

TABLE OF CONTENTS

1	Introduction -----	1
	1.1 - Background-----	1
	1.2 - Guidance and Legislation -----	1
	1.3 - Site Characteristics-----	1
	1.4 - Flood Classification -----	2
	1.5 - Flood History -----	5
	1.6 - Hydrology -----	5
2	Flood Risk Assessment-----	8
	2.1 - Fluvial-----	8
	2.2 - Tidal -----	13
	2.3 - Pluvial -----	13
	2.4 - Groundwater -----	14
	2.5 - Sequential Test and Exception Test -----	15
3	Surface Water Management-----	18
	3.1 - Construction Phase -----	18
	3.2 - Operational Phase -----	20
4	Conclusion & Recommendations-----	23

Appendix A: SITE LAYOUT

Appendix B: EA DATA



RAINCLOUD

1 INTRODUCTION

1.1 Background

Raincloud Consulting Ltd ('Raincloud') has been commissioned to undertake a Flood Risk Assessment (FRA) for the proposed solar farm ('the Development') on land between the A16 and the Coronation Channel of the River Welland, approximately 100 metres (m) south of the operational Pilgrim Foods Factory, Spalding ('the Site').

The Development comprises ground mounted solar photovoltaic panels and associated infrastructure which would connect via underground cable to the existing Pilgrim Foods factory, north of the Development.

The Development is located wholly within the jurisdiction of South Holland District Council (the Council) and the Development layout is provided in Appendix A.

1.2 Guidance and Legislation

This document is intended to meet the requirements of:

- Environment Agency ('EA');
- South East Lincolnshire Strategic Flood Risk Assessment (SEL SFRA)¹;
- Updated South Holland District Council Strategic Flood Risk Assessment (SH SFRA);
- South Holland District Council Surface Water Drainage Strategy;
- Lincolnshire County Council Preliminary Flood Risk Assessment (PFRA); and
- The revised National Planning Policy Framework (NPPF).

1.3 Site Characteristics

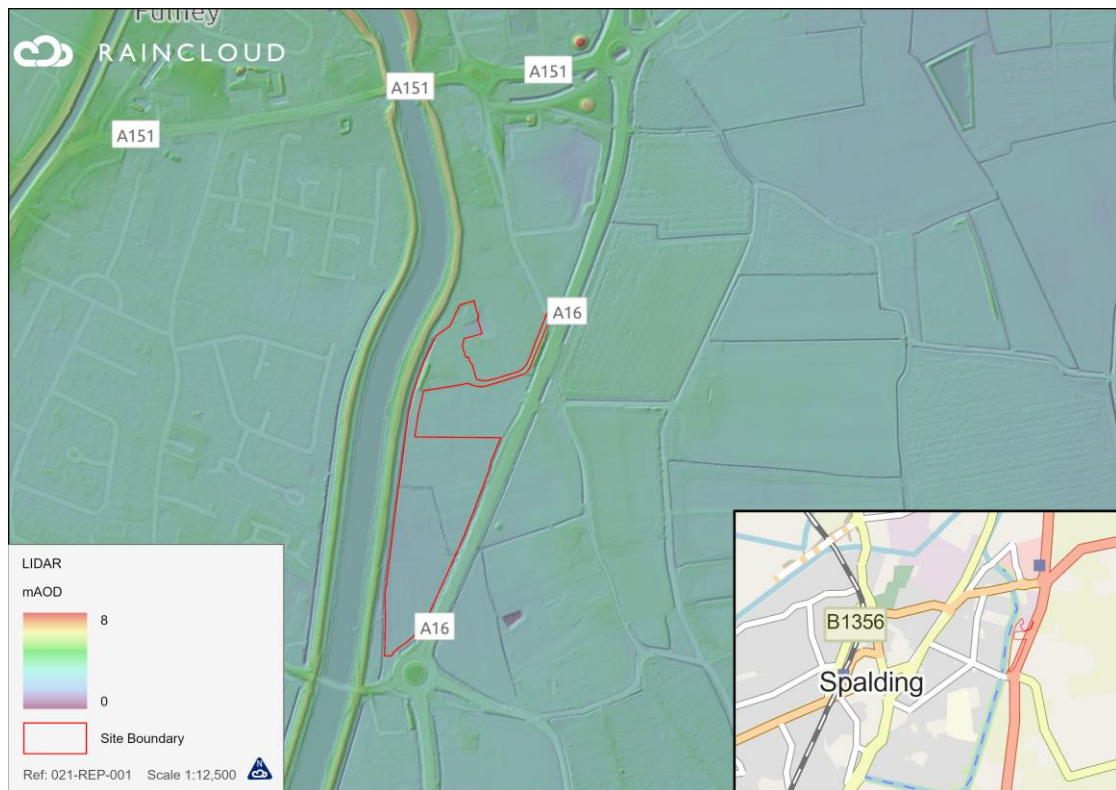
The Site is located immediately adjacent to the Coronation Channel of the River Welland to the west and the A16 road to the east.

The Site is greenfield and in pastoral use.

The Site slopes gently from north to south from approximately 4.0 m above ordnance datum (AOD) to 2.5 m AOD, as shown in Plate 1.

¹ <https://southeastlincslocalplan.org/water/>

Plate 1: Topography at the Site



1.4 Flood Classification

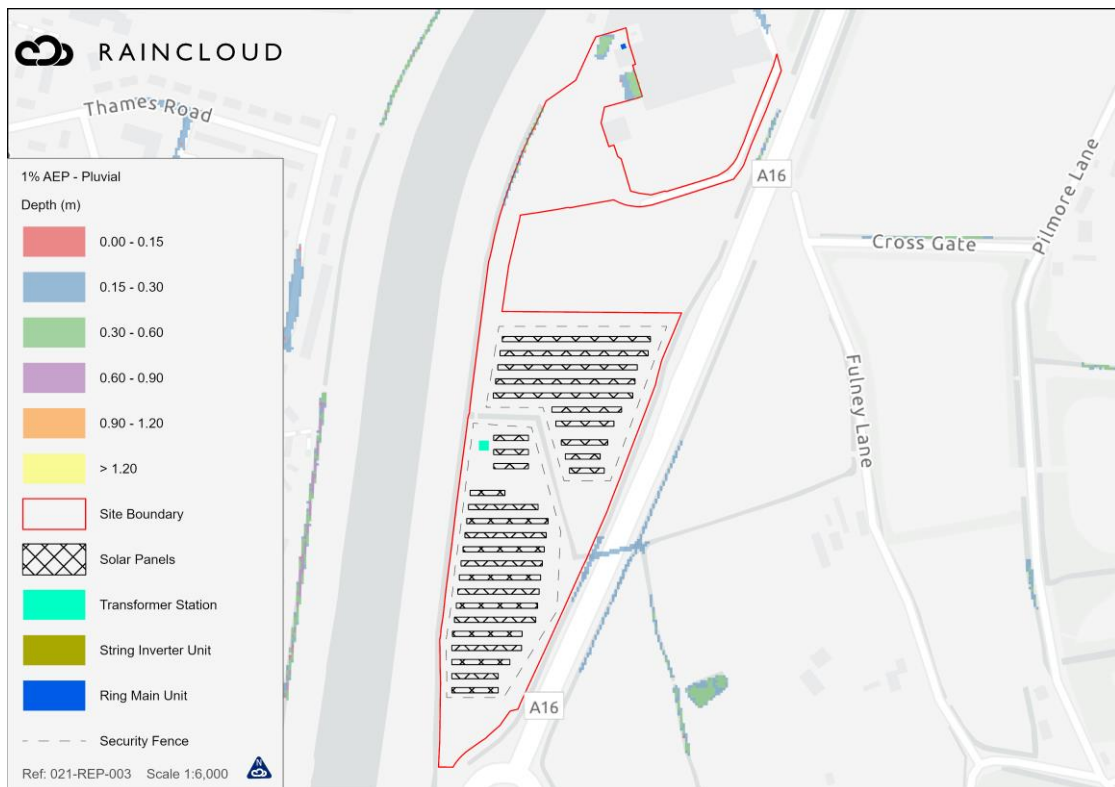
The EA Flood Map for Planning shows that the Site is entirely located in Flood Zone 3a, as is much of the wider area, and in an area classed as having a Reduction in risk of flooding from rivers and sea due to the presence of flood defences, as shown in Plate 2.

Plate 2: Flood Zones



No electrically sensitive aspects of the Development (e.g. inverters, transformers, substation) are shown to be at risk of pluvial flooding during the 3.33 %, 1 % and 0.1 % AEP events, as shown in Plate 3.

Plate 3: Pluvial Flood Extents



The Site is located outside the extents of flooding should there be a breach in the retaining walls of reservoirs within the catchment. As such, reservoir flooding has been scoped out of this assessment.

The Site is greenfield and drainage infrastructure is not observed in proximity. As such, flooding from artificial sources has also been scoped out of this assessment.

1.5 Flood History

Anecdotal evidence suggests that the Site has not previously flooded.

The EA historic flood outline dataset also indicates that the Site has not previously flooded.

1.6 Hydrology

The Site lies within the primary catchment of the River Welland. Following the floods of 1947, the river was straightened and widened and, in 1953, the Coronation Channel was constructed to protect Spalding from floods.

Flows enter Coronation Channel from the River Welland at Cowbit Sluice, approximately 1.9 km southwest of the Site.

The Coronation Channel is a fluvially dominated watercourse with earth embankment flood defences. The tidal limit is located approximately 820 m north at Marsh Road, where a tidal sluice gate operates to prevent tidal propagation upstream. Similarly, the River Welland

through Spalding is fluvially dominated and Fulney Lock tidal defences are located approximately 915 m northwest of the Site.

There is a man-made drainage ditch in the centre of the Site draining northwest which discharges into a linear field ditch draining north to south.

Plate 4 shows the main hydrological features in proximity to the Site.

Plate 4: Flood Defences in proximity to Site



2 FLOOD RISK ASSESSMENT

Flood risk will be classed as Negligible (where little or no risk is identified), Low (where theoretical risk is identified but mitigating factors may influence flood levels) or Moderate to High (where modelled levels or historical events show risk to the Site).

Several factors will be considered when attributing the residual risk of flooding to the Development, including:

- The depth of flooding;
- The hazard to life during flood water ingress;
- The velocity of floodwater;
- Flooding extent / ingress into site;
- Type of infrastructure affected; and
- Intervening structures / flood protection.

The Conclusion section of this FRA provides justification for the risk category using professional judgement and experience of assessing similar types of projects / scenarios.

2.1 Fluvial

The EA provided data from the Welland Catchment Strategic Flood Model (2016) for a number of flood return periods. Anticipating a Development lifespan of 30 years, the climate change allowance within the EA data is appropriate for planning as national guidance states that an uplift of 10 % should be applied to fluvial flows, as per the 2050s epoch Higher Central allowance for the Welland Catchment.

The flood levels for the model nodes closest to the Site are shown in Table 1.

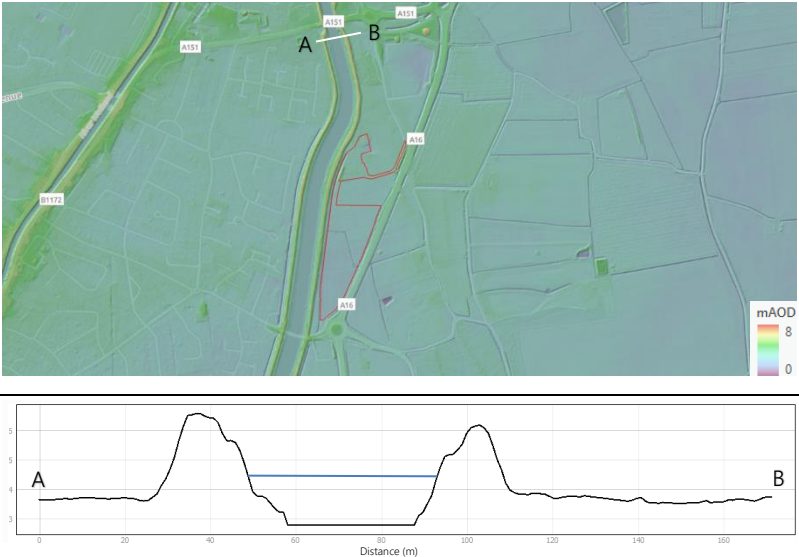
Table 1: Flood Levels - Coronation Channel

Node	1 % AEP level (m)	1 % AEP + 20 % level (m)	0.1 % AEP level (m)
WELLAND 11073.5	4.43	4.44	4.68
WELLAND 11616.7	4.45	4.46	4.68
WELLAND 12088.4	4.45	4.47	4.68

Flood defence crest levels on the eastern bank of the Coronation Channel range from 5.22 m AOD to 5.57 m AOD². Cross sectional analysis using 1 m spatial LiDAR shows that the 1 % AEP, 1 % AEP + 20 % climate change and 0.1 % AEP events would be contained within the embankments at either side of the Coronation Channel, as shown in Table 2.

² <https://environment.data.gov.uk/asset-management/index.html?element=http%3A%2F%2Fenvironment.data.gov.uk%2Fasset-management%2Fid%2Fasset%2F504995&layer=all-assets>

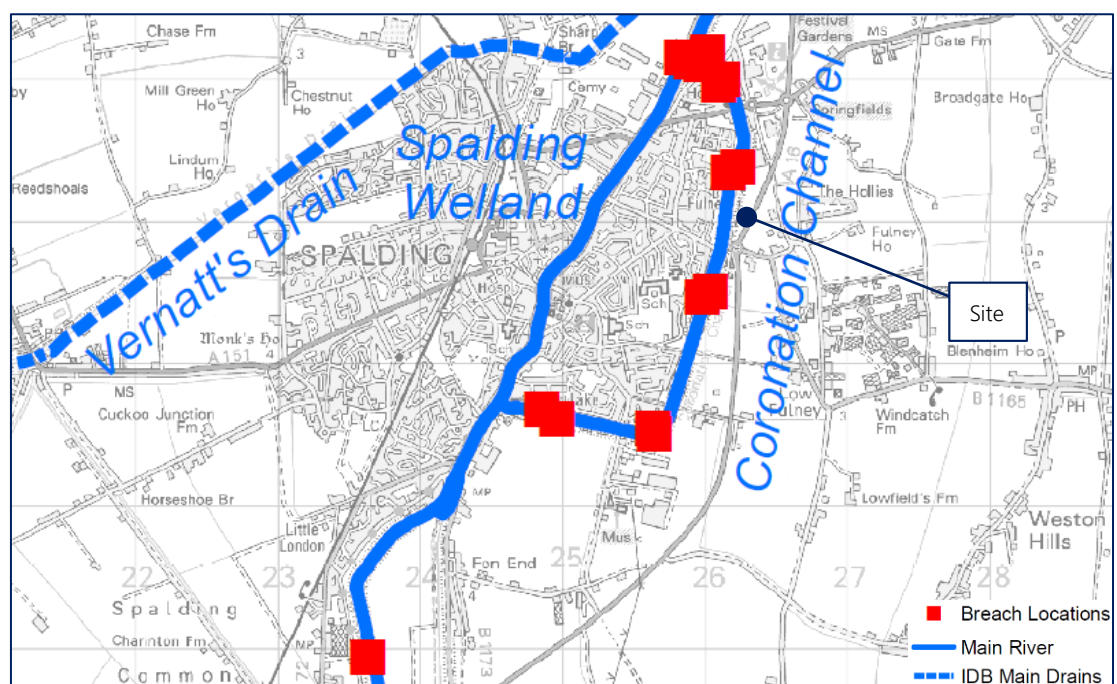
Table 2: Cross Sectional Analysis

Node	1 % AEP + 20 % level (mAOD)	Defence crest level (mAOD)	Node Location and Cross Section (flood level in blue)
WELLAND 11073.5	4.44	6.2	
WELLAND 11616.7	4.46	5.8	
WELLAND 12088.4	4.47	5.3	

As such, the Site is not at risk of flooding from an overtopping event for all return periods in a non-tidal surge scenario. Under normal tidal conditions, tide-locking would occur, preventing river flows discharging due to high tidal levels downstream of Marsh Road, however the Welland Catchment Modelling Update Volume 2³ study considers these conditions and no overtopping is modelled for the 1 % AEP event.

No fluvial breach analysis has been undertaken by the EA. The South East Lincolnshire Strategic Flood Risk Assessment (SFRA)⁴ presents breach analysis for a fluvially dominant 1 % AEP event and identifies several breach locations within the South Holland District, including two breaches immediately adjacent to the Site, as shown in Plate 5.

Plate 5: Fluvial Breach Locations (taken from SFRA)



The Site, and wider area, would be impacted to depths of up to 2 m during a 1 % AEP breach scenario for the year 2016 and greater than 2 m for the year 2115, based on the 2016 Update of South Holland Strategic Flood Risk Assessment – Spalding Maps⁵. The defence breach scenario represents a residual flood risk based on the modelled flood levels and flood defence data provided by the EA, which shows no overtopping during the same return period, as shown in Plates 5 and 6.

³ Welland Catchment Modelling Update Volume 2. River Welland Hydraulic Modelling Report (September 2016). Environment Agency

⁴ <http://www.southeastlincslocalplan.org/wp-content/uploads/2018/01/SE-Lincolnshire-SFRA-2017-v6-24th-Jan-2018.pdf>

⁵ <https://southeastlincslocalplan.org/2016-update-of-south-holland-strategic-flood-risk-assessment-spalding-maps/>

Plate 5: Fluvial Breach Depths (2016)

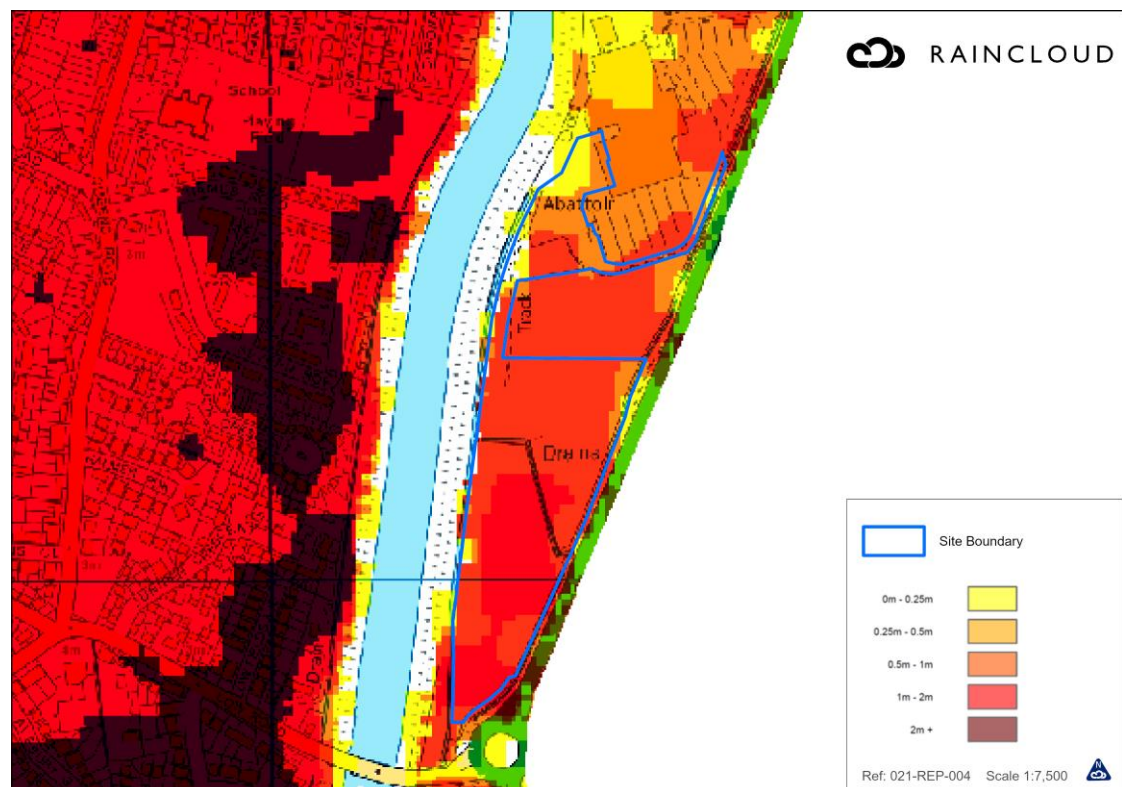
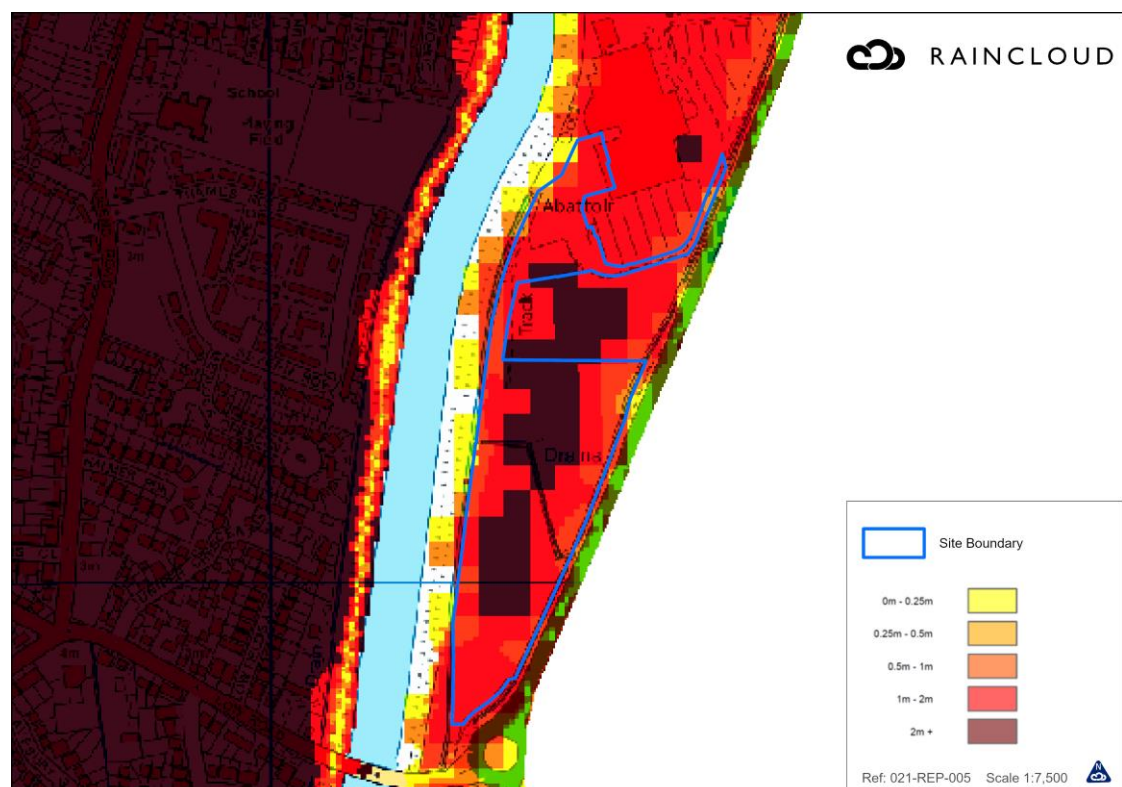


Plate 6: Fluvial Breach Depths (2115)



As such, a defence overtopping scenario during an extreme tidal locking event remains a more realistic flood mechanism as opposed to a breach event. Acknowledging the overtopping scenario as the 'true' form of flood risk based on the existing tidal flood defence system in place, the breach scenario poses a residual risk should such infrastructure fail.

The flood embankments have a Condition Rating of Fair and are inspected every two years by the EA. Whilst a breach / structural failure of the defences is possible, the shallow incline of the embankment is likely to ensure stability under pressure from flood waters.

Under a breach of fluvial defences the Development would be resilient to some extent as the PV arrays tables are elevated from ground level by approximately 0.8 m while the PV racking system is made of high-tensile strength alloy metal, as shown in Plate 7, meaning the Development would be safe under a breach scenario.

Due to the thin nature of the PV racking system the effect of flood displacement and flow conveyance under fluvial breach would not be discernible.

Plate 7: Typical PV racking system⁶



As such, the risk of the Development flooding from fluvial sources is **Low**.

⁶ Photo credit: Rob Sutton, Cotswold Archaeology

2.2 Tidal

As outlined in Section 1.6, Marsh Road Sluice gate acts to prevent tidal propagation up Coronation Channel and similarly, Fulney Lock acts to prevent propagation of tidal waters up the River Welland.

Downstream of these locations the rivers are embanked to a height required to defend against extreme tidal surges³.

As such, breach of tidal embankments is the only mechanism whereby out of channel flows are predicted.

EA data, presented in Appendix B, shows that the nearest modelled breach location is approximately 500 m north of the Marsh Road Tidal Sluice.

A breach during the 0.5 % AEP and the 0.1 % AEP, for the year 2115, would not encroach on the Site, partly due to the elevated nature of the A16 and other roads which would act as topographical barriers to flood water.

The EA have also provided breach outputs for the River Nene⁷ approximately 21 km east of the Site and flood outlines are contained to the east of the A1101 road, approximately 20 km east of the Site.

As such, the risk of flooding from tidal sources is **Low**.

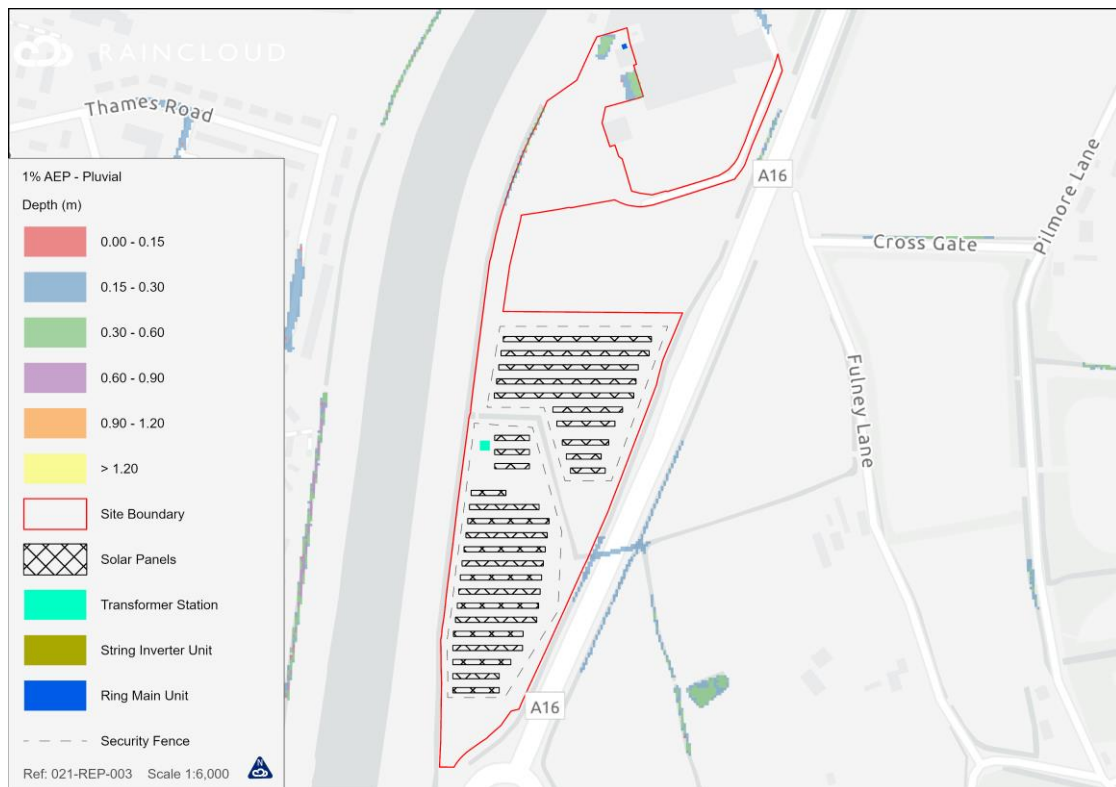
2.3 Pluvial

Electrically sensitive infrastructure, such as inverters are located outside the 3.3 %, 1 % and 0.1 % AEP surface water flooding extent, as shown in Plate 3 of this FRA.

The only infrastructure located within the 1 % AEP event is the PV arrays which will be raised off the ground by 0.8 m on a racking system and therefore will not be affected by the shallow pluvial depths (0 – 0.15 m depth), as shown on Plate 8.

⁷ Environment Agency Flood Risk Mapping and Data Management: Anglian Region Strategic Flood Risk Management Framework
Tidal Nene and Tidal Welland Hazard Mapping (2011)

Plate 8: 1 % AEP depths



The Site is in agricultural use. As such, the baseline scenario will not generate substantial surface water run-off rates, and the risk of pluvial flooding is **Negligible**.

Management of surface water runoff from the Development is detailed in Section 2.6 of this FRA.

2.4 Groundwater

The EA Long Term Flood Risk service⁸ reports "*Flooding from groundwater is unlikely in this area*" and the Site slopes to lower ground at the extremities of the Site, suggesting groundwater is unlikely to emanate at ground level within the Development parcel.

British Geological Survey records indicate that groundwater was struck within a borehole⁹, approximately 25 m north of the Site at a depth of 3.5 m and rising to 2.8 m below ground level, while other logs show water struck at 4.8 m depth.

At these depths it is unlikely that the Development, particularly the PV racking system will interact with groundwater.

⁸ <https://check-long-term-flood-risk.service.gov.uk/risk>

⁹ http://scans.bgs.ac.uk/sobi_scans/boreholes/473756/images/17689267.html

The PV arrays will be raised off the ground by 0.8 m on a racking system and therefore will not be affected in the event that groundwater emerges at the surface.

As such the risk of groundwater flooding is **Negligible**.

2.5 Sequential Test and Exception Test

Paragraph 167 of the NPPF states that developments located within Flood Zone 3 should apply a risk based sequential test in order to steer proposed development towards areas classed as having a lower probability of flooding. (*i.e.* in Flood Zone 1). Paragraph 169 of the NPPF does, however, acknowledge that under certain circumstances it may not be possible to locate the development on land identified as having a lower risk of flooding and infrastructure can be located in Flood Zone 2 or 3 for certain infrastructure, subject to passing the Exception Test.

The land at the Site is owned by Pilgrim's Pride, who are the largest higher welfare producer of pork products in the world. The firm's Spalding factory employs 550 people and works with approximately 350 farms and is an important asset for the company to attain its objectives in supplying higher welfare pork to its customers.

Pilgrim have targets for net zero emissions by 2030 with onsite electricity generation at Pilgrim sites being a vital component in achieving net zero emissions targets. The firm have already invested £10 million into GHG reduction projects in the last year.

Following significant recent increases in energy costs for all businesses, the proposed Development looks to support the future feasibility of the Spalding Pilgrim site, through renewable electricity generated onsite. This will also provide greater job security for those employed by Pilgrim. The energy produced from the Development would only be used internally with there being no plans to export electricity to the national grid.

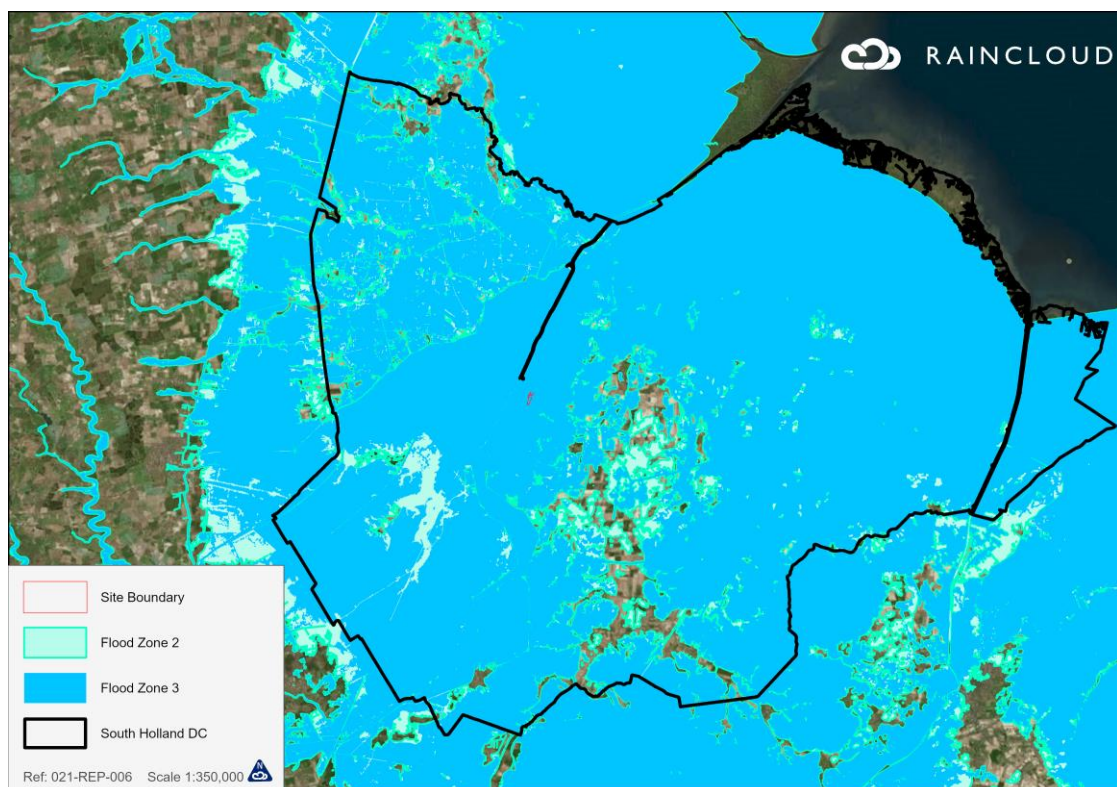
The potential for installing a solar development at the Site has been assessed through feasibility work, which examined key technical and environmental issues. The relatively flat topography of the site is well suited to solar PV development. The site is well contained by existing field boundaries and is separated from residential properties by the river to the east, the main road to the south and west, and the existing industrial area to the north. The site also benefits existing access to the A16 which runs north-south along the eastern boundary which would enable construction and maintenance vehicles to gain entry via main road networks.

Key considerations for Site selection have included:

- Proximity to an available grid connection;
- Proximity to local communities;
- Topography;
- Shading;
- Solar irradiation levels;
- Access to the site for construction;
- Archaeological assets;
- Agricultural land classification (ALC);
- Landscape designations; and
- Ecological designations.

It should be noted that the South East Lincolnshire Strategic Flood Risk Assessment (March 2017) identifies that approximately 74 % of South Holland lies within the floodplain (68 % in Flood Zone 3, 6 % in Flood Zone 2), meaning the wider area offers very few sites available for solar development in Flood Zone 1, as shown in Plate 9.

Plate 9: Flood Zones in South Holland DC



Additionally, due to the close proximity of the Site to the point of connection into the existing factory to the north means that there will mean minimal environmental disruption and power loss due to the short cable route. Locating the Development in Flood Zone 1 (assuming a suitable site could be located) would lead to a substantial cable route and associated environmental damage and power loss.

For these reasons the Development meets the requirements set out in Table 3 of the Planning Practice Guidance and meets the requirements of the Sequential Test of the NPPF.

The two criteria set out in the Exception Test should be applied to developments are:

- 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.

The Development will contribute to the decarbonisation of energy supply infrastructure, therefore contributing to wider sustainability aims.

This FRA has demonstrated that the Site is not at risk up to, and including, the 0.5 % AEP event plus climate change event and will not contribute to flooding offsite.

As such, the Sequential and Exception tests are passed *i.e.* the Site is located appropriately (Essential Infrastructure in Flood Zone 3), as per EA Flood Risk and Coastal Change Guidance.

3 SURFACE WATER MANAGEMENT

3.1 Construction Phase

3.1.1 Pollution Prevention

Given the relatively short construction phase and gently sloping Site, it is not anticipated that significant amounts of sediment will be generated. The Development will adhere to a Construction Environmental Management Plan ("CEMP" - to be provided by the Construction Contractor), which will comply with the relevant guidance.

3.1.2 Run-off Rates

Rural Sustainable Drainage Systems (RSuDS) are not a new concept, but they are not widespread in the rural environment and can present many opportunities for improving our management of water at source. They are a collection of physical structures used to mimic natural processes. In rural environments, it is an approach for managing the detrimental impact of rainfall on fields where run-off is a major threat to the flora, fauna and chemical status of our surface waters.

RSuDS slow down or prevent the transport of pollutants to watercourses by breaking the delivery pathway between the pollutant source and the receptor. By intercepting run-off and trapping sediment before it leaves the field they help maintain and manage the provision of good water quality by preventing the loss of soil, chemicals, nutrients, and faecal organisms. A further benefit is their ability to temporarily capture water and slow down flow. This can reduce localised flooding and provide valuable aquatic habitats in the form of micro-wetlands for farmland wildlife and will encourage the downward movement of water to recharge aquifers.

Research in the United States by Cook & McCuen (2013) outlines that solar panels do not have a significant effect on runoff volumes or peak flows, however where ground beneath panels is bare there may be an increase in peak discharge.

Milazzo et al. (2023)¹⁰ reviews the role of grassland for erosion and flood mitigation in Europe and provides quantification that permanent grassland mitigates better runoff than arable land.

Whilst the Natural England Technical Information Note 101 (TIN101) "*Solar Parks: maximising environmental benefits*" has been archived, the principles relating to solar parks, their siting, their potential impacts and mitigation requirements for the safeguarding of the natural environment are still relevant.

¹⁰ The role of grassland for erosion and flood mitigation in Europe: A meta-analysis. Agriculture, Ecosystems & Environment Volume 348, 1 June 2023, 108443 <https://doi.org/10.1016/j.agee.2023.108443>

TIN101 states:

"The key to avoiding increased run-off and soil into watercourses is to maintain soil permeability and vegetative cover. Permeable land surfaces underneath and between panels should be able to absorb rainfall as long as they are not compacted and there is some vegetation to bind the soil surface".

As such, a suitable grassland sward will be developed in areas underneath the PV arrays before the construction phase, where appropriate.

3.1.3 PV Array Installation

Whilst the PV arrays and racking system does not involve the installation of hardstanding, the installation methods could lead to soil compaction if not managed properly.

Installation of the racking system (mounting frame) should only occur when soil conditions are suitable e.g. dry enough that tyre imprints are not deeper than 10 cm when tracking across land. The Construction Contractor will be responsible for monitoring conditions, in consultation with the Ecological Clerk of Works.

The mounting framework is likely to be delivered by a vehicle with a trailer and is unlikely to cause soil compaction.

The racking system will then be pile driven into the ground to a depth of typically 1 to 2 m, depending on ground conditions using similar tracked mini pile driver machinery, as shown in Plate 10.

Plate 10: Mini pile driver examples



The PV modules are likely to be secured to the racking system by hand and therefore soil compaction is unlikely to occur during this stage, as shown in Plate 11.

Plate 11: PV module installation¹¹



Should vehicles cause compaction during the installation of the PV arrays then this should be ameliorated using typical small-scale horticultural machinery.

3.2 Operational Phase

RSuDS components from the construction phase (grassland) will remain in place for the operational phase of the Development.

The raised nature of PV Arrays will not prevent soil from absorbing rainwater as the panels will not be placed directly on the ground and each PV Row will be separated, with the same area of soil / grassland available for infiltration as per the baseline scenario.

Once rainfall has fallen off a PV Array, the water will be able to spread and flow along the ground under the PV Arrays evenly into the rain-shadow of the row below, so as to mobilise the same percentage of the ground for infiltration as was available prior to the installation of PV Arrays.

The PV Array will comprise rows of solar panel modules mounted on metal frames and pile driven into the ground to limit the footprint of PV array units.

The panels would be mounted at approximately 0.8 m from the ground at the lowest point.

Installation of the PV arrays does not involve the introduction of hardstanding at ground level meaning the superficial cover for the majority of the Site will remain the same as the baseline.

As the baseline vegetation is arable crops the establishment of grassland will be beneficial in terms of vegetation cover and soil stabilisation, as the land will not be tilled.

¹¹ Keele University

Additionally, the PV array tables will have regular rainwater gaps to prevent water being concentrated along a single drip line. As such, rainfall landing on the solar panels will drain through rainwater gaps and infiltrate into the ground beneath and between each row of panels, as shown in Plate 12.

Plate 12: Rainwater gaps on PV array table



Control of run-off from the PV Arrays will be implemented through the land management techniques based upon RSuDS methods that will be implemented before the construction phase, in accordance with the EA's guidance¹².

The limited installation of impermeable surfaces will prevent a significant increase in surface water run-off.

Grassland beneath the solar panels and between the rows of PV arrays will be established, in accordance with Natural England guidance, as shown in Plate 13.

¹² https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/291508/scho0612buwh-e-e.pdf

Plate 13: Established grassland and vegetation cover at Solar Farm



The exact grass seed mix will be determined following soil testing.

The grassland will be managed through an initial and long-term management plan and should be secured through an appropriately worded planning condition.

The promotion of managed grassland will prevent surface water from the drip line from compacting the ground and therefore limit the potential for rilling and soil mobilisation.

Maintenance of solar farm equipment and other regular equipment used onsite, such as any operational vehicles, tools and machinery will be carried out by the relevant operational staff. The maintenance will be carried out based on specific guidance and method statements by appropriately trained staff, in line with the required maintenance schedules. This will minimise the risk of compaction of soils and pollution of watercourses.

4 CONCLUSION & RECOMMENDATIONS

The Site is not modelled to flood from fluvial sources during non-extreme tidal locking scenarios for 1 % AEP, 1 % AEP + 20 % climate change and 0.1 % AEP events.

During a breach of tidal defence embankments flood water does not encroach upon the Site for the 0.5 % AEP and 0.1 % AEP events, plus future climate change up to the year 2115.

The only mechanisms for flooding at the Site are extreme tidal surge causing tidal locking and fluvial breach. Both scenarios are considered unlikely and present a residual risk to the Development.

The Development is classified as Essential Infrastructure and is therefore compatible with Flood Zone 3.

The Development is compliant with both the NPPF and local planning policy,

APPENDIX A: SITE LAYOUT

APPENDIX B: EA DATA