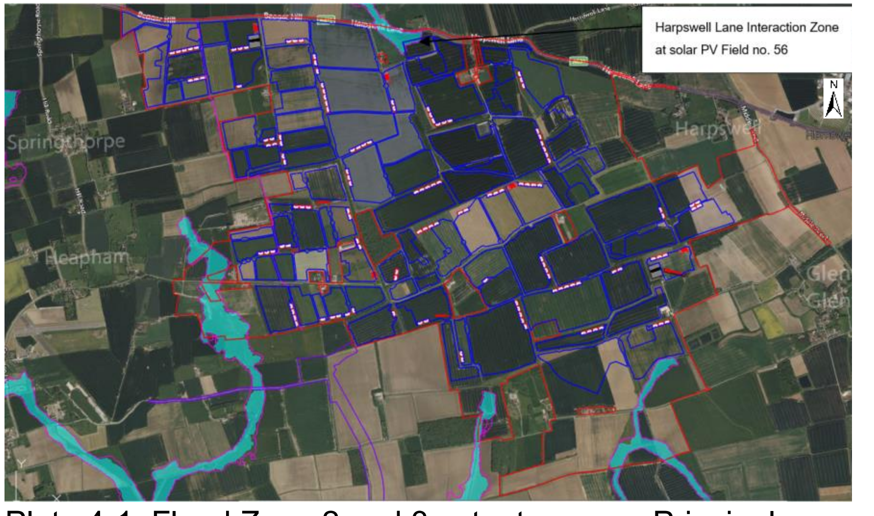
4.1.3 Through the sequential test process and design iterations, all proposed buildings/compound areas and the majority of the solar PV panels and mounting structures will be located outside of Flood Zones 2 and 3 i.e. in Flood Zone 1.

4.1.4 The River Trent, River Till and other ordinary watercourses will not be impacted by a change in flood risk level within the Cable Route Corridor as no above ground installations are proposed for the operational phase of the Scheme.

4.1.5 Any proposed infrastructure shown to be at risk from flooding during the with-Scheme scenario is to be mitigated as discussed further in **Section 7**.

4.1.6 **Table 4-1** summaries the flood risk as a result of the Scheme.

Table 4-1: With-Scheme Flood Risk Summary (Operational Phase)

Flood Risk Source	Flood Risk Level	Comments
Fluvial	Low (Principal Site) – with two small areas (circled in Blue) in Principal Site where solar PV panels are proposed.	The majority of the Principal Site is deemed to be at low risk of fluvial flooding for the with-Scheme scenario. One area noted previously in **Plate 3-1** and indicated by the label below in **Plate 4-1**, a small area of proposed PV field no. 56 adjacent to its northern edge, overlapping with the Environment Agency Flood Zone 2 and 3 extents. The area of overlap is hereby referred to in this FRA as the "Interaction Zone".  Plate 4-1: Flood Zone 2 and 3 extents across Principal Site. **Source: DEFRA online Flood Zone 2 Dataset (Ref. 22) (2024), DEFRA online Flood Zone 3 Dataset (Ref. 23) (2024). Copyright and database right 2024. Esri, Maxar, GeoEye, Earthstar Geographics, CNES/Airbus DS,**

USDA, USGS, AeroGRID, IGN, and the GIS User Community Esri, HERE, Garmin, © OpenStreetMap contributors, and the GIS user community

Plate 4-2 displays the Interaction Zone in more detail, which limited to an area covering approximately 0.35ha in solar PV field no. 56.

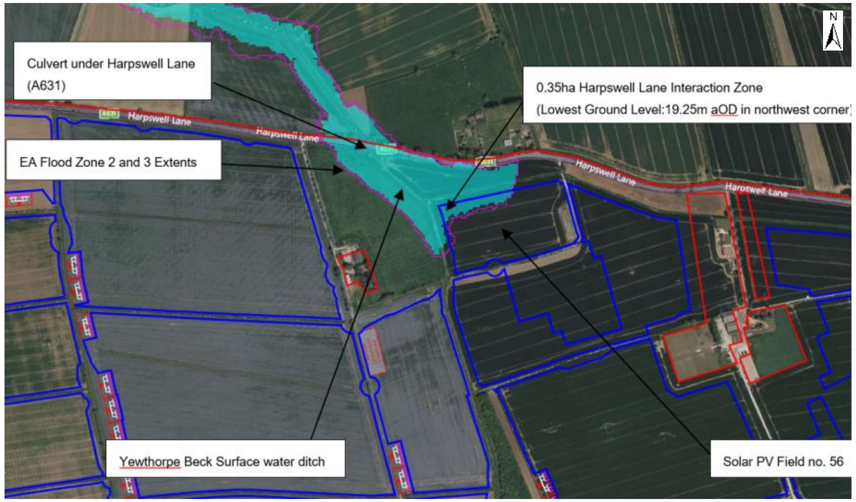
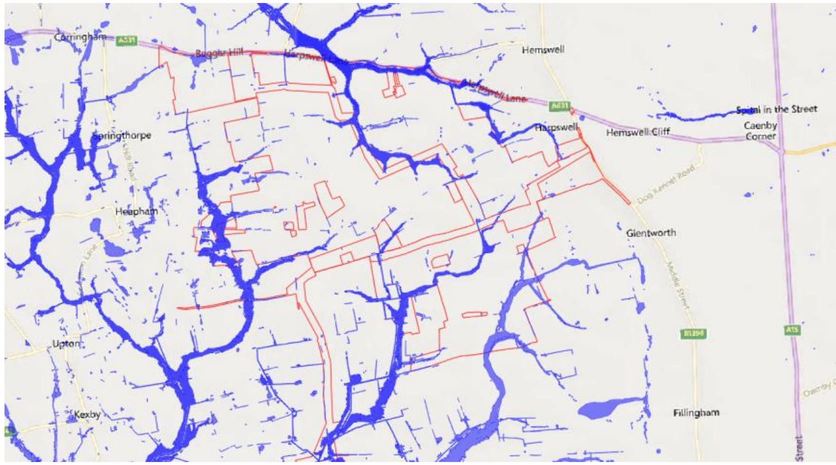


Plate 4-2: Flood Zone 2 and 3 extents

Source: DEFRA online Flood Zone 2 Dataset (Ref. 22) (2024), DEFRA online Flood Zone 3 Dataset (Ref. 23) (2024). Copyright and database right 2024. Esri, Maxar, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community Esri, HERE, Garmin, © OpenStreetMap contributors, and the GIS user community

Flood Risk Source	Flood Risk Level	Comments
		Solar PV panels and mounting structures proposed within the Interaction Zone will not alter the existing flood extents topography and are proposed to be installed at heights to enable sufficient freeboard of at least 300mm during the design storm event flood depth, including allowances for climate change. Solar PV panels are to be mounted at the typical height 600mm above ground level across the remaining Solar PV fields within the Principal Site (all remaining solar PV fields are designated as Flood Zone 1 land). Raised PV panels with sufficient freeboard are proposed within the Interaction Zone, will be located in Flood Zones 2 and 3. i.e. all other above ground infrastructure Solar Stations, batteries or inverters are proposed within Flood Zone 1. No fluvial compensation will be required as a result of PV panels being located within the Interaction Zone as the mounting structure legs are proposed to be less than 100mm in diameter. The impact on floodplain volume loss within the Interaction Zone due to the Scheme has been discussed in consultation with the Environment Agency, IDB and LLFA and is envisaged to result in negligible impact due to the small areas involved. The typical density of PV panels proposed across the Scheme is 1,500 per ha, the resultant loss of flood plain volume during the design scenario due to PV mounting structure legs for the Yewthorpe Beck floodplain south of Harpswell Lane is approximately 1.03m^3. Calculations of

Flood Risk Source	Flood Risk Level	Comments
		the flood volume loss are included in Annex E of this report. Risk remains Medium with no increase in flood risk to the Scheme or elsewhere.
Tidal	Low	No change to flood risk level as a result of the Scheme. Principal Site not impacted by Tidal risk.
Pluvial (surface water)	Medium	 **Plate 4-3 Surface Water Flood Mapping** **Source: DEFRA online RoFSW Dataset (Ref. 23) (2023)** Surface water flood risk is generally low across the Principal Site, with some areas of Medium risk associated with natural topography valleys draining north and south from the Scheme. Solar PV panels and mounting structures will not increase surface water flood risk as they

Flood Risk Source	Flood Risk Level	Comments
		are not considered to alter the exiting drainage regime. Any increased surface water runoff from impermeable areas is proposed to be managed to mimic the pre-Scheme conditions for up to and including the 1 in 100 + 40% Climate Change (CC) event as detailed in the **Outline Drainage Strategy** (**Appendix 10-4** of the ES **[EN010142/APP/6.2]**). Flood Risk will not increase elsewhere as a result and, therefore, remains Medium.
Groundwater	Low	The **Outline Drainage Strategy** (**Appendix 10-4** of the ES **[EN010142/APP/6.2]**) does not propose to utilise infiltration techniques to discharge increased surface water runoff. No change to flood risk level.
Sewers	Low	The Scheme does not impact any existing sewage infrastructure, and no new infrastructure is proposed. No change to flood risk level.
Artificial sources	Low (Principal Site)	The Scheme does not impact artificial sources of flood risk and does not propose above ground infrastructure located within the vicinity of an existing artificial flood risk source. The anaerobic digesting pit adjacent to Field 59 is considered to be maintained within an environmental permit under the regulations (Ref. 29) with a low residual risk to the Scheme. No change to flood risk level.

4.2 Climate Change

4.2.1 As of July 2021, the guidance (Ref. 27) for climate change allowances used in FRAs have changed, and now propose peak river flow allowances based on Water Framework Directive catchment areas, instead of nationwide allowances in previous iterations of guidance. The DEFRA mapping website ‘Climate change allowances for peak river flow in England (Ref. 24) (accessed January 2024) has been reviewed to confirm the revised climate change allowances for the two catchment areas that cover the Order limits. These values have been used in this assessment. Refer to **Plate 4-4** below.

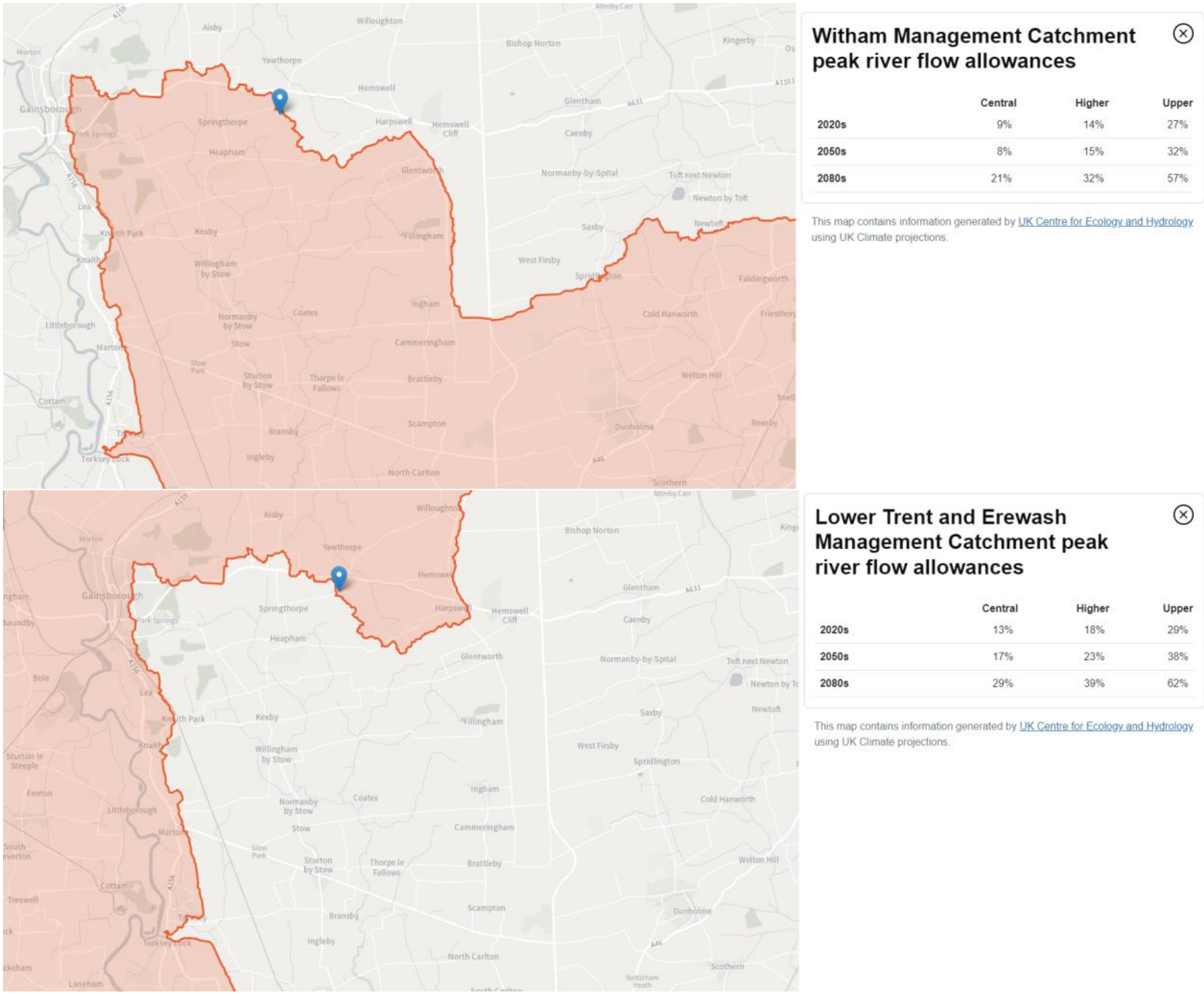


Plate 4-4: Peak River Flow Climate Change Allowances per Catchment

4.2.2 Climate change allowances relate to predicted percentage increase in peak river flows as a result of the effects of climate change, which development projects like the Scheme must take into account in their design.

4.2.3 The current allowance for design purposes for the Order limits are the Higher Central allowance of 39% and 32% (for Essential Infrastructure), for the Lower Trent and Erewash Management Catchment and Witham Management Catchment, respectively.

4.2.4 As the Scheme is located across the two Management Catchments, the highest value of 39% allowance has been used to provide a robust assessment for design across the whole Scheme based on a worst-case scenario.

4.2.5 An additional assessment for Essential Infrastructure projects is the application of the H++ Scenario climate change allowance for sea level rise; a sensitivity assessment to ensure infrastructure can operate in extreme events involving a tidal influence. Previously, the H++ Scenario would be applied to Infrastructure projects of this scale. The H++ scenario provides an estimate of sea level rise and river flood flow change beyond the likely range (i.e. an extreme event beyond expected climate change allowances) but within physical plausibility. It is useful for contingency planning to understand what might be required if climate change were to happen much more rapidly than expected.

4.2.6 **Section 4.3** discusses the H++ scenario for the Scheme.

Credible Maximum Scenario (CMS)

4.2.7 The online Environment Agency guidance ("Flood risk assessments: climate change allowances") (Ref. 34) indicates that for "Assessing credible maximum scenarios for nationally significant infrastructure projects, new settlements or urban extensions":

"*If you develop NSIPs you may need to assess the flood risk from a credible maximum climate change scenario*" (CMS)

4.2.8 The test should be treated as a 'sensitivity test', to help you assess how sensitive a proposal is to changes in the climate for different future scenarios. This will ensure a proposed development can be adapted to large-scale climate change over its lifetime to ensure infrastructure remains operational in times of extreme flooding.

4.2.9 The CMS allowance to be referred to in this assessment is the Upper End for the 2080s Epoch, from **Plate 4-4** this value is 62%. This is based on the Upper End allowance for climate change, which in this case (using the Lower Trent and Erewash Management Catchment.

4.2.10 **Section 4.4** below discusses flood risk within the context of climate change allowances. Annex C includes a fluvial flood level technical note which discusses the areas of PV panels located in Flood Zone 2 and 3 and reviews and applies these climate change allowances in the assessment.

4.3 With-Scheme Tidal Flood Risk

4.3.1 Sea level rise and the H++ scenario have been considered in this FRA. An assessment of sea level rise has been undertaken to demonstrate the Principal Site is not at risk of sea level rise, from climate change or when incorporating the H++ scenario.

4.3.2 The River Trent tidal mapping in the WLDC SFRA (Ref. 11) indicates tidal flood risk limited to the western extent of the Cable Route Corridor, with no impact on the Principal Site. Furthermore, tidal defences are in place along the River Trent; however, the calculations have been undertaken assuming these are not in place.

4.3.3 There are a range of allowances for each river basin district and epoch for sea level rise. They are set out in Table 2 of the Environment Agency online Climate Change Assessment guidance (Ref. 25) and are based on percentiles. A percentile describes the proportion of possible scenarios that fall below an allowance level. **Table 4-2** below indicates the sea level rise estimate, for the epochs for the Humber River basin catchment.

Table 4-2: Extract from Table 2 of Environment Agency Sea Level Rise Tables (Online) (Ref. 26)

Area of England	Allowance	2000 to 2035 (mm/yr)	2000 to 2035 (mm) – Cumulative Total	2036 to 2065 (mm/yr)	2036 to 2065 (mm) – Cumulative Total	2066 to 2095 (mm/yr)
Humber	Higher central	5.5	193	8.4	252	11.1
Humber	Upper end	6.7	235	11	330	15.3

4.3.4 The sea level rise allowances account for slow land movement. This is due to ‘glacial isostatic adjustment’ from the release of pressure at the end of the last ice age. The northern part of the UK is slowly rising and the southern part is slowly sinking. This is why net sea level rise is predicted to be less for the north-west and north-east than the rest of the country.

4.3.5 The design life of the Scheme is anticipated to be approximately 60 years and decommissioning is expected to commence thereafter, albeit the operational life may extend beyond this date.

4.3.6 Sea level rise poses a potential risk to the Cable Route Corridor, but it is not considered to impact the Principal Site. It has been estimated, using the Environment Agency’s online sea level rise data for the Humber River basin management area, sea level could rise by up to approximately 902mm by the year 2088; assessed by accumulating the mm/yr increase in sea level depth in each epoch up to the year 2068. Refer to Calculations in **Annex D** for more detail.

4.3.7 A rise of 902mm would provide a tidal flood level of 609m AOD. Applying the H++ analysis as a sensitivity test, i.e. applying a maximum 1.9m rise, the tidal level could theoretically reach 7.09m by 2100.

4.3.8 The lowest site level across the Principal Site is 13.13m AOD (from LiDAR review). This level is over 6m above the H++ level. Therefore, sea level rise is not considered to pose a risk to the solar PV panels and battery/compound areas of the Scheme. There is no permanent above ground infrastructure proposed along the Cable Route Corridor. As such, no mitigation is required to protect finished levels of infrastructure due to sea level rise.

4.3.9 Combined fluvial and tidal modelling is not considered necessary for this Scheme as it is not reasonable to assume sea level will rise a further 6m to the lowest level of the Principal Site, even with fluvial interaction, due to the landscape topography around the River Trent catchment and lower lying expanses of land around the Trent floodplain.

4.3.10 In summary, the flood risk to structures (Principal Site) and the risk to people associated with sea level rise is considered low, with no mitigation required.

4.4 With-Scheme Fluvial Flood Risk

4.4.1 The following section provides an assessment of fluvial flood risk level to and from the Principal Site. The assessment demonstrates that the Scheme will not result in an increase to existing flood risk levels within and surrounding the site through the implementation the **Outline Drainage Strategy** (**Appendix 10-4** of the ES **[EN010142/APP/6.2]**) and identifies any areas within the Principal Site Order limits where mitigation measures are required to protect the proposed Scheme infrastructure from future fluvial flood events when taking climate change into consideration.

Fluvial Flood Risk as a result of the Scheme Infrastructure

4.4.2 The **Outline Drainage Strategy** (**Appendix 10-4** of the ES **[EN010142/APP/6.2]**) proposes that increased surface water flows from the Scheme as a result of new impermeable areas within the Principal Site will be managed and discharged to watercourses in-situ at existing greenfield rates via sustainable drainage techniques.

4.4.3 The strategy to control the with-Scheme discharge rates to mimic the pre-Scheme run-off conditions, mitigates any increases to peak river flow rates within the watercourses utilised for outfall locations within the Principal Site boundary. This strategy will result in no increase to fluvial flood risk levels within vicinity of the Principal Site throughout the design life of the Scheme.

Fluvial Flood Risk to the Scheme Infrastructure

4.4.4 The majority of the Principal Site is located within Flood Zone 1; therefore, all proposed Scheme infrastructure within this designation can be assessed to remain at low risk from the effects of fluvial flooding throughout the Scheme's design life.

4.4.5 Four small areas at higher fluvial flood risk than the majority of the Principal Site, i.e. land assessed as Flood Zone 2 or Flood Zone 3, are located within Principal Site's Order limits. The identification of the four areas discussed previously in **Table 3-2** demonstrates only one of these areas is proposed as having above ground infrastructure installed as a result of the Scheme (Harpswell Lane Interaction Zone).

4.4.6 The above ground infrastructure proposed within the Harpswell Lane Interaction Zone consists of Solar PV panels and mounting structures which are deemed to be suitable for placing in areas designated as Flood Zone 2 and 3 providing there is sufficient freeboard depth between the PV panels and the expected flood level. A summary of the separate technical assessment of this expected flood level is included in **Annex C** of this FRA is provided within this section and details of the mitigation measures required to ensure sufficient freeboard to the Solar PV panels within the Harpswell Lane Interaction Zone are provided in **Section 7** of the report.

4.4.7 The three remaining areas of Environment Agency Flood Zone 2 and 3 extents within the Principal Site Order limits do not have above ground infrastructure proposed (these areas are designated as having potential for ecological enhancements) and therefore considered to not change from the pre-Scheme scenario, meaning no mitigation measures for the effects of future fluvial flood events will be required.

4.4.8 Security fencing will be installed around the PV fields. Field 56 in the Harpswell interaction zone will have security fencing within the Flood Zone 3 extents. The fencing is typical 2.5m high open mesh chain fencing on timber posts. The fencing will not impede flood flows in and out of the floodplain.

4.4.9 The overall fluvial flood risk level for the Principal Site and surrounding areas in the with-Scheme scenario is therefore assessed to remain unchanged from the pre-Scheme Scenario.

Fluvial Flood Risk Level Assessment

4.4.10 The Environment Agency confirmed, in their response on 19 January 2023 to an Environment Agency Product Data request, that there are no designated main rivers and no detailed hydraulic modelling available for the watercourses in the Principal Site.

4.4.11 In order to assess the fluvial flood risk to the solar PV fields in the vicinity of the fluvial flood risk area within the Harpswell interaction zone, a catchment runoff approach has been undertaken to estimate potential flood depths, including allowances for climate change.

4.4.12 The assessment is based on the contributing pluvial runoff catchment area and the peak runoff rates that it can feasibly generate, related to the channel capacity and predicted flood risk as a result of exceeded channel capacity.

4.4.13 The minimum assessment parameters to base the assessment on and to assess suitability in addressing flood risk are set out below:

a. Flood Estimation Handbook (FEH) web service data has been used to assess the flood risk runoff rates;
b. Predicted flood level assessment undertaken using climate change allowances for the 2080’s Epoch for both the Higher Central and Upper End in lieu of a hydraulic model of the Yewthorpe Beck;
c. Design Climate Change Allowance: 32%;
d. Credible Maximum Scenario / Sensitivity Test: 62%;
e. Minimum Design Freeboard of 300mm; and
f. Credible Maximum Scenario depths shall not submerge the PV panels but can utilise the freeboard allowance.

4.4.14 As there is no detailed hydraulic model to assess the climate change values above, a conservative assessment of climate change based on excess catchment flows has been undertaken to provide an appropriate assessment of flood risk to the Solar PV panels in the Principal Site where they are at potential risk of flooding. Further detail is set out in the Technical Note which is included in **Annex C** of this FRA.

4.4.15 The Technical Note sets out the methodology, analysis, findings and proposes mitigation measures.

4.4.16 The analysis incorporates allowances for climate change as discussed in **Section 4.2**, consisting of allowances for the design flood event and a sensitivity check for the Credible Maximum Scenario flood event which are detailed at the end of this section.

4.4.17 The online flood risk mapping (Ref. 30) indicates the Harpswell Lane interaction zone contains a small area of solar PV panels within solar field no. 56, where fluvial flooding may occur between the ground level and the bottom of the solar PV panel.

4.4.18 A typical solar PV mounting structure secures the PV panel from underneath so that the lowest point of the PV Module is at least 600mm above ground level.

4.4.19 **Chapter 3: Scheme Description** of this ES **[EN010142/APP/6.1]** notes in paragraph 3.4.11 that solar PV panels will be equipped with sensors to detect flood waters and trigger the panel to tilt to increase the distance from the ground to the base of the panel. However, in order to provide a robust review of flood risk, the minimum height of 600mm has been used to undertake the assessment, providing a conservative approach in case of sensor failure.

4.4.20 3D surface models developed from LiDAR and drone survey data of the Principal Site and surrounding areas was developed using Autodesk Civils 3D software, providing geometric and ground level data of the surface water ditch and its surrounding floodplain adjacent to field no. 56.

4.4.21 An analysis of the watercourse channel and floodplain discharge capacities, and the catchment runoff volumes and flow rates was undertaken to enable a prediction of the design flood level.

4.4.22 The assessment determined the design flood level as 19.76m AOD.

4.4.23 The Technical Note proposes to mitigate the risk of fluvial flooding to the PV infrastructure by setting the lowest point of the PV panels to be mounted within the flood depth extents at 20.06m AOD. At this level the height of the PV panels above ground will enable a freeboard depth of 300mm (deemed suitable as per standing advice for development by the Environment Agency (Ref. 31)) between the lowest level of the PV panels and the expected fluvial flood level for the 1 in 100 year + Higher Central climate change allowance event. (i.e. the design allowance for the Scheme).

4.4.24 **Table 4-3** presents the lowest ground level and proposed lowest level solar PV panels in solar field no's 51, 56 and 57 within the interaction zone, as assessed from the 3D ground surface model.

Table 4-3 – Proposed Solar PV Panel Levels in Solar PV field no. 51, 56 and 57

Lowest Ground Level	Predicted Flood Level (1 in 100 year + CC Higher Central Allowance)	Predicted Flood Level (1 in 100 year + CC Upper End Allowance)	Proposed Lowest level of the base of solar PV Panels in FZ 3	Freeboard to base of raised solar PV Panel level (1 in 100 year + CC Higher Central Allowance)	Freeboard to base of raised solar PV Panel level (1 in 100 year + CC Upper End Allowance)
19.25m AOD	19.76m AOD	19.82m AOD	20.06m AOD	300mm	220 mm

4.4.25 The analysis estimates the predicted flood levels within the Harpswell Lane interaction zone, taking into account climate change. The analysis findings demonstrate that there will be no increased risk from fluvial flooding to the solar PV panel infrastructure proposed within the assessed climate change flood extent of field no's. 51, 56 and 57 when the base of the PV panel, when at their lowest height, is no lower than 20.06m AOD (i.e. at least 220mm higher than the credible maximum scenario flood level).

4.4.26 The Fluvial Flood Level Technical Note, therefore, demonstrates that there will be sufficient freeboard between the predicted worst case flood depth level and the solar PV Module infrastructure for up to the 1 in 100 year event, including allowances for climate change.

4.4.27 During a stakeholder consultation meeting held on 04.09.2023, the fluvial flood risk methodology and approach was presented to the Environment Agency, LLFA and IDBs. All stakeholders concluded that the fluvial flood risk assessment approach was deemed appropriate and proportional to the proposed Scheme. Therefore, it is considered that no additional detailed fluvial modelling is required as a result of this assessment.

4.4.28 A copy of the minutes from the consultation meeting are included in **Appendix 10-5** of the ES **[EN010142/APP/6.2]**.

4.4.29 The Fluvial Risk Technical Note provides an assessment of pluvial catchment runoff for the Yewthorpe Beck surface ordinary watercourse upstream of the Harpswell Lane interaction zone in lieu of a hydraulic model. To ensure a robust approach in estimating the greenfield runoff rates; for the design scenario flood event, the pluvial runoff assessment uses 150% greenfield rate in place of the 1 in 100 year + 32% (upper central allowance) climate change event, and in place of the 1 in 100 year + 62% (higher central allowance) climate change event, 200% of the greenfield rate is used to assess the credible maximum scenario.

4.4.30 The approach taken within the Fluvial Flood Risk Technical Note to estimate greenfield runoff rates was presented to the water environment stakeholders during a meeting on the fourth of September 2023. The feedback during the meeting concluded that with no further hydraulic modelling proposed, the approach was deemed "*appropriate to the scale and nature of the proposed development*". The minutes form the stakeholder meeting are included in **Appendix 10-5** of the ES **[EN010142/APP/6.2]**.

4.4.31 It is considered that fluvial flood risk to the Scheme infrastructure throughout its design life, including allowances for climate change a review of the credible maximum scenario can be sufficiently mitigated through the proposal to locally increase the mounting height of PV panels.

Floodplain Compensation Assessment

4.4.32 With any proposed scheme that has potential flood risk and consequential floodplain loss, an assessment of compensation should be provided. As discussed in this FRA, there is no permanent above ground infrastructure, other than Solar PV panels, that will be located with Flood Zone 2 and 3 extents. All other permanent above ground infrastructure and operational phase site compounds within the Principal Site will be located in Flood Zone 1.

4.4.33 The Fluvial Flood Risk Level Assessment estimates a design flood depth of 19.76m AOD within PV field 56, adjacent to the Yewthrorpe Beck ordinary watercourse, during the 1 in 100 year + climate change event (i.e. effectively the climate change extents of Flood Zone 3a).

4.4.34 The Fluvial Flood Risk Technical Note identifies the estimated flood risk depth level extends into a small number of Solar PV Panels in Fields 51 and 57 in addition to field 56, resulting in the lowest mounting height of Solar PV panels in these areas being set to 20.06m AOD to mitigate the risk of fluvial flooding.

4.4.35 **Plate 4-5** (extracted from Figure 7 of **Annex C: Fluvial Flood Risk Level Assessment Technical Note**) presents an overview of where the 19.76m AOD contour overlaps with fields 51, 56 and 57.

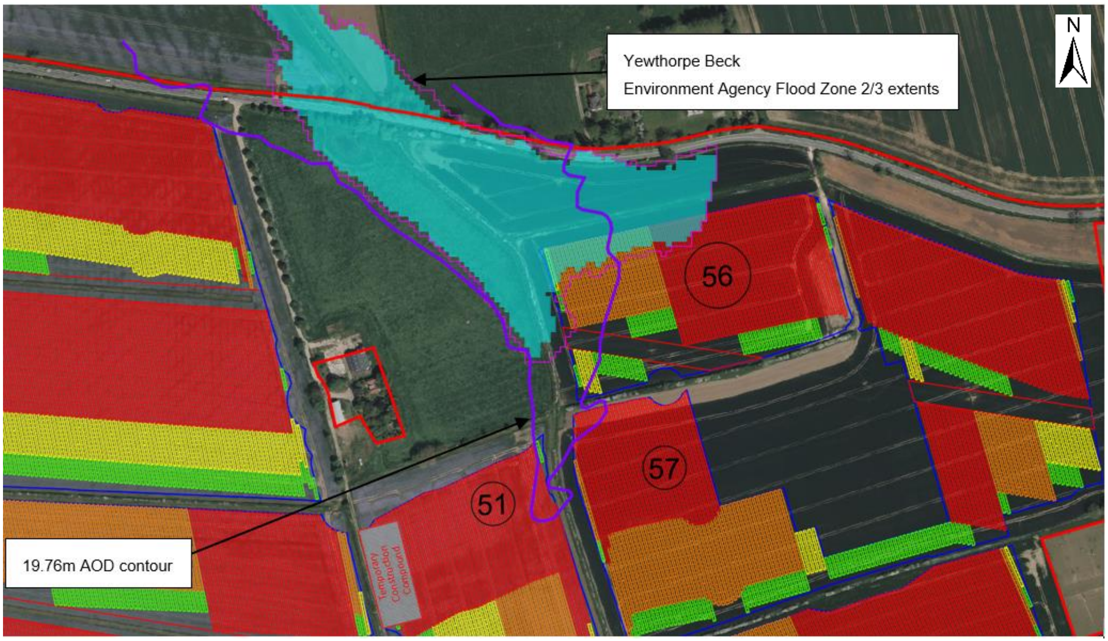


Plate 4-5: Design Flood Depth Extent

Source: Copyright and database right 2024. Esri, Maxar, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community Esri, HERE, Garmin, © OpenStreetMap contributors, and the GIS user community

4.4.36 **Plate 4-5** displays the design fluvial flood depth extent. This contour is considered to be a more robust representation of the Flood Zone 3a + climate change extents (determined by the fluvial flood risk assessment analysis). The online flood mapping displayed in **Plate 4-5**, including the area east of the design flood depth extent is based on 2004 National Generalised J-Flow modelling carried out for the initial release of the Flood Zones. This has been confirmed by the Environment Agency in their Product 4 data request response on 19 January 2023. This older modelling doesn't take into account channels, or their capacities which can result in unrepresentative outlines.

4.4.37 Each Solar PV panel is supported on three individual legs, using steel I beams and Sigma beams. The proposed density of the panels is approximately 1,562 panels per hectare. Each panel is support by two I beams and a Sigma Beam (for tracking panels; fixed panels will have thinner legs due to less weight to support).

4.4.38 A volumetric floodplain compensation calculation, assessing all three of the identified fields has been undertaken to determine if floodplain compensation is required. **Annex E** of this FRA includes further details and the volumetric assessment of the Solar PV panel support legs.

4.4.39 **Table 4-4** provides the cumulative results of the volumes occupied by the PV mounting structure leg within the design fluvial flood depth extents. See **Annex E** included within this FRA for full calculations.

Table 4-4: Total Volumes of PV Mounting Structures in Flood Depth Extents

PV field No.	Total PV field area within design flood depth extents (ha)	Total mounting structure leg cross sectional area within design flood depth extents (m^2)	Average depth within design flood depth extents (mm)	Total leg volume within design flood depth extents (m^3)
56	0.68	4.12	250	1.03
57	0.062	0.03	250	0.01
51	0.11	0.11	125	0.01
TOTAL	**0.852**	**-**	**-**	**1.05**

4.4.40 The results indicate that total of 1.05m^3 of floodplain volume is lost as a result of the Solar PV Panel infrastructure within the design flood depth extents. Across an area of 0.85ha, this results in an increase in the flood depth of approximately 0.34mm.

4.4.41 From practical experience, it is considered current fluvial modelling outputs can predict approximate flood depths within model cells to +/-10mm in tolerance. With LiDAR and drone survey tolerances between +/- 150mm and +/- 20-30mm respectively, it is considered a hydraulic model would not feasibly assess the floodplain loss at this scale of floodplain loss within a tolerance less than +/- 10mm.

4.4.42 Therefore, it is considered, with the estimated flood depth increase of 0.34mm, there will be no material increase in flood risk on the site or elsewhere. With the lack of receptors downstream of the interaction zone (open greenfield space) floodplain compensation is not required for the Scheme.

4.4.43 In summary, fluvial flood risk is not increased as a result of the Scheme, to the Scheme or elsewhere.

4.5 With-Scheme Surface Water Flood Risk

4.5.1 As discussed within **Table 3-2**, the surface water flood risk is generally low across the Principal Site for the Pre-Scheme scenario. However, as the Principal Site covers a considerable area, localised areas with variations from medium to high surface water flood risk are present. These medium to high risk areas are associated with topographical low spots and/or with the areas immediately surrounding the two watercourses identified in the Fluvial Flood Level Technical Note (Annex C).

4.5.2 The **Outline Drainage Strategy** (**Appendix 10-4** of the ES **[EN010142/APP/6.2]**) discusses in detail the increases in total impermeable area across the Principal Site for the with-Scheme scenario. The increases in impermeable area are envisaged to result in localised increases to surface water run off rates directly associated with BESS, on-site substations and operational phase compounds. The increase in surface water runoff from these areas is proposed to be managed via sustainable drainage techniques to temporarily attenuate the increased surface water flows before discharging to surrounding watercourses at restricted rates to mimic the pre-Scheme conditions for up to and including the 1 in 100 year + 40% climate change event.

4.5.3 As discussed within the **Outline Drainage Strategy** (**Appendix 10-4** of the ES **[EN010142/APP/6.2]**), it is considered that total impermeable areas where solar PV panels are proposed for the with-Scheme scenario will remain consistent to the pre-Scheme state. Therefore, the proposed PV panel areas are considered to not impact the post-Scheme surface water flood risk level associated specially in relation to the two watercourses identified in the Fluvial Flood Level Technical Note (**Annex C**). Further detail of the with-Scheme impermeable areas is discussed within the **Outline Drainage Strategy** (**Appendix 10-4** of the ES **[EN010142/APP/6.2]**).

4.5.4 Therefore, it is envisaged that there will be no increase to surface water flood risk on or surrounding the Principal Site for the with-Scheme scenario.

4.5.5 Surface water flood risk remains low overall.

4.6 With-Scheme Other Sources of Flood Risk

4.6.1 There are no Artificial Sources of flood risk within the Principal Site; therefore, flood risk remains low from Artificial Sources.

4.6.2 An anaerobic digestion pit is located adjacent to Field 59. The pit is approximately 100m by 100m in size and up to 2.0m deep above existing ground level. A pit of this size will fall within environmental permitting regulations and is considered to be in good working order and any embankments are monitored and maintained in good condition, to comply with the regulations (Ref. 29).

4.6.3 Groundwater flood risk is anticipated to remain unchanged, as there are no proposals for discharging surface water runoff via infiltration methods.

4.6.4 The with-Scheme scenario does not propose to interact or alter any existing sewer infrastructure and therefore will result in no change to flood risk from such sources. Construction risk of exposing or damaging sewers during the construction and decommissioning phases of the Scheme will be included and managed via the **CEMP [EN010142/APP/7.8]** and **DEMP [EN010142/APP/7.10]** respectively.

4.6.5 It is envisaged that flood risk levels from other sources (groundwater, sewers, or artificial bodies) within and surrounding the Order limits will remain unchanged.

4.6.6 Flood Risk from Artificial sources remains low (residual).

4.7 Temporary Construction Compounds (Principal Site)

4.7.1 The proposed temporary construction compounds each occupy an area of approximately 0.33ha.

4.7.2 During the construction phase of the Principal Site, there are five proposed temporary construction compounds proposed, illustrated on **Sheet 1** within **Chapter 10, Figure 10-5** of the ES **[EN010142/APP/6.1]**.

4.7.3 All five temporary construction compounds are located within Flood Zone 1. One of the five temporary construction compounds is located near to the flood risk area identified to be associated with Yewthorpe Beck, an ordinary watercourse. The Yewthorpe Beck has been subject to an assessment of climate change from the risk of fluvial flooding within this FRA. The predicted worst case climate change level for the credible maximum scenario (CMS) associated with Yewthorpe Beck is 19.82m AOD. The lowest approximate ground level of the temporary construction compound located nearest to the predicted flood extents is approximately 21.00m AOD. As it is considered the predicted level of 19.82m AOD is a conservative estimate of the flood level to assess the credible maximum scenario, the temporary construction compound is considered to be at low risk of fluvial flooding when taking into account climate change as the lowest ground level around the temporary construction compound is approximately 1.18m above the CMS level.

4.7.4 All five temporary construction compounds are located within areas of very low surface water flood risk and low risk from groundwater, sewers and other artificial sources.

4.7.5 The temporary construction compounds are proposed to be in place for up to 36 months during the Construction Phase, being replaced with solar PV panels during the Operational Phase. The assessment of solar PV panels during the Operational Phase where temporary construction compounds are proposed within the Principal Site conclude that no mitigation measures will be required within construction compound locations.

4.7.6 Therefore, it is considered the temporary construction compounds within the Principal Site are considered to be at low risk of flooding from all sources.

4.8 Flood Risk Summary

4.8.1 As previously discussed, the Scheme is not envisaged to impact fluvial, tidal, groundwater, sewers, or artificial risk levels of flooding within or surrounding the Order limits.

4.8.2 The increase in surface water runoff rates as a result of the with-Scheme scenario will be managed via sustainable drainage techniques proposed to mimic the pre-Scheme conditions detailed within the Outline Drainage Strategy (**Appendix 10-4** of the ES **[EN010142/APP/6.2]**), resulting in no impact to flooding from surface water sources within or surrounding the Order limits.

4.8.3 The pre- and post-Scheme flood risk conclusions are presented in **Table 4-4**.

Table 4-4: Flood Risk Summary (Principal Site)

Flood Risk Source	Pre-Scheme Flood Risk Level	Post-Scheme Flood Risk Level	Comments
Fluvial	Low (Principal Site)	Low (Principal Site)	Discharge from impermeable areas detailed in the **Outline Drainage Strategy** (**Appendix 10-4** of the ES **[EN010142/APP/6.2]**) are to be restricted to Greenfield rates, mitigating increases to peak river flow rates. Solar PV Panel infrastructure within Flood Zones 2/3 “interaction zones” are not envisaged to alter the existing flood extents’ topography and are proposed to be installed to enable sufficient freeboard during the worst case flooding scenarios.
Tidal	Low (majority of Order limits) – High (areas associated with watercourses)	Low (majority of Order limits) – High (areas associated with watercourses)	No change to flood risk level.
Pluvial (surface water)	Low	Low	Increased surface water runoff is proposed to be managed to mimic the pre-Scheme conditions for up to and including the 1 in 100 + 40% climate change event. No change in flood risk level.
Groundwater	Low (Principal Site and majority of Cable Route Corridor) – High (Cable Route Corridor within Bassetlaw District Council Boundary)	Low (Principal Site and majority of Cable Route Corridor) – High (Cable Route Corridor within Bassetlaw District Council Boundary)	The Outline Drainage Strategy (**Appendix 10-4** of the ES **[EN010142/APP/6.2]**) does not propose to utilise infiltration techniques to discharge increased surface water runoff. Groundwater during construction will be addressed within the **Framework CEMP [EN010142/APP/7.8]** and **Framework DEMP [EN010142/APP/7.10]**. No change to flood risk level.
Sewers	Low	Low	No change to flood risk level.
Artificial sources	Low (Principal Site and majority of Cable Route Corridor) – Medium	Low (Principal Site and majority of Cable Route Corridor) – Medium (small	No change to flood risk level.

Flood Risk Source	Pre-Scheme Flood Risk Level	Post-Scheme Flood Risk Level	Comments
	(small area of Cable Route Corridor where crossing the River Trent)	area of Cable Route Corridor where crossing the River Trent)	

4.9 The Sequential and Exception Tests – Principal Site

4.9.1 The Sequential and Exception Tests have been undertaken to satisfy both NPS EN-1(Ref. 1) and NPPF(Ref. 4) requirements, as set out in **Section 2.2** of this FRA.

4.9.2 The Principal Site includes areas of high risk of flooding although is predominantly within Flood Zone 1.

4.9.3 The location of the Principal Site was dictated in part by the availability of a grid connection point at National Grid Cottam Substation. **Chapter 4 Alternatives and Design Evolution** of the ES **[EN010142/APP/6.1]** provides an explanation of site selection process along with how the Scheme had considered alternatives taking into account wider environmental and planning considerations.

4.9.4 As set out in **Chapter 4: Alternatives and Design Evolution** of the ES **[EN010142/APP/6.1]** the location of the Principal Site was informed by the considerations outlined in the NPS EN-3 (Ref. 2) in relation to the siting of solar PV development.

4.9.5 A sequential approach has been applied to the layout and design of the Principal Site whereby the two on-site substations, BESS and the majority of the solar PV arrays located in areas with the lowest risk of flooding from any source. As shown on **Figure 3-1: Indicative Principal Site Layout Plan [EN010142/APP/6.3]**, there is one area where Solar PV panels are located within Flood Zone 2 and 3 extents. Where required, embedded mitigation within the design has been included, for example, setting the minimum level of the base of solar PV panels in fluvial flood extents in fields 51, 56 and 57 to 20.06m AOD to remain operation in times of flood. In particular, east-west tracking panels are to be used enabling them to be tilted and as such provide greater resilience to instances of flooding in these areas. The Sequential Test is therefore considered passed for the Principal Site due to flood risk from any source to be low following the embedded mitigation.

4.9.6 In addition, the Scheme will include habitat creation and enhancement as set out in **Chapter 9: Ecology and Nature Conservation** of the ES **[EN010142/APP/6.1]**. This will contribute to the Scheme providing biodiversity net gain in line with the Environment Act 2021 (Ref. 33). There are areas of high-risk flooding within the Principal Site which are excluded for solar panels and are proposed to be used for ecological enhancement. Safeguarding these flood risk areas for ecological enhancement will secure these areas from future development, mitigating potential future increases to flood risk.

4.9.7 As detailed within **Section 7** of this FRA, embedded mitigation measures and an **Outline Drainage Strategy** (**Appendix 10-4** of the ES **[EN010142/APP/6.2]**), secured by a requirement of the DCO will be implemented, in order to ensure that the Scheme is safe for its lifetime and that there will be no increases in flooding elsewhere. Thus, the Scheme satisfies the second requirement of the Exception Test and will remain safe throughout its lifetime without increasing flood risk to third party land.

4.9.8 Therefore, as demonstrated above the Principal Site is considered to pass the Sequential and Exception Test.

5. Assessment of Flood Risk (Cable Route Corridor)

5.1 Flood risk from all sources

5.1.1 Long term flood risk resulting from the Cable Route Corridor is considered to be as existing, as the infrastructure will be buried throughout the Corridor with no permanent aboveground built development.

5.1.2 **Table 5-1** below sets out the flood risk from all sources for the Cable Route Corridor only.

Table 5-1: Flood Risk Assessment

Flood Risk Source	Pre-Scheme Flood Risk Level	Post-Scheme Flood Risk Level	Comments
Fluvial	High (Cable Route Corridor cross the River Till and Trent to where it connects to the National Grid Substation at Cottam.	High (Cable Route Corridor cross the River Till and Trent to where it connects to the National Grid Substation at Cottam.	**Source: (Figure 9.1 and 9.2 of WLDC SFRA (Ref. 11)) and online mapping (Gov.uk).** No change to flood risk level and no increase in flood risk. No permanent above ground infrastructure being located in the Cable Route Corridor. No long term flood risk and no mitigation required (i.e. no floodplain compensation or raising of ground levels/floor levels. No alternative Cable Route Corridor available that would avoid Flood Zones 2/3 completely.
Tidal	Medium to High along majority of cable route in tidal Trent reaches.	Medium to High along majority of cable route in tidal Trent reaches.	**Source: (Figure 9.1 and 9.2 of WLDC SFRA (Ref. 11)).** No change to flood risk level and no increase in flood risk.
Pluvial (surface water)	Medium to High along cable route through interaction with fluvial Flood Zones	Medium to High along cable route through interaction with fluvial Flood Zones	**Source: (Online SW Mapping, Gov.uk (Ref. 30)).** No change to flood risk level and no increase in flood risk. No mitigation required for below ground cables. Any interaction with existing below ground drainage (land drains) will be managed and reinstated during construction and decommissioning and set out in the **CEMP [EN010142/APP/7.8]** and **DEMP [EN010142/APP/7.10]** respectively.
Groundwater	Low to Medium	Low to Medium	**Source: British Geological Society (BGS) Online (Ref. 28) and Lincolnshire County Council (LCC) PFRA (Ref. 7).** No historical groundwater flooding events are mentioned specifically within West Lindsey. However, where the Cable Route Corridor crosses the Rivers Trent and Till, groundwater may be elevated within the alluvial deposits. There is no risk mapping for groundwater in this area, but as soils are largely impermeable the risk is considered medium, as the bedrock geology would not support large amounts of water storage, such as an aquifer. There may be a risk of groundwater ingress to excavations during the laying and potential removal of cables during the

Flood Risk Source	Pre-Scheme Flood Risk Level	Post-Scheme Flood Risk Level	Comments
			construction and decommissioning phases, the management of any water ingress to the excavations will be included in the **CEMP [EN010142/APP/7.8]** and **DEMP [EN010142/APP/7.10]** respectively.
Sewers	Low	Low	**Source (WLDC SFRA (Ref. 11) and LCC PFRA (Ref. 7)):** No change to flood risk level. There are no confirmed sewers in the vicinity of the Cable Route Corridors. As there is no proposed connection to public sewers along the Cable Route Corridor, there will be no increase in sewer flood risk as a result of the Scheme. Construction and decommissioning risk of exposing or damaging sewers will be included and managed via the **CEMP [EN010142/APP/7.8]** and **DEMP [EN010142/APP/7.10]** respectively.
Artificial sources	Medium to High (residual) – Flood risk from artificial sources are confined to small areas of the cable route corridor with a medium risk. However, the risk is increased when river levels are in high or flood conditions	Medium to High (residual) – Flood risk from artificial sources are confined to small areas of the cable route corridor with a medium risk. However, the risk is increased when river levels are in high or flood conditions	No change to flood risk level and no mitigation required.

5.2 Temporary Construction Compounds (Cable Route Corridor)

5.2.1 Within the Cable Route Corridor during the construction phase, there will be 6 temporary construction compounds within cable route corridor boundary. The temporary construction compounds are illustrated within **Chapter 10**, on **Sheets 1 to 3 of Figure 10-5**, of the ES **[EN010142/APP/6.1]**.

5.2.2 Four of the temporary construction compounds are located within Flood Zone 1, when viewed against the online flood map for planning, and have a low risk of flooding from all other sources; one of which is near to Flood Zone 2 and 3 extents, at the junction of Fillingham Lane and Willingham Road, approximately 2.7km due east of Willingham-by-Stow, as shown in **Plate 5-1** below.

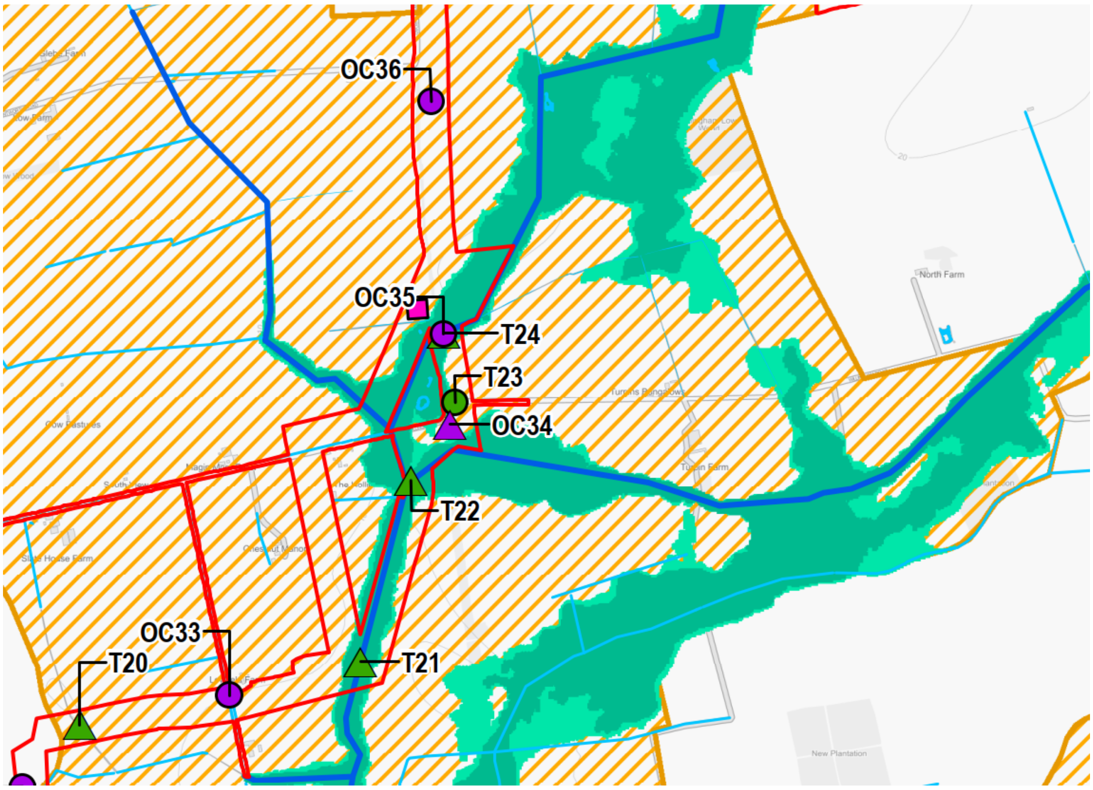


Plate 5-1 Extract of Chapter 10, Sheet 2 of Figure 5 of the ES [EN010142/APP/6.1]

5.2.3 Due to this temporary construction compound being located near to the Flood Zone 2 and 3 extents, this has been assessed in more detail for potential fluvial flood risk impacts.

5.2.4 Review of freely available LiDAR data, in lieu of a topographical survey of the Cable Route Corridor, indicates the proposed compound is located with a lowest ground level of approximately 10.0m AOD in the south east corner, rising to 11.0m AOD in the north west corner. In lieu of detailed hydraulic modelling for this ordinary watercourse, review of the online long term flood map for planning (Ref. 30), available from the DEFRA web service, has been used to indicate the approximate present day Flood Zone 3 level of 10.4m

AOD. Surrounding ground levels in the LiDAR data appear to support this level with similar levels on the opposite extent to the south in this area.

5.2.5 As the temporary construction compound will be present for up to 36 months and will be returned to the current existing conditions post construction phase, it is considered there will be no change in long term flood risk from all sources during the operational phase of the Scheme, with flood risk remaining low, and therefore no requirement to assess future climate change levels.

5.2.6 To prevent a potential flood risk increase to the temporary construction compound and flood risk elsewhere, it is proposed to locate all staff and operational buildings within this temporary construction compound above 10.7m AOD, providing 300mm freeboard to estimated Flood Zone 3 extents. The potential area of flood risk to the compound below this level covers approximately 0.04ha (approx. 12% of the compound area). This area is proposed to only store materials and easily removable plant in case of a flood event.

5.2.7 It is therefore considered the proposed temporary construction compound indicated in **Plate 5-2** will not increase flood risk to the Cable Route Corridor or elsewhere.

5.2.8 The remaining two proposed temporary construction compounds within the Cabel Route Corridor Boundary are located within Flood Zone 3. The Flood Zone 3 extents here are associated with the floodplain of the River Trent adjacent to the existing Cottam Power Station site. The flood risk extents around the existing Cottam Power Station benefit from fluvial flood defences, and therefore are considered to be at a lower residual risk of fluvial flooding.

5.2.9 Review of Figure 9-2 from the publicly available Gate Burton Energy Park Environmental Statement, which has been submitted for DCO indicates, the area proposed for the two temporary construction compounds are within the defended area, as shown in **Plate 5-2** below; note that **Plate 5-2** shows the Gate Burton Order Limits; however, the proposed construction compounds for Tillbridge Solar Farm are marked for clarity.

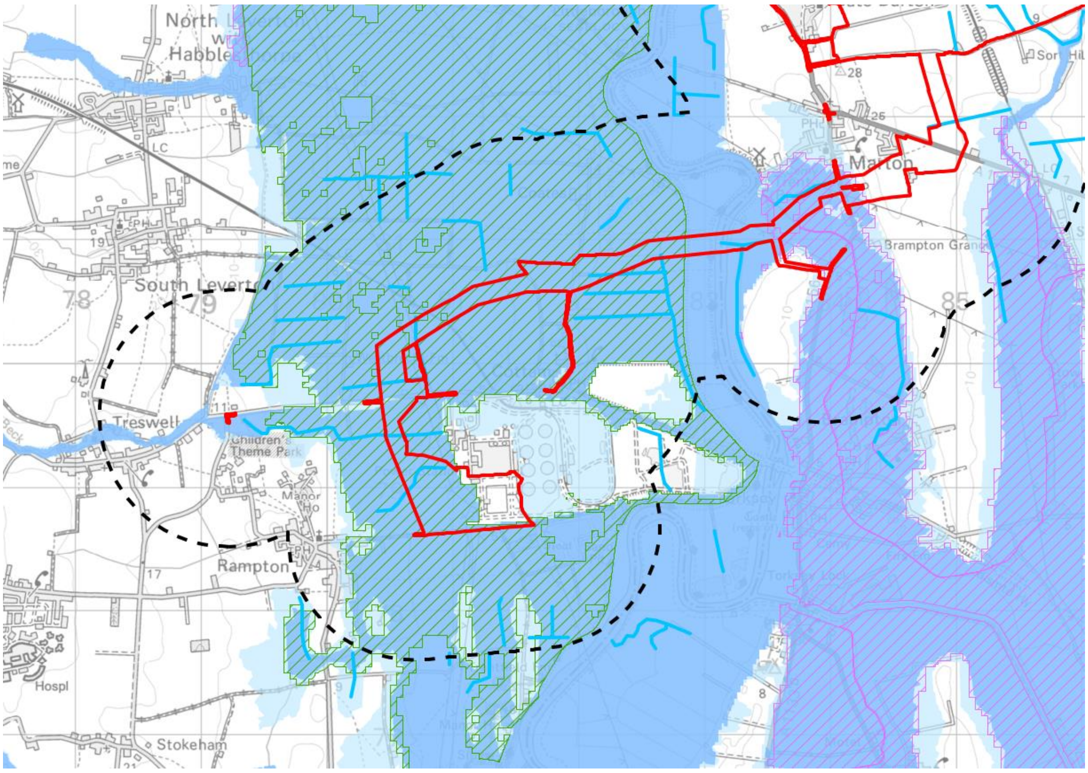


Plate 5-2 extract of Figure 9-2 of the Gate Burton Energy Park Environmental Statement (Ref. 37)

5.2.10 The residual risk is a medium flood risk according to the online long term flood risk mapping for surface water. Whilst these are still located within Flood Zone 3, the temporary nature (up to 36 months), limited spatial extent compared to Flood Zone 3 extent, presence of flood defence infrastructure on the River Trent and, distance from potential receptors that could be impacted, indicate the likelihood of increased flood risk from these is considered to be low.

5.2.11 All temporary construction compounds will be returned to the current existing site conditions post construction phase, therefore there will be no change in long term flood risk from all sources to and from all of the temporary construction compounds within both the Principal Site and the Cable Route Corridor.

5.3 The Sequential and Exception Tests – Cable Route Corridor

5.3.1 The Cable Route Corridor covers areas of high risk of fluvial flooding (Flood Zone 3). Whilst other cable route corridor options were considered, these would also cover areas of Flood Zone 3 in order to connect to National Grid Cottam Substation. In addition, consideration has been given to the potential of a shared corridor with neighbouring solar developments within the area (Gate Burton Energy Park, West Burton Solar Project and Cottam Solar Project) in order to minimise the cumulative impact in regards to disruption as well as environmental impacts along with reducing the number of affected landowners. There are therefore no alternative routes at lower risk of flooding from any source.

5.3.2 In this instance, it is therefore necessary to apply the Exception Test for the Cable Route Corridor and demonstrate that:

a. The development would provide wider sustainability benefits to the community that outweigh the flood risk; and

b. The development will be safe for its lifetime taking account of the vulnerability of its users, without increasing flood risk elsewhere and where possible will reduce flood risk overall.

5.3.3 By their nature, the construction compounds will be temporary with no long term impact to the wider environment, with the existing baseline conditions reinstated once construction is complete. There is little room to create wider sustainability benefits from the temporary construction compounds, as they will be removed in 36 months. The development will remain safe for its operational lifetime with no increase to long term flood risk, as the temporary construction compounds will not be in place during operation.

5.3.4 Through the generation of low carbon electricity the Scheme will contribute to the urgent need to decarbonise electricity generation in the UK as established in the Net Zero Strategy: Build Back Greener (October 2021) (Ref. 35), and the British Energy Security Strategy (April 2022) (Ref. 36). It will contribute to the UKs obligations for net zero under the Climate Change Act 2008 (as amended) (Ref. 37). It is also in line with the current planning policy on renewable energy (NPS EN-3 (Ref. 2)) which recognises the need for sustained growth in solar capacity to meet net zero emissions by 2050. Therefore, the Scheme will have both a national, and global significance, through its decarbonisation of the nation’s electricity generation, and is clearly commensurate with national energy policy which will be detailed further within the **Statement of Need [EN010142/APP/7.1]** and the **Planning Statement [EN010142/APP/7.2]** which have been submitted with the DCO Application.

5.3.5 Therefore, the Cable Route Corridor is considered to pass the Sequential and Exception Test.

6. Drainage Strategy

6.1 Drainage Strategy Principles

6.1.1 The **Outline Drainage Strategy** included in **Appendix 10-4** of the ES **[EN010142/APP/6.2]** proposes a system for new impermeable areas during the with-Scheme scenario designed to accommodate the 1 in 100-year storm, plus a 40% allowance for an increase in peak rainfall intensity due to climate change.

6.1.2 The Strategy assumes the solar PV panels and access roads will not lead to an increase in impermeable area within the Scheme and that 100% of the runoff from the BESS areas, on-site substations areas, and intermediate warehouses areas will contribute to runoff managed by the new system.

6.1.3 The **Outline Drainage Strategy [EN010142/APP/6.2]** proposes to attenuate runoff via sustainable drainage techniques (excluding infiltration to ground due to assumed geological conditions) and restrict at greenfield rates to watercourses within the Order limits as per the existing conditions.

6.1.4 Foul drainage is not considered within the **Outline Drainage Strategy [EN010142/APP/6.2]** as no connection to the public sewer is proposed, drainage will be dealt with via a septic tank arrangement or similar sealed system, emptied and maintained to recommended manufacturer advice.

6.1.5 Further details including contributing areas, runoff rates, water quality assessment and maintenance requirements are included within the report.

7. Residual Risks and Mitigation

7.1 Residual risks to the Scheme

7.1.1 A residual fluvial risk remains in relation to the areas of solar PV within Flood Zone 3. The solar PV panels in the flood risk areas are proposed to be raised by up to 220 mm to provide additional protection against this risk. The Solar PV panel mounting structure legs do not materially remove floodplain volume, with the relatively few panels that will be located in Flood Zone 3. Therefore, floodplain compensation is not considered to be required.

7.1.2 In addition, the solar PV panels are tracking panels and will be fitted with sensors to detect flood water and can tilt the panels to raise them to a minimum ground clearance of 1.5m.

7.1.3 Residual flood risk from all sources to and from the Scheme is considered to be low.

7.2 Safe Access

7.2.1 Through the Sequential Test process and design iterations, there are no buildings located within the floodplain. During the operational phase, the only structures within the floodplain are solar PV panels. All compounds during the operational phase for site staff, on-site substations and battery storage units have been located out of flood zones and it is envisaged access to solar PV panels within Flood Zone 3a would not be undertaken during flooding conditions.

7.2.2 On-site substations and battery storage units will not be manned unless for maintenance / carrying out works. During a flood event, the affected infrastructure will not be accessed or manned until flood waters recede.

8. Conclusions

8.1.1 This FRA has been prepared to support the ES.

8.1.2 No additional flood risk mitigation or floodplain compensation is considered to be required for the Scheme to be compliant with flood risk policy and guidance.

8.1.3 The FRA demonstrates flood risk, from all sources, will not increase as a result of the Scheme, within the Order limits or elsewhere. A separate **Outline Drainage Strategy** of the ES (**Appendix 10-4 [EN010142/APP/6.2])** demonstrates surface water drainage will be managed effectively to ensure there is no increase in surface water runoff from the Scheme above the existing regime.

9. Annexes

Annex A – Topographical Surveys

Tillbridge Solar

Tillbridge Solar Project
EN010142

Volume 6
Environmental Statement
Appendix 10-3:Flood Risk Assessment Annex A Topographical Surveys
Document Reference: EN010142/APP/6.2

Regulation 5(2)(a)
Infrastructure Planning (Applications: Prescribed Forms and Procedure) Regulations 2009

April 2024
Revision Number: 00

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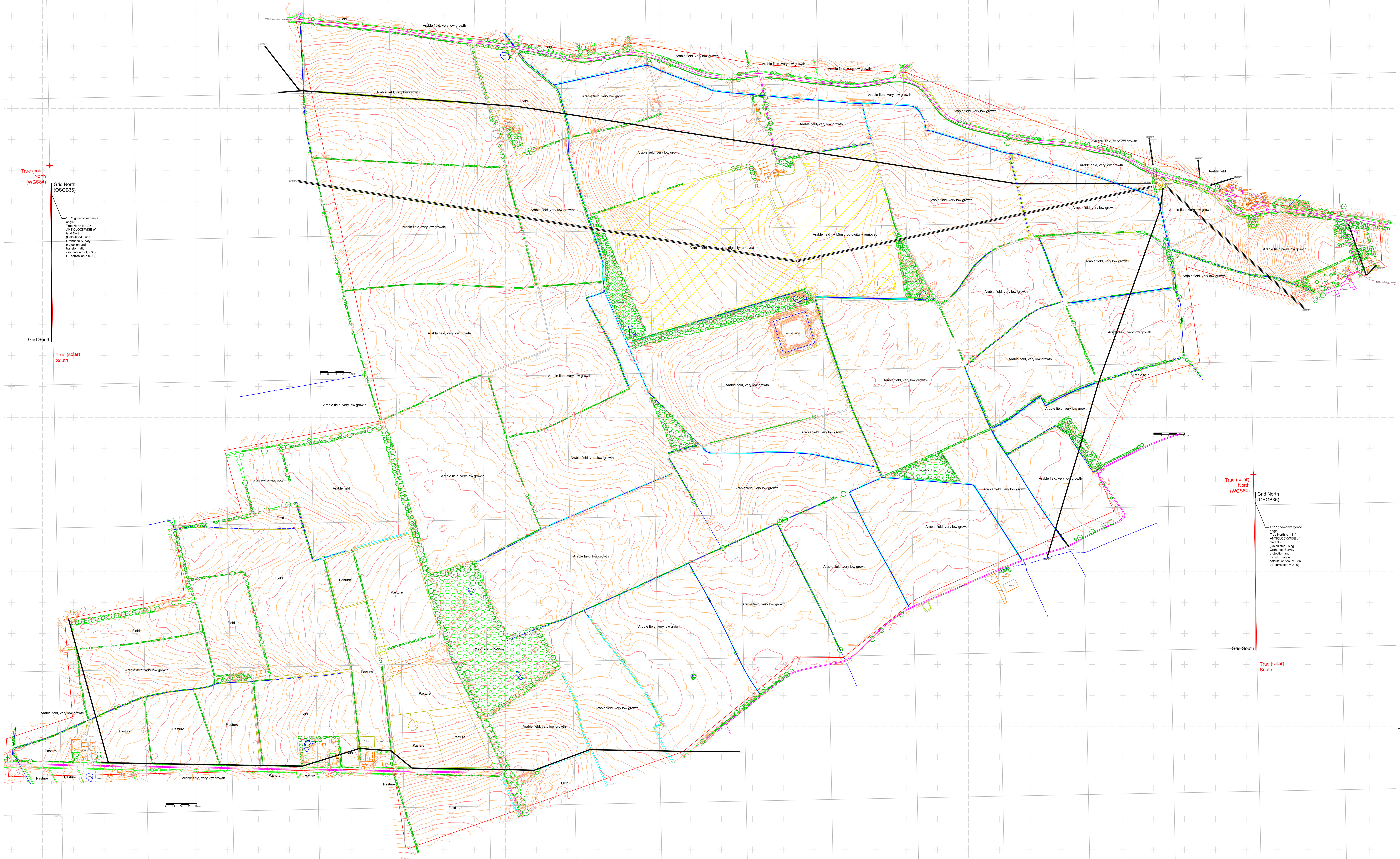

LEGEND

- Tree canopy/hedgerow/foliage. Heights where given are to nearest meter.[1]
- Tree shapes for use in *PVcase*. **These do not represent exact tree locations**, but rather, entities which will be automatically recognised and converted to appropriate shading elements by *PVcase*. Areas of forest are therefore filled with trees of appropriate height. Height to nearest meter.[1]
- Water (dashed for apparent drainage feature or approx. path)
- Sealed road
- Unsealed track
- Power-line (or other overhead line) with utility post
- Fence, gate
- Railway track
- Public footpath/bridleway
- Apparent field boundary (As seen from aerial survey. NOT official boundary.)
- UAV mapping boundary (approx.)
- Building or other permanent structure
- Stone wall

ELEVATIONS

- Elevation of point above vertical datum (see 'COORDINATE REFERENCE SYSTEM AND DATUM' at bottom).[2]
- Contours (0.25 m) of digital surface model (dashed when over areas of obvious crop or vegetation).[3,4]

G.I.S. DATA

- 100m grid in OSGB36 map projection
- LAT. LONG. — The specific lines of latitude and longitude which pass through the site are marked in degrees, minutes, seconds (WGS84).
- NORTH — Grid North follows the direction of the North-South lines of the OSGB36 grid.
  True North follows lines of longitude, which converge on the axis of rotation of the Earth. True South points to the equator.
  The convergence angle (precision 2 d.p.) between Grid North and True North for this specific location is given.
  Magnetic North is not shown (but will be different again).

Third-party data

Site boundaries from client. Approx. public footpath routes from OS map.

NOTES

1. Heights of hedgerows and dense trees are marked alongside the foliage. All tree/hedge heights given are approximate heights above nearby ground, based on the Digital Surface Model.
2. It is important to note that this grid is from a Surface Model, not a Terrain Model, and therefore point-heights can only be interpreted as terrain when on areas of earth or hardstanding.
3. Likewise, the Contours are surface contours, not terrain contours, so should be interpreted carefully. Where contours are obviously not on earth or hardstanding, they are dashed.
4. Contours are generated from a subsampled (10m) terrain model to provide smooth but representative contour lines. Where contours cross trees, the path of the contour below the tree(s) is approximated.
5. Lat./long. lines are precisely calculated, but should be considered approximate because they represent a spherical coordinate system on a map projection. Locations and dimensions are accurate in the underlying map projection. But conversion of coordinates from the map projection to lat./long. (if required) should be performed using the appropriate transformation, not by inference from this plot.
6. Features hidden under dense vegetation (e.g. walls, fences) are only marked if visible from drone footage (or location otherwise provided or noted).

REVISIONS

1.0	10 June. 2022	Published to client [MP]

PROJECT

GRETA II Ltd - UAV SURFACE TOPOGRAPHY
GRETA II Project in Lincolnshire, U.K.

TITLE

GRETA II LINEWORK ("CAD") -

above

Above Surveying Ltd.
Block C2 Knowledge Gateway
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E: support@abovesurveying.com

DETAILS

GRETA II LIMITED, 3rd Floor, Palladium House, 1-4 Argyll Street, London, England, W1F 7LD (Luke Murray)

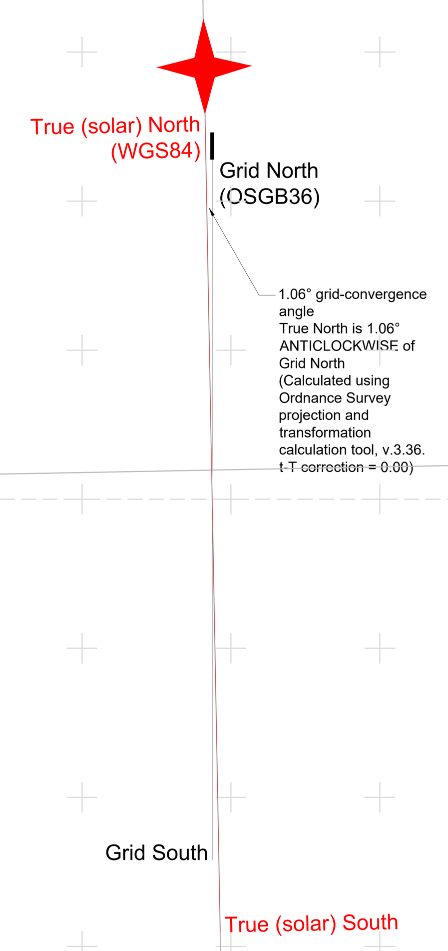
LOCATION

Manor Farm, Common Ln, Heapham DN21 5XB

SCALE OF MAIN DRAWING:
1:5000 when printed 100% on A0
Do not scale from this plot. All dimensions to be checked on-site.

COORDINATE SYSTEM AND DATUM

OSGB36, British National Grid Map Projection (EPSG: 27700). Units: meters
Elevations relative to sea level as height in meters above Ordnance Datum Newlyn (ODN) (EPSG: 5101). Geoid model, OSGM15.



SCALE OF MAIN DRAWING:
1:3000 when printed 100% on A0
Do not scale from this plot. All dimensions to be checked on-site.

LEGEND

- Tree canopy/hedgerow/foliage. Heights where given are to nearest meter.[1]
- Tree shapes for use in *PVcase*. **These do not represent exact tree locations**, but rather, entities which will be automatically recognised and converted to appropriate shading elements by *PVcase*. Areas of forest are therefore filled with trees of appropriate height. Height to nearest meter.[1]
- Water (dashed for apparent drainage feature or approx. path)
- Sealed road
- Unsealed track
- Power-line (or other overhead line) with utility post
- Fence, gate
- Railway track
- Public footpath/bridleway
- Apparent field boundary (As seen from aerial survey. NOT official boundary.)
- UAV mapping boundary (approx.)
- Building or other permanent structure
- Stone wall

ELEVATIONS

- Elevation of point above vertical datum (see 'COORDINATE REFERENCE SYSTEM AND DATUM' at bottom).[2]
- Contours (0.25 m) of digital surface model (dashed when over areas of obvious crop or vegetation).[3,4]

G.I.S. DATA

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- LAT. LONG. — The specific lines of latitude and longitude which pass through the site are marked in degrees, minutes, seconds (WGS84).
- NORTH — Grid North follows the direction of the North-South lines of the OSGB36 grid.
True North follows lines of longitude, which converge on the axis of rotation of the Earth. True South points to the equator.
The convergence angle (precision 2 d.p.) between Grid North and True North for this specific location is given.
Magnetic North is not shown (but will be different again).

Third-party data

Site boundaries from client. Approx. public footpath routes from OS map.

NOTES

1. Heights of hedgerows and dense trees are marked alongside the foliage. All tree/hedge heights given are approximate heights above nearby ground, based on the Digital Surface Model.
2. It is important to note that this grid is from a Surface Model, not a Terrain Model, and therefore point-heights can only be interpreted as terrain when on areas of earth or hardstanding.
3. Likewise, the Contours are surface contours, not terrain contours, so should be interpreted carefully. Where contours are obviously not on earth or hardstanding, they are dashed.
4. Contours are generated from a subsampled (10m) terrain model to provide smooth but representative contour lines. Where contours cross trees, the path of the contour below the tree(s) is approximated.
5. Lat./long. lines are precisely calculated, but should be considered approximate because they represent a spherical coordinate system on a map projection. Locations and dimensions are accurate in the underlying map projection. But conversion of coordinates from the map projection to lat./long. (if required) should be performed using the appropriate transformation, not by inference from this plot.
6. Features hidden under dense vegetation (e.g. walls, fences) are only marked if visible from drone footage (or location otherwise provided or noted).

REVISIONS

1.0	10 Aug. 2023	Published to client [TAJC]

PROJECT

Tribus Energy - UAV SURFACE TOPOGRAPHY Tillbridge Solar (GRETA II) Project in Lincolnshire, U.K.

TITLE

TILLBRIDGE SOLAR (GRETA II)
ADDITIONAL LINEWORK "CAD"

DETAILS

GRETA II LIMITED, 3rd Floor, Palladium House, 1-4 Argyll Street, London, England, W1F 7LD (Luke Murray)

above

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LOCATION

Manor Farm, Common Ln, Heapham DN21 5XB

COORDINATE SYSTEM AND DATUM

OSGB36, British National Grid Map Projection (EPSG: 27700). Units: meters
Elevations relative to sea level as height in meters above Ordnance Datum Newlyn (ODN) (EPSG: 5101). Geoid model, OSGM15.

Annex B – Site Layout Plan

Tillbridge Solar

Tillbridge Solar Project

EN010142

Volume 6
Environmental Statement

Appendix 10-3:Flood Risk Assessment Annex B
Site Layout Plan
Document Reference: EN010142/APP/6.2

Regulation 5(2)(a)
Infrastructure Planning (Applications: Prescribed Forms and Procedure) Regulations 2009

April 2024
Revision Number: 00

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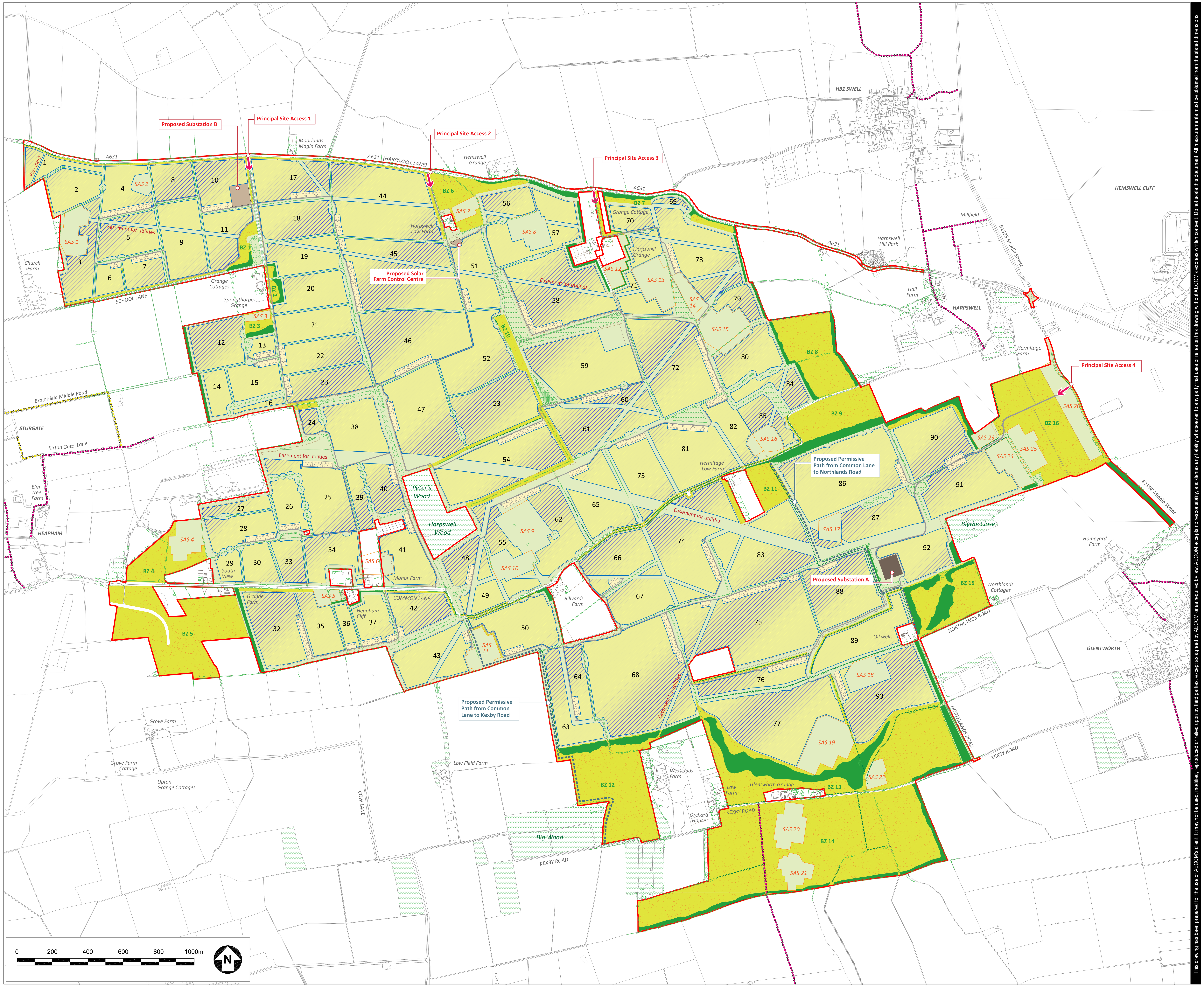
Revision: 0 Drawn: NA Checked: NW Approved: AT Date: 2024-03-28



AECOM

PROJECT

Tillbridge Solar Project

CLIENT

Tillbridge Solar Ltd

CONSULTANT

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London, E1 8FA
United Kingdom
T +44-0207-645-2000

LEGEND

ORDER LIMITS (SITE BOUNDARY)

- PRINCIPAL SITE ORDER LIMITS

EXISTING FEATURES AND CONSTRAINTS

- EXISTING WOODLAND AND HEDGEROWS WITHIN AND AROUND SITE
- PUBLIC RIGHT OF WAY
- TEMPORARY VOLUNTARY BRIDLEWAY (STURGATE)

INDICATIVE PROPOSED SCHEME

- PROPOSED AREAS OF SOLAR PANELS WITH IMPROVED GRASSLAND BENEATH
- PROPOSED SOLAR STATIONS AND BATTERY ENERGY STORAGE STATIONS (BESS)
- PROPOSED GRAVEL MAINTENANCE ACCESS TRACKS
- PROPOSED INFRASTRUCTURE: SUBSTATIONS AND SOLAR FARM CONTROL CENTRE
- PROPOSED MAIN SITE ACCESS LOCATIONS
- PROPOSED TIMBER/WIRE MESH DEER FENCE WITH CCTV CAMERAS ON POLES
- PROPOSED NEW NATIVE WOODLAND PLANTING
- BZ 12 — PROPOSED BIODIVERSITY ZONES WITH HABITATS INCLUDING GRASSLAND (FOR GROUND NESTING BIRDS) HEDGEROWS, TREE BELTS, GRASSLAND FOR GROUND NESTING BIRDS, ISOLATED TREES, WETLANDS, SPECIES-RICH MEADOWS ETC. (REFERENCE NUMBERS TO LARGER AREAS)
- PROPOSED NATIVE HEDGEROWS (INDICATIVE ALIGNMENTS)
- OTHER PROPOSED AREAS OF GRASSLAND (INCLUDING SPECIES-RICH) OUTSIDE OF PANEL AREAS AND ACCESS TRACKS
- SAS — SENSITIVE ARCHAEOLOGY SITES (WITH REFERENCE NUMBERS): NO DEVELOPMENT
- 123 — PANEL AREA REFERENCE NUMBERS
- PROPOSED PERMISSIVE PATH

NOTES

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ISSUE PURPOSE

DCO Submission

PROJECT NUMBER

60677969

FIGURE TITLE

Indicative Principal Site Layout Plan

FIGURE NUMBER

Figure 3-1

Annex C – Fluvial Flood Level Technical Note

Tillbridge Solar

Tillbridge Solar Project

EN010142

Volume 6

Environmental Statement

Appendix 10-3:Flood Risk Assessment Annex C
Fluvial Flood Risk Technical Note
Document Reference: EN010142/APP/6.2

Regulation 5(2)(a)
Infrastructure Planning (Applications: Prescribed Forms and Procedure) Regulations 2009

April 2024
Revision Number: 00

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AECOM		AECOM Limited Marlborough Court 10 Bricket Road St Albans Hertfordshire AL1 3JX United Kingdom T: +44(0)1727 535000 aecom.com
To: The Environment Agency IDB LLFA **CC:**		**Project name:** Tilbridge Solar Farm **Project ref:** 60682158 **From:** AECOM Limited **Date:** 05 January 2024 (Rev 01)

Technical Note

Fluvial Flood Level Analysis

REV 01 Update Summary

- This Technical Note refers to the Scheme masterplan layout issued within Annex C of **Appendix 10-3: Flood Risk Assessment** (FRA) of the ES **[EN010142/APP/6.2]**. The following changes relevant to the assessment of fluvial flood risk have been made to the Scheme's solar panel infrastructure for the DCO submission:

  1. The removal a Solar PV field previously labelled as field no. 124 at PEIR stage, including all proposed above ground solar infrastructure within the Environment Agency Flood Zone 2 and 3 extents in the southeastern corner of the Principal Site, previously referred to as the Kexby Road Interaction Zone. This field is now designated within Field EM 13, noted for opportunities for Ecological Enhancement.
  2. The removal of the field previously labelled as field no. 61a at PEIR stage, including all proposed above ground solar infrastructure within the Environment Agency Flood Zone 2 and 3 within the Harpswell Lane Interaction Zone on the northern boundary of the Principal Site. This field is now designated within Field EM 6, noted for opportunities for Ecological Enhancement.

  The Technical Note, therefore, no longer considers Kexby Road as a source of fluvial flood risk to above ground built infrastructure within the Principal Site, as there is no longer any proposed permanent or temporary above ground built development within the fluvial extents to the south east of the Principal Site. As such, the previously designated Kexby Road Interaction Zone has been removed from this Technical Note. The flood risk to the Scheme from solar panels in the remaining Harpswell Interaction Zone will be assessed.

  The predicted flood depth analysis location for assessing the fluvial flood depths at the Harpswell Lane Interaction Zone has been adjusted to be adjacent to the northwest corner of Field no. 56 (previously labelled as no. 61b at the PEIR stage). Refer to Figure 2 below.

- Topographical drone surveys carried out on 10.06.2022 and 09.08.2023 made available after the Preliminary FRA submission date, provided additional topographic data for the Principal Site boundary. However, the latest topographical drone surveys do not improve the definition of the smaller ordinary watercourses, compared to the LiDAR data previously used. The Yewthorpe Beck geometry has, therefore, remained the same as the previous revisions of Technical Note. The revised drone topographic data for the land either side of the ordinary watercourse at the Harpswell Lane Interaction Zone has been referenced to replace LiDAR where available to provide more recent ground levels than the LiDAR data. LiDAR data has still been used to establish contributing catchment areas.

Background

AECOM has been commissioned by Tribus Clean Energy Ltd to prepare a Flood Risk Assessment (FRA) as an Appendix to **Chapter 10** of the **Environmental Statement (ES) [EN010142/APP/6.1]**, in relation to the Development Consent Order (DCO) application for the construction, operation and decommissioning of the Tillbridge Solar Project (the Scheme) located approximately 13km north of the city of Lincoln, near Gainsborough, Lincolnshire, UK.

The **FRA** appended to the ES **[EN010142/APP/6.1]** has identified one surface water ditch within the Principal Site Boundary with associated Environment Agency Flood Zone 2 and 3 extents that extends into one of the proposed Solar photovoltaic panel (PV) fields where above ground Solar PV Modules are proposed to be mounted. The surface water ditch is an ordinary watercourse (Yewthorpe Beck), flowing south to north, which crosses under Harpswell Lane via a culvert downstream of Field 56. The approximate area of overlap of Flood Zone 2 and 3 extents within the Solar PV field is 0.35 ha. This area is referred within the FRA as the Harpswell Lane Interaction Zone.

Figure 1 identifies the extents of the Principal Site in red and the location of the Harpswell Lane Interaction Zone within proposed Solar PV Field 56.

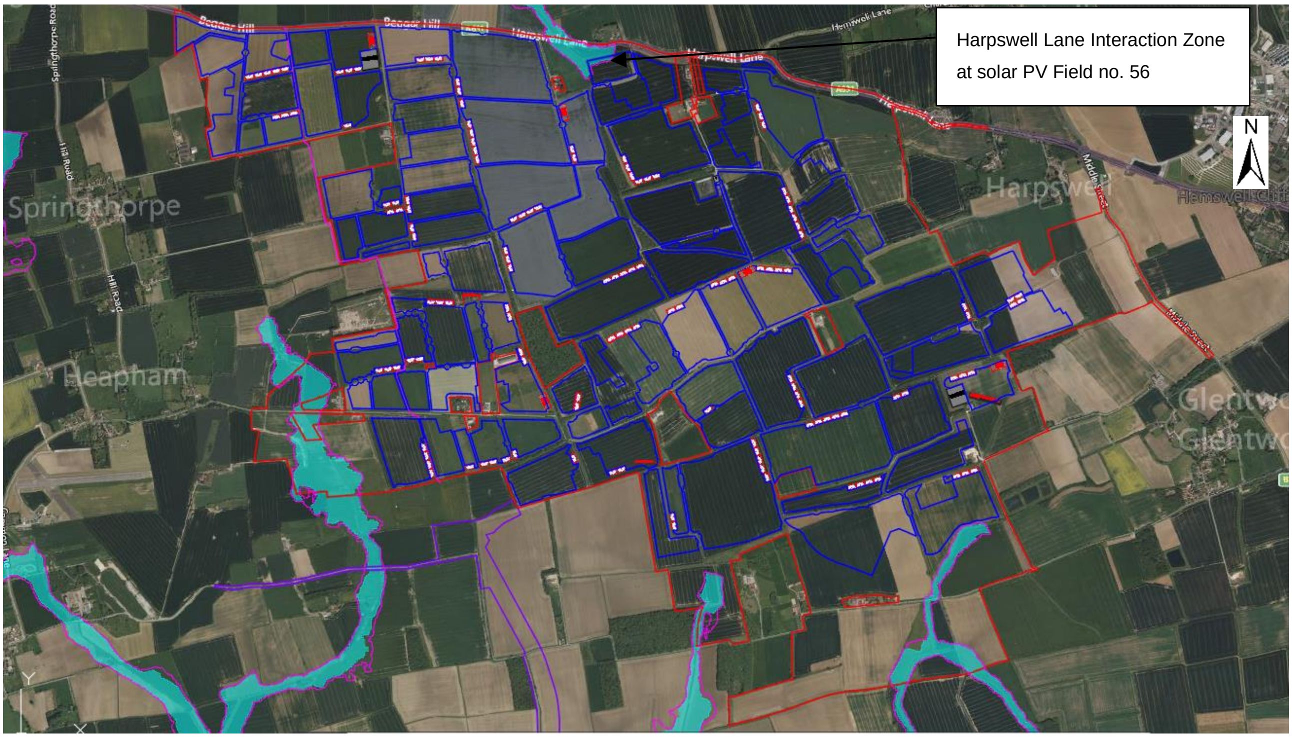

Figure 1 - Site Location Plan (Red: Principal Site Boundary, Blue: Solar PV Fields, Purple: Cable Route Corridor, Cyan/Magenta: EA Flood Zone 2/3 Extents)

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A Hydraulic model of the Yewthorpe Beck ordinary watercourse is not available at the time of writing, as such this Technical Note provides an alternative analysis to detailed hydraulic modelling to assess the future risk of fluvial flooding (including the effects of climate change) to the proposed Solar PV modules within the Harpswell Lane Interaction Zone. Consultation with the Environment Agency, IDBs and LLFA during a meeting held on 04.09.2023 resulted in the following analysis methodology being recognised by all parties as appropriate for the relatively small scale of fluvial flood risk. **Appendix 10-5: Water Environment Stakeholder Meeting Minutes** of the ES **[EN010142/APP/6.1]** provides the minutes from this meeting.

Context

This Technical Note provides the findings of the analysis predicting the estimated flood levels within the Harpswell Lane Interaction Zone and provides evidence to demonstrate the predicted flood levels will not cause additional flood risk to the PV Panel infrastructure for the design life of the Scheme.

Please note; this Technical Note does not have concern to potential changes to flood risk on or off site as a result of the Scheme, this is covered within the **FRA** within **Chapter 10: Water Environment** of the ES **[EN010142/APP/6.1]**.

Figure 2 indicates the extents of where present day Flood Zone 2 and 3 overlaps with solar PV field 56.

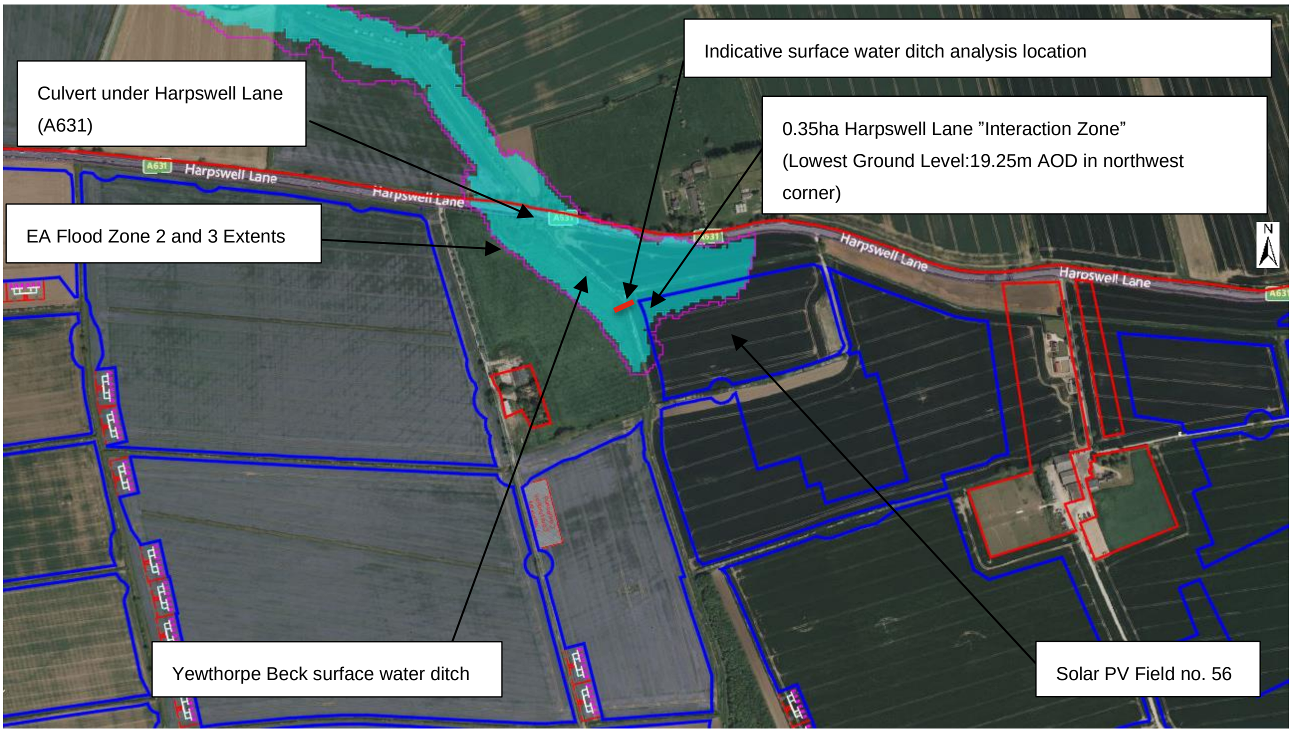

Figure 2 - Harpswell Lane Interaction Zone

Source: Copyright and database right 2024. Esri, Maxar, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community Esri, HERE, Garmin, © OpenStreetMap contributors, and the GIS user community

It is understood that a typical Solar PV mounting structure secures solar PV Modules from underneath so that the lowest point of the PV Module is fixed 600mm above ground level. **Figure 3** provides an example diagram of a mounted solar PV Panel module cross section, where dimension C would be 600mm for a typically mounted solar PV Module.

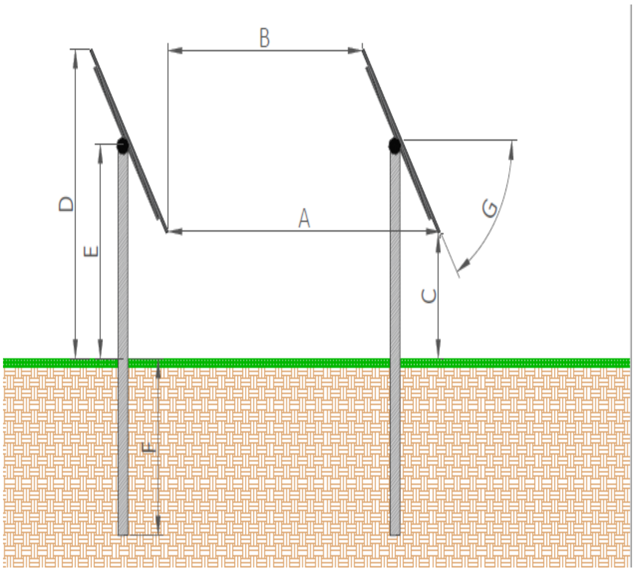

Figure 3 - Example PV Panel Cross Section

Analysis Method

In order to carry out the assessment to fluvial flood risk to the solar infrastructure proposed within the Harpswell Lane Interaction Zone, the following parameters have been defined to predict the expected flood level during the design and worst case fluvial flood events:

1) The contributing catchment area upstream of the surface water ditch analysis location.
2) The greenfield run-off rates expected to enter the surface water ditch at the analysis location for the design and sensitivity scenarios (taking into account increased flows for climate change).
3) The existing capacity of the ditch at the analysis location.
4) The excess discharge during the design and sensitivity scenarios that can not be conveyed by the existing channel capacity at the analysis location expected to cause flooding into the Harpswell Lane Interaction Zone.
5) The expected depth the excess discharge would rise to above the surface water ditch bank level into the Interaction Zone flood channel.

Analysis

1) The contributing catchment area upstream of the surface water ditch analysis location.

LiDAR Map data and Drone Survey data for the Principal Site and its surrounding area has been used to develop a 3D surface with watershed lines using Autodesk Civils 3D software. The watershed lines provide an estimated catchment outline for the Yewthorpe Beck surface water ditch. It should be noted that LiDAR data is used in defining the watershed boundaries as it provides greater coverage of the Yewthorpe Beck contributing catchment, whereas the topographical drone survey data only provided data within the Principal Site Boundary. **Figure 4** shows the estimated upstream catchment extent of the Yewthorpe Beck ordinary watercourse up to the culvert at Harpswell Lane.

Figure 4 - Estimated Ditch Catchment Areas

Source: Copyright and database right 2024. Esri, Maxar, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community Esri, HERE, Garmin, © OpenStreetMap contributors, and the GIS user community

2) The greenfield run-off rates expected to enter the surface water ditch at the analysis location for the design and sensitivity scenarios (taking into account increased flows for climate change).

The Harpswell Lane Interaction Zone and the contributing catchment to the Yewthorpe Beck are located within the Lower Trent and Erewash Management Catchment. The Environment Agency Climate Change Allowances for peak river flow in England and have been incorporated into the greenfield runoff rate calculations in line with statutory guidance.

The greenfield runoff discharge rate contributing to the surface water ditch upstream of the analysis location has been calculated by the HR Wallingford Greenfield Runoff Rate Estimation Tool (using FEH Data), see Appendix A for calculations. The 3D surface extracted from the LiDAR data provides level data to estimate a gradient of the long profile of the surface water ditch bed (1:96) to be used in calculating the existing ditch capacity, see **Appendix B** for existing ditch capacity calculations.

For the 2080's Epoch; the "Higher Central" (design) allowance requires an additional 39% for fluvial modelling and the "Upper End" (sensitivity) allowance requires an additional 62% for fluvial modelling.

In order to ensure a robust approach to the analysis, a conservative overestimate of the potential discharge rates that the surface water ditch may become subject to have been used. The design discharge rate for the surface water ditch has been taken as the greenfield 1 in 100 year rate increased by 50% (1.5 x 1 in 100 year rate), and the sensitivity check discharge rate has taken as the greenfield 1 in 100 year rate increased by 100% (2 x 1 in 100 year rate). **Table 1** provides the estimated Greenfield Runoff rates using the FEH method and the increased design and sensitivity discharge rates to be used in this analysis. (Refer to **Appendix A** for Greenfield Runoff Rate Calculations)

Table 1 – Greenfield Runoff Rates (Using FEH Data)

Ditch	Catchment Area (km^2)	Qbar (Cumecs)	1 in 1 year (Cumecs)	1 in 30 year (Cumecs)	1 in 100 year (Cumecs)	1 in 100 year + 50% (Cumecs) Higher Allowance (Design)	1 in 100 year + 100% (Cumecs) Upper Allowance (Sensitivity)
Harpswell Lane	8.05	1.6	1.4	4.0	5.8	**8.7**	**11.6**

3) The existing capacity of the ditch at the analysis location.

The open channel flow calculation undertaken to estimate the existing capacity of the surface water ditch utilised 0.25m contours produced in ArcGIS software from LiDAR map data obtained from the DEFRA website to estimate the cross sectional profiles of the existing ditch at the analysis location. Unfortunately, the topographical drone surveys do not provide sufficient detail due to the small scale of the ditch.

An extract from Google Street View shown in **Figure 5**, provides a good view of the surface water ditch conditions downstream of the culvert under Harpswell Lane; a Manning's n value of 0.8 (grass channel, not maintained with dense weeds in average condition) has therefore been used for the roughness value in the open channel calculation, to demonstrate a conservative approach.

Figure 5 - Downstream google street view of ditch from Harpswell Lane (October 2009)

The Interaction Zone appears to be located upstream of a culverted section of Harpswell Lane (A637). As details of the culvert are not currently available, it has been assumed that the cross sectional area of the culvert is no smaller than the surface water ditch channel at the analysis location, therefore the cross sectional area of the surface water ditch has been used in the analysis.

The open channel flow calculation provides the maximum discharge rate of the surface water ditch at the analysis location. (See **Appendix B** for calculations including details cross section geometry)

Table 2 – Existing Ditch Capacity

Ditch	Capacity (Cumecs)
Harpswell Lane	**0.8**

4) The excess discharge during the design and sensitivity scenarios that can not be conveyed by the existing channel capacity at the analysis location expected to cause flooding into the Harpswell Lane Interaction Zone.

The excess discharge rate that can not be contained and conveyed within the exiting surface water ditch profile during the flood events is calculated by comparing the difference between the 1 in 100 year + CC (Cumecs) Higher/Sensitivity Allowance discharge rates (**Table 1**) with the Existing Ditch Capacity (**Table 2**).

Table 3 - Excess Discharge Rates

Flood Event	Expected Greenfield rate entering surface water ditch (Cumecs)	Existing Ditch capacity (Cumecs)	Excess discharge rate (Cumecs)
1 in 100 year + 50% (Cumecs) Higher Allowance (Design)	8.7	0.8	**7.9**
1 in 100 year + 100% (Cumecs) Upper Allowance (Sensitivity)	11.6	0.8	**10.8**

5) The expected depth the excess discharge would rise to above the surface water ditch bank level into the Interaction Zone flood channel.

A further open channel flow calculation uses the following parameters to determine the expected flood depth across the Harpswell Interaction Zone during flood events:

- The geometry of the adjacent land (flood channel) to the surface water ditch analysis location provided by the topographical drone survey to determine the cross sectional profile of the flood channel predicted to be partially filled with greenfield runoff during flood events; and,
- The excess discharge rates during the flood events to calculate the expected flood depth above the bank level of the surface water ditch.

Figure 6 provides a schematic diagram of the cross section at the analysis during a flood event.

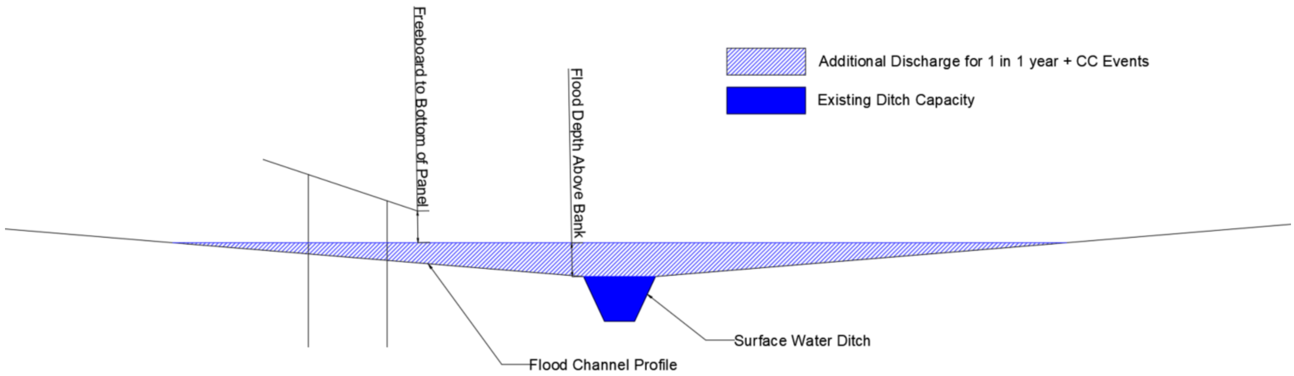

Figure 6 - Example Analysis Cross- Section (not to scale)

Table 4 provides the expected flood depth levels above the surface water ditch bank level at the analysis location for the higher and upper flood event scenarios.

Table 4 – Predicted flood levels (1 in 100 year + CC Higher Central Allowance)

Flood Event	Max Flood Depth Above Bank (m)	Top of Bank Level (m AOD)	Flood Level within Interaction Zone (m AOD)
1 in 100 year + 50% Higher Central Allowance (Design)	0.51	19.25	**19.76**

Flood Event	Max Flood Depth Above Bank (m)	Top of Bank Level (m AOD)	Flood Level within Interaction Zone (m AOD)
1 in 100 year + 100% Upper End Allowance (Sensitivity)	0.57	19.25	**19.82**

Table 5 shows the lowest ground level within the Harpswell Lane Interaction Zone taken from the topographical surveys, and therefore the expected lowest level of a typically mounted PV Module (600mm above ground) within the Interaction Zone.

Table 5 - Lowest Ground and Bottom of PV Panel Levels

Location	Lowest Ground Level (m AOD)	Lowest level of typically mounted PV Module (m AoD)
Solar PV field no. 56	19.25	**19.85**

The expected flood levels in Field 56 are compared in **Table 6** against the height of typically mounted solar PV Modules in the lowest point of solar PV field no. 56 to determine the if 300mm of freeboard between the Higher Central (design) flood event depth and the lowest level of the solar PV Modules is achieved without the need for raising.

Table 6 - Freeboard of typically mounted Solar PV Modules (Field 56)

Flood Event	Flood Depth (m AOD)	Lowest level of typically mounted PV Module (m AOD)	Freeboard to Bottom of typically mounted PV Module 600mm above ground (mm)
1 in 100 year + 50% Higher Allowance (Design)	19.76	19.85	90

The findings in **Table 6** demonstrate the requirement to mount the PV Modules in the Interaction Zone higher than the typical detail due to the predicted flood risk level.

Table 7 below provides the recommended minimum lowest height PV Modules should be mounted at within the Harpswell Lane Interaction Zone to mitigate the risk of damage to components due to flood water during the Higher (design) flood event. The increase in minimum level can be achieved by lengthening the module mounting structure legs (or in effect, “raising” the panels by 220mm from the typical height).

Table 7 - Proposed increase in mounting height to achieve 300mm freeboard (Field 56)

Solar PV Modules location	Freeboard to bottom of typically mounted PV Panel (mm)	Increase in minimum lowest PV Module level required to achieve 300mm from flood level (mm)	Proposed lowest level of raised mounted PV Module (m AOD)
Harpswell Lane Interaction Zone	90	210	**20.06**

Table 8 demonstrates the freeboard achieved between the 1 in 100 year + 100% Upper Climate Change flood depth and the proposed “raised” minimum level of the solar PV Modules to be mounted within the Interaction Zone.

Table 8 - Freeboard sensitivity check against raised PV Modules (Field 56)

Flood Event	Flood Depth (m AOD)	Proposed lowest level of raised mounted PV Module (m AOD)	Freeboard to Bottom of “raised” PV Module (mm)
1 in 100 year + 100% Upper Allowance (Sensitivity)	19.82	20.06	**240**

Table 8 demonstrates that the lowest level of the proposed raised PV Modules will provide 240mm of freeboard during the 1 in 100 year + 100% climate change flood event (i.e. credible maximum scenario).

Proposed Mitigation Measures

The methodology of the analysis undertaken within this Technical Note provides a robust estimate of the flood depth for the design flood event scenario. To ensure the proposed mitigation measure to raise the height of Solar PV panels is also robust, the design event flood depth level (19.76 m AOD) has been mapped onto the 3D surface of the area surrounding the Harpswell Lane interaction zone as a Purple contour line using Autodesk Civil 3D software. As shown below in **Figure 7**, this contour line extends into Solar PV Field no.56 and further upstream of the Harpswell Lane Interaction Zone, marginally into Solar PV Fields no. 57 and 51.

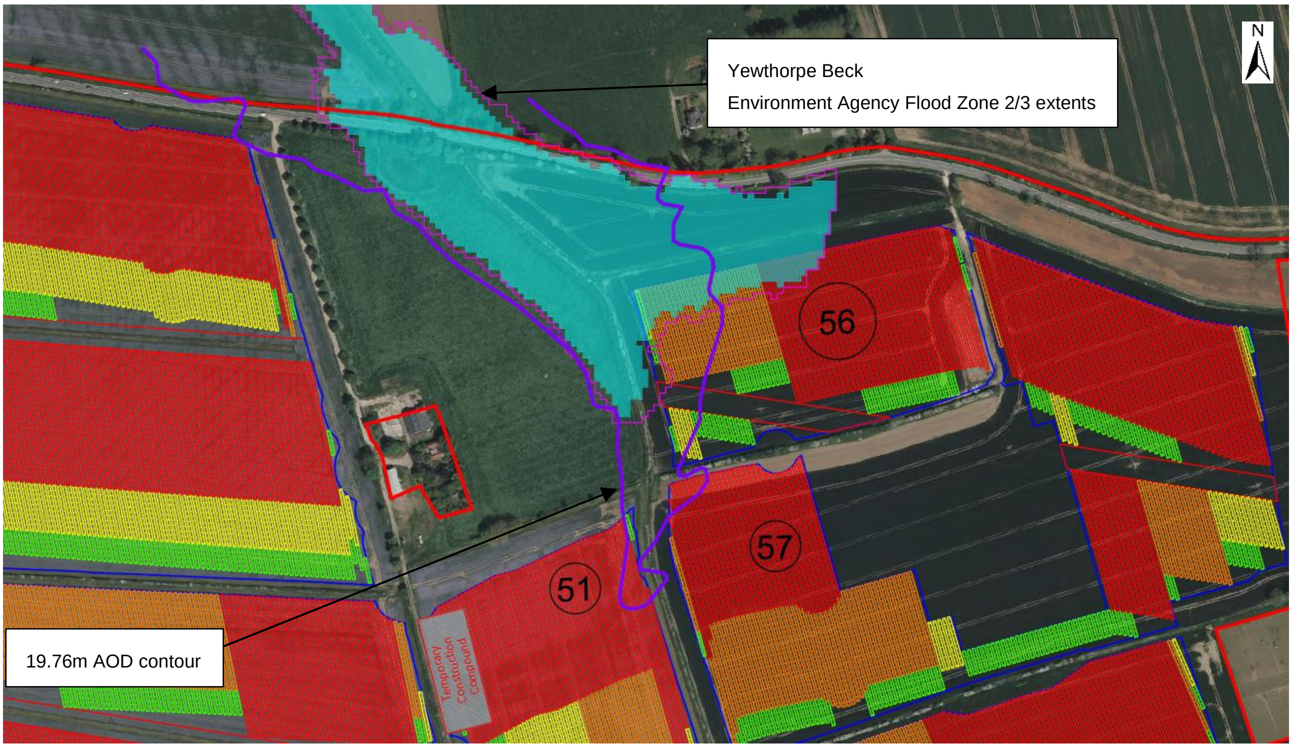

Figure 7 - Design Flood Depth Extent (Purple line as 19.76m AOD)

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It is therefore also proposed include Solar PV Fields no. 51 and 57 in the fluvial flood risk mitigation measure by ensuring any Modules mounted in these fields area also no lower than 20.06m AOD.

Although, it is not envisaged that flooding will occur within fields 51 and 57 during the design flood events, due to the Harpswell Lane topography being lower than the lowest points of Solar PV Fields, 51, 56 and 57, at approximately 19.00m AOD, as mentioned previously in lieu of a hydraulic model of the Yewthorpe Beck ordinary watercourse, a conservative approach to the mitigation measures is proposed, to ensure a robust approach that demonstrates the Scheme will remain operational in times of flood.

Summary

An analysis has been undertaken to predict the flood levels within the Harpswell Interaction Zone for the 1 in 100 year + CC events.

Typically mounted Solar PV Modules would not provide sufficient freeboard during flood events when taking climate change into account, without mitigation.

The PV Panels within Field 56, 57 and 51 will not be installed lower than 20.06m AOD to mitigate the risk of flooding from the surface water ditch (Yewthorpe Beck).

The proposed mitigation provides a robust approach to demonstrate the Scheme can operate during times of flood, for up to and including the 1 in 100 year + Climate Change events.

Appendix A – Greenfield Calculations

hrwallingford

Greenfield runoff rate estimation for sites

www.uksuds.com | Greenfield runoff tool

Calculated by:	Phoebe Martin
Site name:	Tillbridge Solar
Site location:	Harpswell Lane

Site Details

Latitude:	53.39435° N
Longitude:	0.69479° W
Reference:	2669640080
Date:	Jan 11 2024 12:07

This is an estimation of the greenfield runoff rates that are used to meet normal best practice criteria in line with Environment Agency guidance "Rainfall runoff management for developments", SC030219 (2013) , the SuDS Manual C753 (Ciria, 2015) and the non-statutory standards for SuDS (Defra, 2015). This information on greenfield runoff rates may be the basis for setting consents for the drainage of surface water runoff from sites.

Runoff estimation approach

FEH Statistical

Site characteristics

Total site area (ha): 805

Methodology

Q_{MED} estimation method:	Calculate from BFI and SAAR
BFI and SPR method:	Specify BFI manually
HOST class:	N/A
BFI / BFIHOST:	0.365
Q_{MED} (l/s):	
Q_{BAR} / Q_{MED} factor:	1.12

Hydrological characteristics

	Default	Edited

Notes

(1) Is Q_{BAR} < 2.0 l/s/ha?

When Q_{BAR} is < 2.0 l/s/ha then limiting discharge rates are set at 2.0 l/s/ha.

(2) Are flow rates < 5.0 l/s?

Where flow rates are less than 5.0 l/s consent for discharge is usually set at 5.0 l/s if blockage from vegetation and other materials is possible.

SAAR (mm):	583	603
Hydrological region:	5	5
Growth curve factor 1 year:	0.87	0.87
Growth curve factor 30 years:	2.45	2.45
Growth curve factor 100 years:	3.56	3.56
Growth curve factor 200 years:	4.21	4.21

Lower consent flow rates may be set where the blockage risk is addressed by using appropriate drainage elements.

(3) Is SPR/SPRHOST ≤ 0.3?

Where groundwater levels are low enough the use of soakaways to avoid discharge offsite would normally be preferred for disposal of surface water runoff.

Greenfield runoff rates

	Default	Edited
Q_{BAR} (l/s):		1635.23
1 in 1 year (l/s):		1422.65
1 in 30 years (l/s):		4006.31
1 in 100 year (l/s):		5821.42
1 in 200 years (l/s):		6884.31

Appendix B – Existing Ditch Capacity Calculations

AECOM

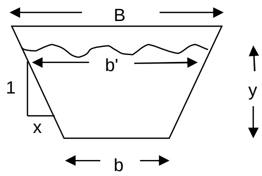
OPEN CHANNEL FLOW CALCULATIONS

Project: *Tillbridge Solar* **Job No:**
Section: *Harpswell Lane Exising Ditch (full)* **Date:** *28.11.22*
Sheet No: *1* **of** *1*
Made By: *PM* **Checked By:** CB

Free Board	0.00	m
Width of channel base, b=	2.50	m
Channel side slope, 1 in x=	2.1	
Max. water depth, y=	0.75	m

Cover	Pipe	Depth	side slope
		0.75	

Existing ground level=	18.750	m
Invert level of channel=	18.000	m
Top channel width, B=	5.60	m



area, A=	3.0563
wetted perimeter,P=	5.988911
top width at top water level, b'=	5.65
hydraulic radius, R=	0.510318
hydraulic mean depth, Dm=	0.540929
Velocity, m/s=	**0.257633**

Bed slope 1 in 960
Manning's, n= 0.08

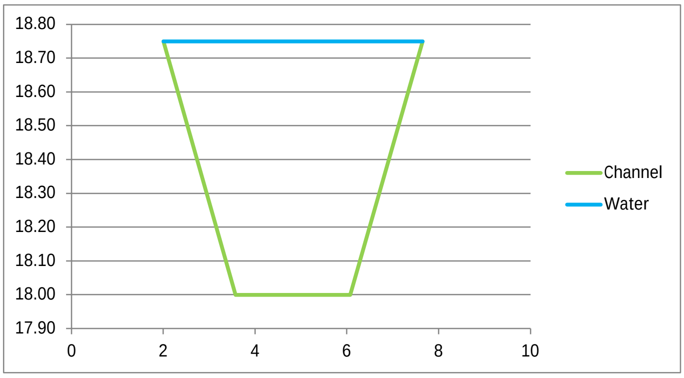
Q= 0.7873913 cumecs or 787.39 l/s

ROUGHNESS VALUES

Type of channel	Condition	Manning's n
Grass channel, regularly maintained	Average, good	0.050
Grass channel, not maintained with dense weeds	Good Average Poor	0.050 0.080 0.120
Concrete	Average Poor	0.013 0.016
Black top	Average Poor	0.017 0.021

SIDE SLOPES

Material	Side Slope (H:V)
Rock	Nearly vertical
Muck and peat soils	¼:1
Stiff clay or earth with concrete lining	½:1 to 1:1
Earth with stone lining or earth for large channels	1:1
Firm clay or earth for small ditches	1½:1
Loose, sandy earth	2:1
Sandy loam or porous clay	3:1



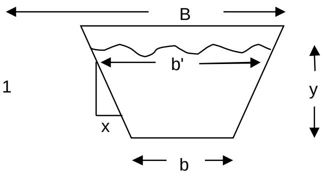
Appendix C – Flood Chanel Calculations

OPEN CHANNEL FLOW CALCULATIONS

Project: *Tillbridge Solar* **Job No:**
Section: *Harpswell Flood Channel (Higher Allowance: excess rate 8.4Cu)* **Date:** *04.01.24*
Sheet No: *1* **of** *1*
Made By: *PM* **Checked By:** CB

				Cover	Pipe	Depth	side slope	half trench width	B
Free Board	0.00	m							
Width of channel base, b=	5.60	m							
Channel side slope, 1 in x=	180.0								
Max. water depth, y=	0.52	m							

Existing ground level= 20.000 m
Invert level of channel= 19.250 m
Top channel width, B= 270.00 m



area, A=	51.5840
wetted perimeter,P=	192.8029
top width at top water level, b'=	192.8
hydraulic radius, R=	0.267548
hydraulic mean depth, Dm=	0.267552
Velocity, m/s=	**0.16751**

C

Bed slope 1 in 960
Manning's, n= 0.08

Q= 8.6408619 cumecs or 8640.86 l/s

ROUGHNESS VALUES

Type of channel	Condition	Manning's n
Grass channel, regularly maintained	Average, good	0.050
Grass channel, not maintained with dense weeds	Good Average Poor	0.050 0.080 0.120
Concrete	Average Poor	0.013 0.016
Black top	Average Poor	0.017 0.021

SIDE SLOPES

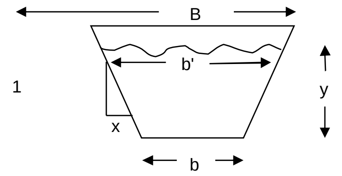
Material	Side Slope (H:V)
Rock	Nearly vertical
Muck and peat soils	¼:1
Stiff clay or earth with concrete lining	½:1 to 1:1
Earth with stone lining or earth for large channels	1:1
Firm clay or earth for small ditches	1½:1
Loose, sandy earth	2:1
Sandy loam or porous clay	3:1

OPEN CHANNEL FLOW CALCULATIONS

Project: *Tillbridge Solar* **Job No:**
Section: *Harpswell Flood Channel (Higher Allowance: excess rate 7.9Cu)* **Date:** *04.01.24*
Sheet No: *1* **of** *1*
Made By: *PM* **Checked By:** CB

Free Board	0.00	m	Cover	Pipe	Depth	side slope	half trench width	B
Width of channel base, b=	5.60	m						
Channel side slope, 1 in x=	180.0							
Max. water depth, y=	0.51	m						

Existing ground level=	20.000	m
Invert level of channel=	19.250	m
Top channel width, B=	270.00	m



area, A=	49.6740
wetted perimeter,P=	189.2028
top width at top water level, b'=	189.2
hydraulic radius, R=	0.262544
hydraulic mean depth, Dm=	0.262548
Velocity, m/s=	**0.165415**

C

Bed slope 1 in	960
Manning's, n=	0.08

Q= 8.2168343 cumecs or 8216.83 l/s

ROUGHNESS VALUES

Type of channel	Condition	Manning's n
Grass channel, regularly maintained	Average, good	0.050
Grass channel, not maintained with dense weeds	Good Average Poor	0.050 0.080 0.120
Concrete	Average Poor	0.013 0.016
Black top	Average Poor	0.017 0.021

SIDE SLOPES

Material	Side Slope (H:V)
Rock	Nearly vertical
Muck and peat soils	¼:1
Stiff clay or earth with concrete lining	½:1 to 1:1
Earth with stone lining or earth for large channels	1:1
Firm clay or earth for small ditches	1½:1
Loose, sandy earth	2:1
Sandy loam or porous clay	3:1

Annex D – Sea Level Rise Calculation

Tillbridge
Solar

Tillbridge Solar Project
EN010142

Volume 6
Environmental Statement
Appendix 10-3:Flood Risk Assessment Annex D Sea Level Rise Calculations
Document Reference: EN010142/APP/6.2

Regulation 5(2)(a)
Infrastructure Planning (Applications: Prescribed Forms and Procedure) Regulations 2009

April 2024
Revision Number: 00

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TILLBRIDGE SOLAR FARM - SEA LEVEL RISE ASSESSMENT - JANUARY 2023

Note

Assessed using Environment Agency OnlineSea Level Rise guidance and Table 1 and 2; https://www.gov.uk/guidance/flood-risk-assessments-climate-change-allowances

A Following maps used to identify which river basin district Scheme is within

River basin district map that zooms in so you can find places close to river basin district boundaries

Guidance Notes on locations/river basin districts, for places in:

1 Thames river basin district use ‘south east’ sea level rise allowances
2 Severn river basin district use ‘south west’ sea level rise allowances
3 Parts of Solway Tweed river basin district on the west coast and Dee river basin district that are in England, use ‘north west’ sea level rise allowances
4 Parts of Solway Tweed river basin district on the east coast that are in England, use ‘Northumbria’ sea level rise allowances
5 The allowances in table 1 account for slow land movement. This is due to ‘glacial isostatic adjustment’ from the release of pressure at the end of the last ice age. The northern part of the UK is slowly rising and the southern part is slowly sinking. This is why net sea level rise is less for the north-west and north-east than the rest of the country.

B Note for Calculations:

1 To calculate sea level using table 1, add the allowances for the appropriate one of the 6 geographical areas:
2 Up to 2035, use the mm for each year rates for the appropriate geographical area, starting from the present day extreme sea levels from Coastal design sea levels – coastal flood boundary extreme sea levels (2018)
3 From 2036 to 2065, get the increase in sea level by adding the number of years on from 2035 (to 2065), multiplied by the respective rate shown in table 1 for the appropriate geographical area – if the whole time period applies use the cumulative total
4 Treat time periods 2066 to 2095 and 2096 to 2125 as you would 2036 to 2065
5 Where it is appropriate to apply a credible maximum scenario, use the H++ allowance. There is no H++ value for sea level rise beyond 2100.

C H++ (Sensitivity)

1 For the change to relative mean sea level use the H++ scenario of 1.9m for the total sea level rise to 2100.

Table 1: sea level allowances by river basin district for each epoch in mm for each year (based on a 1981 to 2000 baseline) – the total sea level rise for each epoch is in brackets

Area of England	Allowance	2000 to 2035 (mm)	2036 to 2065 (mm)	2066 to 2095 (mm)	2096 to 2125 (mm)	Cumulative rise 2000 to 2125 (metres)
Anglian	Higher central	5.8 (203)	8.7 (261)	11.6 (348)	13 (390)	1.20
Anglian	Upper end	7 (245)	11.3 (339)	15.8 (474)	18.1 (543)	1.60
South east	Higher central	5.7 (200)	8.7 (261)	11.6 (348)	13.1 (393)	1.20
South east	Upper end	6.9 (242)	11.3 (339)	15.8 (474)	18.2 (546)	1.60
South west	Higher central	5.8 (203)	8.8 (264)	11.7 (351)	13.1 (393)	1.21
South west	Upper end	7 (245)	11.4 (342)	16 (480)	18.4 (552)	1.62
Northumbria	Higher central	4.6 (161)	7.5 (225)	10.1 (303)	11.2 (336)	1.03
Northumbria	Upper end	5.8 (203)	10 (300)	14.3 (429)	16.5 (495)	1.43
Humber	Higher central	5.5 (193)	8.4 (252)	11.1 (333)	12.4 (372)	1.15
Humber	Upper end	6.7 (235)	11 (330)	15.3 (459)	17.6 (528)	1.55
North west	Higher central	4.5 (158)	7.3 (219)	10 (300)	11.2 (336)	1.01
North west	Upper end	5.7 (200)	9.9 (297)	14.2 (426)	16.3 (489)	1.41

Table 1: River Basin District Sea Level Allowances

Area of England	Allowance	2000 to 2035 (mm/yr)	2000 to 2035 (mm) - Total	2036 to 2065 (mm/yr)	2036 to 2065 (mm) - cumulative	2066 to 2095 (mm/yr)	2066 to 2095 (mm) - cumulative	2096 to 2125 (mm/yr)	2096 to 2125 (mm) - cumulative	Cumulative rise 2000 to 2125 (metres)
Anglian	Higher central	5.8	203	8.7	261	11.6	348	13	390	1.2
Anglian	Upper end	7	245	11.3	339	15.8	474	18.1	543	1.6
South east	Higher central	5.7	200	8.7	261	11.6	348	13.1	393	1.2
South east	Upper end	6.9	212	11.3	339	15.8	474	18.2	546	1.6
South west	Higher central	5.8	203	8.8	264	11.7	351	13.1	393	1.21
South west	Upper end	7	245	11.4	342	16	480	18.4	552	1.62
Northumbria	Higher central	4.6	161	7.5	225	10.1	303	11.2	336	1.03
Northumbria	Upper end	5.8	203	10	300	14.3	429	16.5	495	1.43
Humber	Higher central	5.5	193	8.4	252	11.1	333	12.4	372	1.15
Humber	Upper end	6.7	235	11	330	15.3	459	17.6	528	1.55
North west	Higher central	4.5	158	7.3	219	10	300	11.2	336	1.01
North west	Upper end	5.7	200	9.9	297	14.2	426	16.3	489	1.41

Gov.uk FID Coastal Flood Level Review - Data

Comments

1	Node Point Chainage Taken as nearest to site location - Taken from Data Source: Coastal_Design_Sea_Levels_Coastal_Flood_Boundary_Extreme_Sea_Levels from Defra Download Service (December 2022)
2	Data point FID level used as present day baseline sea level
3	c2_t100 level chosen for worst case 95th percentile level (with 40 year design life)

Point Data								
FID (Node Number)	Shape *	location	chainage	x_bng	y_bng	base_year	hat_od	mhws_od
29	Point	K MAINLAN	_3888	520441	417625.9	2017	4.09	3.36

Return Periods / Level (m AOD)															
t1	t2	t5	t10	t20	t25	t50	t75	t100	t150	t200	t250	t300	t500	t1000	t10000
4.17	4.27	4.42	4.53	4.65	4.68	4.8	4.88	4.93	5	5.06	5.1	5.14	5.24	5.38	5.92
Return Periods / Level Sensitivity															
c1_t1	c1_t2	c1_t5	c1_t10	c1_t20	c1_t25	c1_t50	c1_t75	c1_t100	c1_t150	c1_t200	c1_t250	c1_t300	c1_t500	c1_t1000	c1_t10000
4.16	4.26	4.39	4.5	4.6	4.63	4.73	4.79	4.83	4.89	4.93	4.96	4.98	5.05	5.15	5.45
Return Periods / Level Sensitivity															
c2_t1	c2_t2	c2_t5	c2_t10	c2_t20	c2_t25	c2_t50	c2_t75	c2_t100	c2_t150	c2_t200	c2_t250	c2_t300	c2_t500	c2_t1000	c2_t10000
4.19	4.31	4.47	4.62	4.77	4.82	5	5.11	5.19	5.32	5.41	5.48	5.55	5.73	6.01	7.1

Seal Level Rise Assessment Parameters				
Location	Design Life (yrs)	Estimated Year of First Operation	Baseline Sea Level (mAOD) (1 in 100 year 97.5% Percentile - C2_T100 - Design Worst Case	Lowest Site Level - Tillbridge Solar (mAOD)
Tillbridge Solar (Chainage _3888, FID 29 Coastal Node)	60	2028	5.19	13.13

Seal Level Rise Levels (Table 2)								
End Life (Predicted Worst Case)	River basin District	Higher Central 2000-2035 Total (mm)	Upper 2000-2035 Total (mm)	Higher Central 2036-2065 Total (mm)	Upper 2036-2065 Total (mm)	Higher Central 2066-2095 mm/yr	Upper 2066-2095 mm/yr	Years from 2066 to end life
2088	Humber	193	235	252	330	11.1	15.3	22

Assessment			
	Sea Level Rise (mm)	Level Adjusted to site (mAOD)	Comment
TOTAL Rise (mm) Upper	901.6	6.09	Design Level based on Essential Infrastructure
H++ Scenario (mm)	1900	7.09	Sensitivity Level
	Design Site Level Check Against Sea Level Rise		Scheme Passes Design Assessment against lowest Scheme ground level
	H++ Sensitivity Test		Scheme Passes Sensitivity Assessment

Annex E – Panel Leg Volume Calculation

Tillbridge Solar Project

EN010142

Volume 6
Environmental Statement

Appendix 10-3:Flood Risk Assessment Annex E
Panel Leg Volume Calculations
Document Reference: EN010142/APP/6.2

Regulation 5(2)(a)
Infrastructure Planning (Applications: Prescribed Forms and Procedure) Regulations 2009

April 2024
Revision Number: 00

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DCO Stage: Panel Support Design			Piled HEA 160 I-Beams (cm2)	Rounded (cm2)	Non Piled Sigma Beam S140 (cm2)	Rounded (cm2)
1562 panels per ha		Cross Section Area	38.8	39	8.82	9

DCO Actual Design	
Area 1	Harpswell

Field	ha	PV panels per ha	per area	No. of Panels	HEA 160 Legs per Panel	HEA 160 Cross Section Area leg (m2)	Sigma 140 Legs per Panel	Sigma Cross Section (m2)	Leg Cross Section Area per panel	Total Area (m2)	Average Depth flood risk (m)	TOTAL Leg Volume (m3)	Approx depth increase (mm)
56	0.68	1562	1062	722	1	0.0039	2	0.0009	0.0057	4.12	0.25	1.03	0.34
57	0.062	1562	97	6	1	0.0039	2	0.0009	0.0057	0.03	0.25	0.01	0.00
51	0.11	1562	172	19	1	0.0039	2	0.0009	0.0057	0.11	0.125	0.01	0.00
											TOTAL VOLUME LOST (m3)	1.05	

DCO Stage: Panel Support Design

Table 1: Panel Design (Legs per panel)

	A	B	C	D	E	F	G
1	Size (Qt. of modules per tracker) [-]	Length [m]	Non-drive piles [-]	Drive-piles [-]	Qt. of trackers in project [-]	Qt. of non-drive piles in project [-]	Qt. of drive piles in project [-]
2	15.00	21.37	2	1	5,535	11,070.00	5,535.00

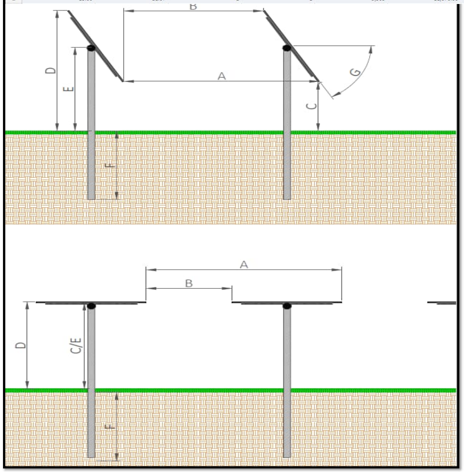


Table 2: Minimum and Maximum Parameters PV Panels

ID	Item	Minimum Value (m)	Maximum Value (m)	Unit
B	Interrow distance	1.6	3.8	m
C	Clearance at maximum tilt	0.6	1.5	m
D	Height at maximum tilt	2.6	3.5	m
E	Axis height	1.5	2.5	m
F	Ground penetration	-	4	m

Table 3: Sigma 140 Design Table

SECTION										GROSS CROSS SECTION PROPERTIES				
Section Type	Section name	h (mm)	b (mm)	c (mm)	h_c (mm)	h_t (mm)	t (mm)	G (kg/m)	A_{paint} (m²/m)	A (cm²)	I_y (cm⁴)	W_y (cm³)	I_z (cm⁴)	W_z (cm³)
S 200	S 200x4	200	65	20	100	36	4,00	11,57	0,78	14,64	814,7	83,13	49,22	13,51
	S 200x3						3,00	8,85		11,19	633,3	64,29	40,02	10,76
	S 200x2,5						2,50	7,45		9,38	535,3	54,21	34,55	9,20
	S 200x2						2,00	6,01		7,53	433,2	43,76	28,53	7,52
	S 200x1,75						1,75	5,28		6,59	380,4	38,37	25,28	6,63
	S 200x1,5						1,50	4,54		5,64	326,8	32,93	21,92	5,72
S 170	S 170x4	170	60	15	70	36	4,00	10,00	0,68	12,66	502,4	60,53	35,91	10,53
	S 170x3						3,00	7,67		9,71	392,9	47,06	29,43	8,44
	S 170x2,5						2,50	6,46		8,15	333,1	39,77	25,50	7,24
	S 170x2						2,00	5,22		6,55	270,3	32,18	21,12	5,93
	S 170x1,75						1,75	4,59		5,74	237,6	28,24	18,74	5,24
	S 170x1,5						1,50	3,96		4,94	204,3	24,25	16,27	4,52
S 140	S 140x4	140	60	15	40	34	4,00	9,05	0,62	11,47	313,5	46,11	34,92	10,21
	S 140x3						3,00	6,97		8,82	246,3	35,91	28,69	8,21
	S 140x2,5						2,50	5,88		7,41	209,2	30,43	24,89	7,05
	S 140x2						2,00	4,75		5,96	170,1	24,66	20,64	5,79
	S 140x1,75						1,75	4,18		5,22	149,7	21,65	18,32	5,11
	S 140x1,5						1,50	3,60		4,48	128,7	18,61	15,92	4,42

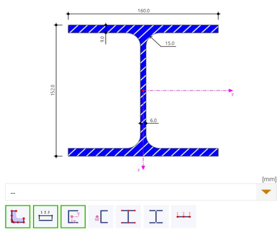
Table 3:HEA 160 Design Table

HEA 160

Geometry			
Depth	h	152.0	mm
Width	b	160.0	mm
Web thickness	t_w	6.0	mm
Flange thickness	t_f	9.0	mm
Inner depth between flanges	h_i	134.0	mm
Root fillet radius	r_1	15.0	mm
Depth of straight portion of web	d	104.0	mm
Sectional Area			
Sectional area	A	38.80	cm²
Bending			
Area moment of inertia about y-axis	I_y	1670.00	cm⁴
Area moment of inertia about z-axis	I_z	616.00	cm⁴
Polar area moment of inertia	I_p	2286.00	cm⁴
Radius of gyration about y-axis	i_y	65.7	mm
Radius of gyration about z-axis	i_z	39.8	mm
Polar radius of gyration	i_p	76.8	mm
Statical moment of area about y-axis	max S_y	123.00	cm³
Statical moment of area about z-axis	max S_z	28.95	cm³
Elastic section modulus about y-axis	W_y	220.00	cm³

HEA 160

- DIN 1025-3:1994-03
- Özkan



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