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MEERDYKE SOLAR FARM
FLOOD RISK ASSESSMENT AND DRAINAGE STRATEGY

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MEERDYKE SOLAR FARM
FLOOD RISK ASSESSMENT AND DRAINAGE STRATEGY

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CONTENTS

APPENDICES

LIST OF ABBREVIATIONS

Above Ordnance Datum	AOD
Agricultural Land Classification	ALC
Annual Exceedance Probability	AEP
Area Benefitting from Defences	ABD
British Geological Survey	BGS
Construction Environmental Management Plan	CEMP
Digital Terrain Modelling	DTM
Environmental Agency	EA
Environmental Impact Assessment Report	EIAR
Flood Risk Assessment	FRA
Lead Local Flood Authority	LLFA
Light Detection and Ranging	LiDAR
Local Planning Authority	LPA
Metres	m
National Planning Policy Framework	NPPF
Norfolk County Council	NCC
Internal Drainage Board	IDB
PV	Photovoltaic
Standard of Protection	SoP
Strategic Flood Risk Assessment	SFRA
Sustainable Drainage Systems	SuDS
Technical Appendix	TA

1. EXECUTIVE SUMMARY

Ramboll UK Limited (Ramboll) has been commissioned by JLL, on behalf of the Downing Renewable Developments LLP (the Applicant) to undertake a Flood Risk Assessment (FRA) to support Environmental Statement (ES) for the construction and operation of a solar PV farm with associated infrastructure, including potential battery storage (the Proposed Development) located on land at Blunts Drove, Walton Highway, Norfolk.

In line with National Planning Policy Framework (NPPF) requirements, the FRA has been prepared for the Proposed Development as the Site is situated within Flood Zone 3 and exceeds 1 hectare (ha) in area.

According to the Environmental Agency's (EA) fluvial and tidal flood map for planning, the whole Site is located in Flood Zone 3 (High Probability) although it is also within an area classified by the EA as an Area Benefitting from Defences (ABD) such that the actual flood risk may be less than typically associated with Flood Zone 3.

Taking in to account the potential for increases in sea levels due to climate change (up to the year 2115), were defences maintained to their current standard the Site would not be affected by the climate change adjusted 1 in 200 (0.5%) Annual Exceedance Probability (AEP) flood.

Were a breach in the defences to occur, the majority of the Site would not be affected by flooding during a climate change adjusted 1 in 200 (0.5%) AEP flood. A limited area in the northwest of the Site could be at risk of shallow flooding during this event. Raising of infrastructure on concrete footings (a concrete slab in the case of the substation and concrete pads in the case of batteries) would provide suitable mitigation against such an event.

The Site is shown to be outside of the extent of the 1 in 100 AEP fluvial flood event including a 65% increase in peak flows to account for climate change. Raising of infrastructure on concrete footings (a concrete slab in the case of the substation and concrete pads in the case of batteries) would provide suitable mitigation against events which exceed this probability.

Mitigation measures that shall be implemented at the Site include:

- The raising of Site infrastructure (including the battery array and substation) above modelled flood depths through the use of open water compatible footings by 0.8 metres (m) above ground levels;
- The use of flood resilient design for switching and control kiosks (watertight design);
- Raising of PV arrays through integral stand design by 0.6m above ground levels; and
- The use of sub-surface cabling that would be integrally resistant to any flooding.

There is the potential that the development of a solar infrastructure compound area could lead to increased rates of surface water runoff from the Site. The implementation of SuDS at the Site, likely to incorporate the use of a swale and shallow detention basin to support infiltration to shallow groundwater in line with existing conditions at the Site, would ensure that no runoff would leave the Site during events with up to a 1 in 100 (1%) AEP storm, also including an allowance for climate change.

Based on the findings of this FRA and in consideration of the recommendations made, it is concluded that any flood risk would be appropriately managed over the lifetime of the development, taking climate change into account and Proposed Development is considered a suitable land use at this location, taking account of the vulnerability of proposed users, and no further flood risk assessment is deemed necessary.

2. INTRODUCTION

2.1 Appointment and Brief

Ramboll UK Limited (Ramboll) has been commissioned by JLL, on behalf of the Downing LLP (the Applicant) to undertake a Flood Risk Assessment (FRA) to support the ES which accompanies the planning application for the construction and operation of a solar PV farm with associated infrastructure, including potential battery storage (the Proposed Development) located on land at Blunts Drove, Walton Highway, Norfolk.

In line with NPPF[1] requirements, this FRA has been prepared for the Proposed Development as the Site is situated within Flood Zone 3 and exceeds 1 hectare in area.

This report has been prepared by Jo Thorp, a hydrologist with five years' experience of preparing flood risk assessment and hydrological assessment for EIA reports, and Chris Day a hydrologist with over 14 years' experience.

2.2 Scope and Objectives

This FRA considers the risks of various sources of flooding to the Site and the consequent risk of flooding to downstream receptors (such as people, property, habitats, infrastructure and statutory Sites) from the Proposed Development as a result of changes in surface water runoff. A comparison is made between the current situation and the future environment following completion of the Proposed Development.

This FRA has been carried out in accordance with the NPPF. It is to be used to assist the Local Planning Authority (LPA) and relevant statutory consultees when considering the flooding issues of the Proposed Development, as part of the planning application.

This report provides the following information:

1. A review of the flood risk to the Site based upon flood data and the flood maps provided by the EA and the relevant Strategic Flood Risk Assessment (SFRA);
2. An assessment of flood risk from all sources including tidal, fluvial, pluvial, groundwater and infrastructure failure to the Proposed Development;
3. An assessment of the compatibility of the Proposed Development for its location based on flood risk and its proposed usage;
4. An assessment of the impact of the Proposed Development in terms of surface water runoff;
5. Proposals for measures to mitigate the generation of surface water runoff as a result of the Proposed Development; and,
6. Proposals to mitigate any residual flood risks to the development.

2.3 General Limitations and Reliance

In preparation of the report, Ramboll has relied upon publicly available information, information provided by the client and information provided by third parties. Accordingly, the conclusions reached in this report are valid only to the extent that the information provided to Ramboll was accurate and complete.

The key sources of information used to prepare this report are footnoted within the document. Ramboll cannot accept liability for the accuracy or otherwise of any information derived from third party sources.

[1] GOV.UK, National Planning Policy Framework (published July 2021) https://www.gov.uk/government/publications/national-planning-policy-framework--2 [accessed August 2022]

Unless stated otherwise, the geological information provided is for general environmental interpretation and should not be used for geotechnical and/or design purposes.

3. SITE DESCRIPTION

3.1 Application Site Description

The Application Site is located 1.3km east of Wisbech and 500m to the east of the A47 trunk road (Figure 1) centred at grid reference 550542, 310445. Extending to 86 hectares, the Application Site forms two parcels of land (East and West Arrays) and is currently used for agricultural purposes. The land falls within Agricultural Land Classification Grade 3a and 3b with pockets of Grade 2 and has a very flat topography, consistently lying below 10 m Above Ordnance Datum (AOD). An overhead powerline intersects the eastern corner of the Site.

The surrounding area is predominantly rural in character, mainly comprising arable fields interspersed with drainage dykes, residential and farm related properties, clusters of trees and woodland, and roads and tracks.

3.2 Proposed Development

The Proposed Development would comprise approximately 125,000 solar panels with a maximum height of 3.1 m, along with associated infrastructure, including battery storage, as illustrated on ES Volume 3: Figure 2.1: Proposed Site Plan. The proposed Development would include the following key components:

- ground mounted solar panels;
- a substation container;
- 10x battery energy storage containers;
- a transformer including housing;
- a switchgear including housing;
- perimeter fencing, security fencing and CCTV;
- Lighting;
- Access Tracks 5m wide, and
- a temporary Site construction compound.

It should be noted that this does not constitute a detailed design layout for the Site and could be subject to alteration, within the parameters for which planning consent is sought, were the application successful.

4. CONSULTATION

4.1 Record of Consultation

Consultation was carried out with statutory consultees and stakeholders as detailed in Table 4.1 below.

Table 4.1: Record of consultation

Consultee Name	Date and Nature of Consultation	Summary of Consultee Response	Report Response Reference
Borough Council of	12/01/2022 Pre-application	The Council responses identifies that a Site-specific FRA shall be required for the Proposed Development and recommends	Provided as Technical Appendix) TA (this document)

Consultee Name	Date and Nature of Consultation	Summary of Consultee Response	Report Response Reference
Kings Lynn and West Norfolk	consultation response	consultation with the EA in respect to flood risk.	
Environment Agency	12/09/2022 Provision of detailed hydraulic modelling (in GIS format)	Modelling outputs for tidal modelling which takes in to account the presence of defences was provided in GIS format for scenarios up to the 1 in 1,000 (0.1%) annual probability flood.	Hydraulic modelling included in Section 5.5
Water Management Alliance	01/07/2022 Email response to request for flood risk information	The Internal Drainage Board (IDB) stated that water levels in the vicinity of the Site are managed by Islington pumping station. The IDB state that they do not have standing advice with regards to flooding, however we support the Lead Local Flood Authority (LLFA)'s standing advice on solar farm drainage strategies.	Standing advice taken in to account in application of buffer from ordinary watercourses to allow maintenance.
Environment Agency	01/09/2022 Provision of Product 8 defence breach data	PDF mapping of flood depths, velocities and hazard were provided as a Product 8 package. Mapping provided by the EA did not incorporate the northern extent of the Site (which has since been requested).	EA hydraulic modelling incorporated to Section 5.5
Norfolk County Council (Lead Local Flood Authority)	16/08/2022 Scoping response	The response strongly recommends that the EIA or planning application be accompanied by a flood risk assessment (FRA) / surface water drainage strategy. This should take in to account all potential sources of flooding, management of surface water drainage through the use of SuDS and development of the drainage strategy with phasing of the Proposed Development. The response sets out the LLFA's policy position with regards to the drainage of solar farms and sets out considerations recommended for consideration by Local Planning Authority (LPA)s as follows: • Is the development Site currently at risk of flooding? • How does the Site currently drain? • Restrict vehicular movements to designated access tracks; • Rutting during the operation phase that could alter • natural flow paths should be avoided where possible; • Specify what type of vegetation will be planted across the Site and how will it be managed in perpetuity; • Drainage strategy should be provided for any large impermeable areas; • No runoff should leave the Site up to the 1% AEP+CC storm; and • A Construction Environmental Management Plan (CEMP) should also be provided.	Methodology for attenuation of any potential increases in surface water runoff detailed in Section 7 CEMP would be prepared by the appointed contractor were the Proposed Development to go ahead

Consultee Name	Date and Nature of Consultation	Summary of Consultee Response	Report Response Reference
Environment Agency	22/08/2022 Scoping response	The EA scoping response acknowledged that details submitted under scoping *'effectively scoped out flood risk'* The EA scoping response identified that defence breach modelling should be incorporated within an FRA and that potential increases in flood risk due to climate change should be taken in to account.	EA defence breach modelling presented in Section 5.5

4.2 Strategic Flood Risk Assessment

The King's Lynn and North Norfolk Level 1 SFRA (November 2018)[2] has been consulted; both with regard to assessment of flood risk at the Site and local planning requirements.

5. REVIEW OF BASELINE DATA

5.1 Hydrological Setting

The Site is located in the Norfolk Fens on an area of land that was historically drained for agricultural use. Drainage dykes, classified as Ordinary Watercourses and under the management of King's Lynn Internal Drainage Board (IDB), are present at the boundaries of the Site. IDB mapping identifies Ordinary watercourses adjacent to the Site as follows:

- North, DRN145P (adjacent to a section of the north west boundary of the Site)
- West, DRN145P1019
- South, DRN145P1001
- East, DRN145P0102 (Smeeth Lode)

The direction of drainage within the Ordinary Watercourses adjacent to the Site is in a south easterly direction to Smeeth Lode which is present at the eastern boundary of the Site. The Smeeth Lode flows in a generally north-easterly direction to Islington Pumping Station, where it is pumped to the River Great Ouse (classified by the EA as a Main River) at Eau Brink approximately 9.7 km north east of the Site.

The River Nene (classified by the EA as a Main River) is located approximately 3.7 km west of the Site at its closest point.

A minor drain bisects the eastern array in a south easterly direction (which appears to drain to Smeeth Lode) and a further minor drain is also present within the western array (which is in connection to the wider drainage network via the north of the Site).

[2] King's Lynn &West Norfolk Council, Flood Risk Assessment- Level 1,https://www.west-norfolk.gov.uk/info/20173/information_for_planning_agents/391/flood_risk_assessment_-_level_1 (last accessed, September 2022)

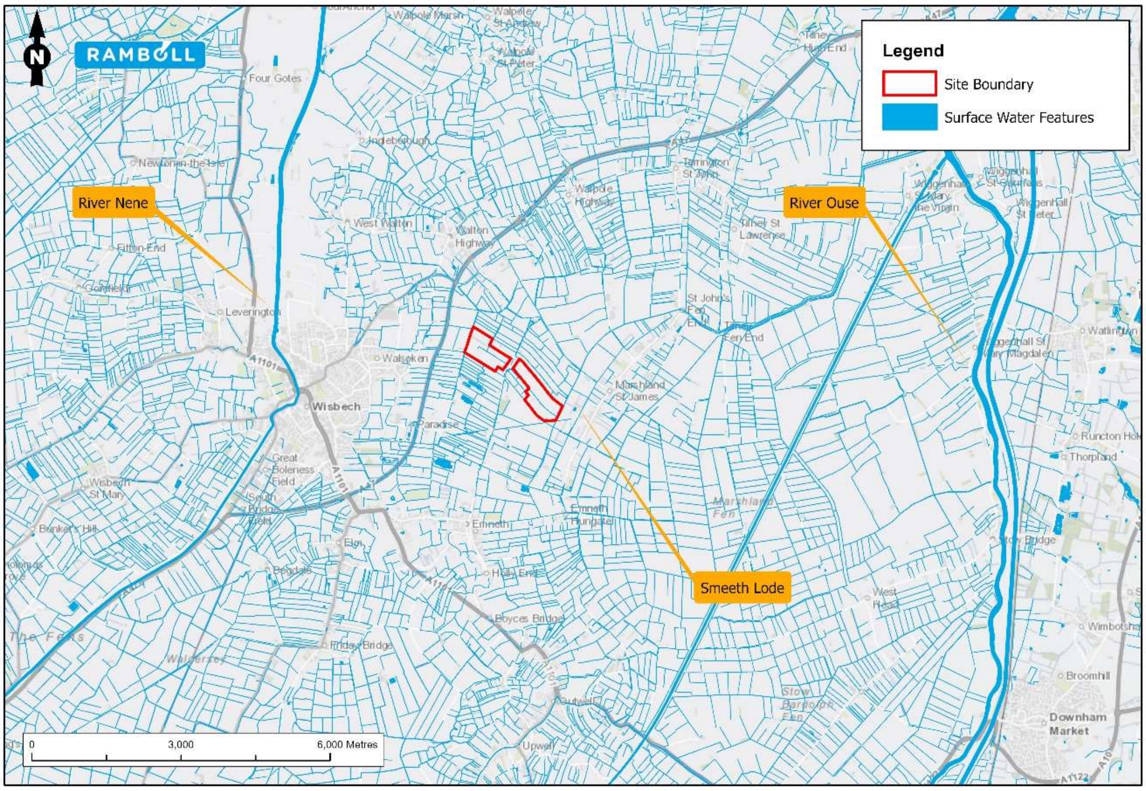

Figure 1: Hydrological setting

5.2 Geological Setting

According to British Geological Survey (BGS) 1:50,000 geological mapping[3], the Site is directly underlain by superficial deposits of clay and silt (tidal flat deposits), further underlain by bedrock geology comprising the Ampthill Clay Formation (mudstone).

Detailed assessment of soils at the Site was carried out on behalf of Ramboll by Askew Land and Soil services[4]. Surveying found that soils underlying the Site are classified as Silty Clay under the Agricultural Land Soil Texture Class Classification (ALC) system.

5.3 Hydrogeological Setting

According to the Aquifer Designation Map (England)[5], The underlying superficial and bedrock geology is classified as Unproductive Strata by the BGS.

According to Agricultural Land Classification assessment, soils are permeable but respond to underdrainage; drained soils are occasionally waterlogged; but undrained soils are waterlogged for long periods in winter. It is therefore likely that groundwater levels at the Site are dependent on water level control carried out by the IDB within the surrounding surface water drainage network.

The Site is not located within a groundwater Source Protection Zone.

[3] British Geological Survey GeoIndex. Available Online: https://www.bgs.ac.uk/

[4] Agricultural Land Classification: Meerdyke Solar Farm, Norfolk. June 2022. Ref.: C882

[5] British Geological Survey. Accessible via Magic Maps: https://magic.defra.gov.uk/magicmap.aspx

5.4 Site Topography

LiDAR (Light Detection and Ranging) aerial topographic survey data has been obtained from the DEFRA Data services Platform for the Site and its surrounds. Digital Terrain Modelling (DTM) is available for the Site at 1 m horizontal resolution and shows that the Site is relatively flat in profile with some limited undulation across the site. Elevations on the western array stand at between 1.0 m AOD and 1.7 m AOD. Land on the eastern array stands at elevations of between 1.0 m AOD and 2.1 m AOD.

5.5 Fluvial and Tidal Flood Risk

EA Flood Map for Planning

According to the EA's fluvial and tidal flood map for planning[6], the whole Site is located in Flood Zone 3 (High Probability). This zone comprises land assessed as having a 1 in 100 or greater annual probability of river flooding (>1% in any year) or a 1 in 200 or greater annual probability of flooding from the sea (>0.5% in any year). Flood Zone designation specifically ignores the presence of flood defences.

The whole Site is within an area classified by the EA as an ABD. According to the EA classification of an ABD indicates that an area would benefit from the presence of defences in a 1 in 100 (1%) annual probability fluvial flood; or 1 in 200 (0.5 %) annual probability tidal flood.

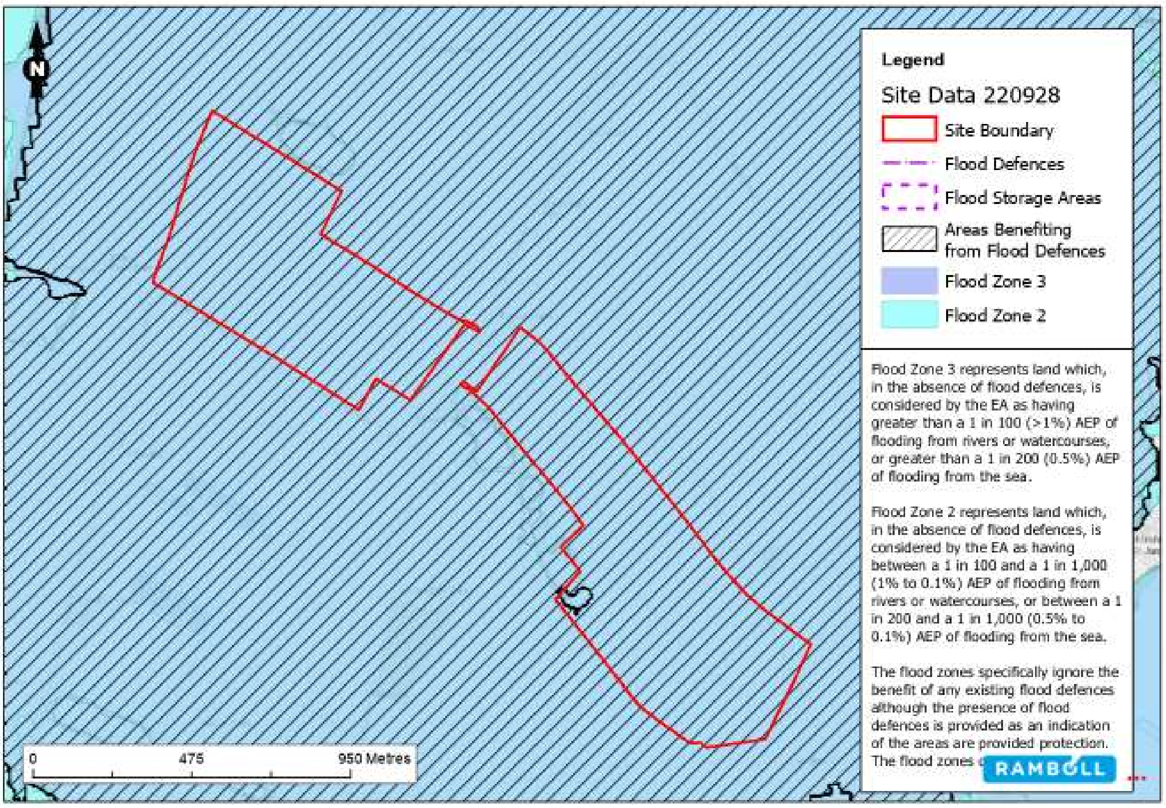

Figure 2: EA Flood Map for Planning

[6] EA Flood Map for Planning. Available Online: https://flood-map-for-planning.service.gov.uk/

Hydraulic modelling (Tidal)

The EA have provided hydraulic modelling for the River Ouse and River Nene. The EA have confirmed that modelling taken from the 2011 Tidal Nene Hazard Mapping should be used for the FRA at the Site. The EA have provided baseline and climate change adjusted mapping of the potential consequences of a breach to defences during both the 1 in 200 (0.5%) and 1 in 1000 (0.1%) annual probability tidal floods.

Under the present-day scenario, the Site would not be affected by flooding were a breach to defences to occur during a 1 in 200 (0.5%) annual probability flood and modelling indicates that waters would remain in channel of the surrounding drainage network. Were a breach to defences to occur during a 1 in 1,000 (0.1%) annual probability flood very shallow overtopping of the drainage network could occur in the northwest of the Site. Under this scenario flooding to depths of between 0.1 and 0.2 m could occur in the vicinity of Site infrastructure.

Were a breach of defences on the River Nene to occur during a 1 in 200 (0.5%) annual probability event, inclusive of a climate change allowance for sea level rises up to 2115, modelling suggests that flood depths of up to 0.3 m could occur in the northwest of the Site and very shallow flooding (<0.1 m) could occur in the south of the western array, as illustrated in Figure 3. The maximum potential hazard as a result of flooding during such an event is 'Danger for Some' (indicating that flooding could present a risk to *children, the elderly and the infirm*).

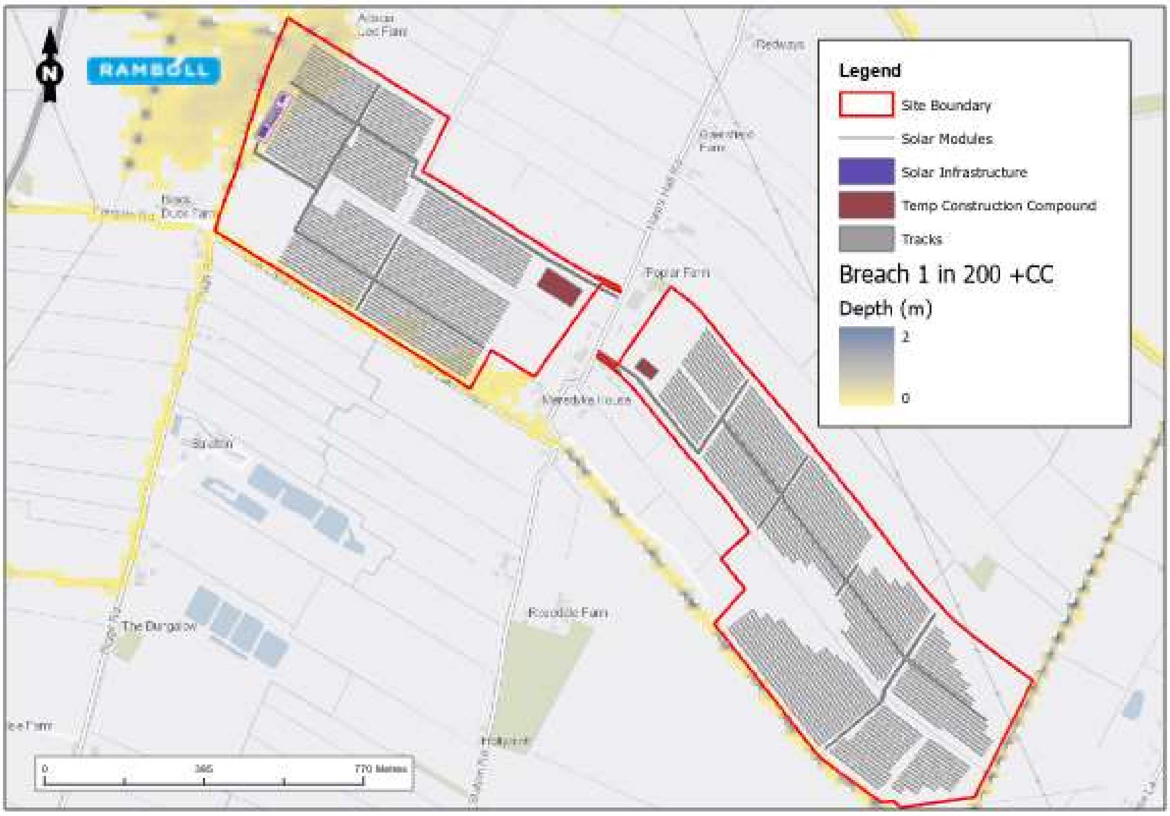

Figure 3: 1 in 200 Breach Model Tidal Flood (River Nene) + Climate Change Allowance

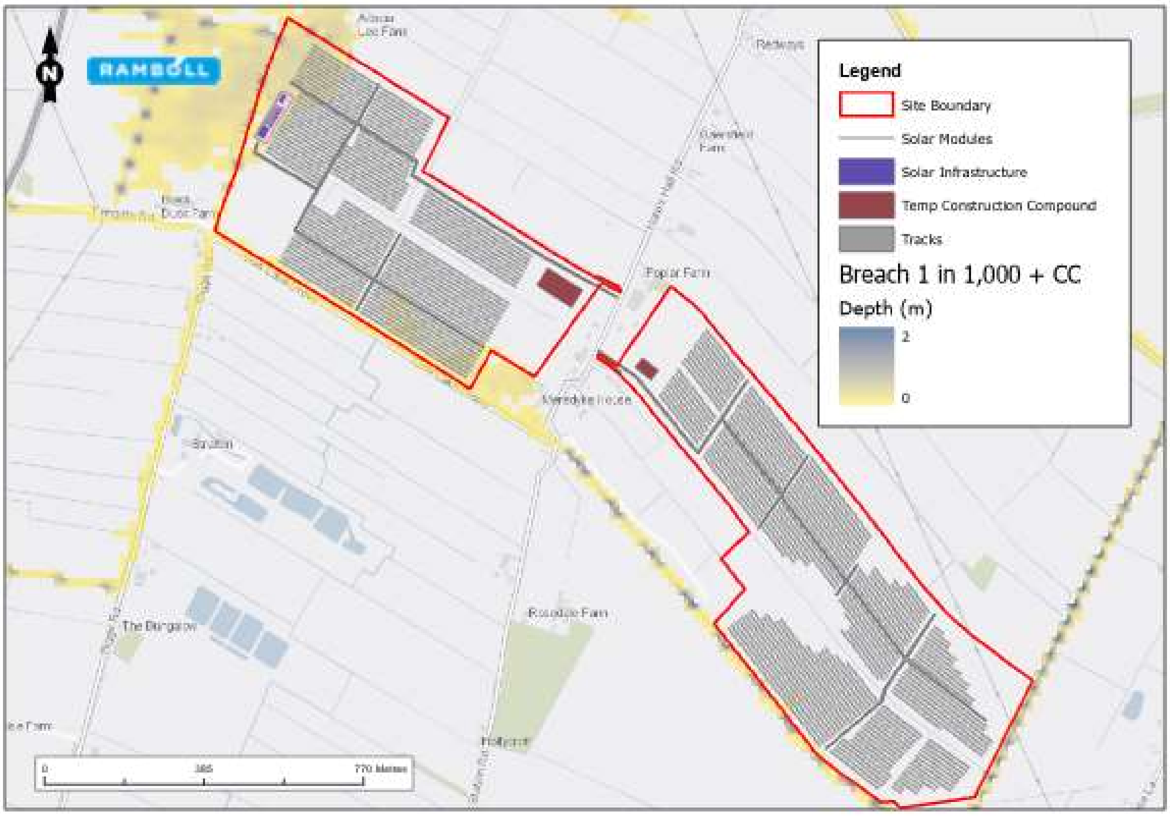

Figure 4: 1 in 1000 Breach Model Tidal Flood (River Nene) + Climate Change Allowance

Were a breach to defences to occur during a 1 in 1,000 (0.1%) annual probability event, inclusive of a climate change allowance for sea level rises up to 2115 modelling suggests that flood depths of up to 0.3 m could occur in the vicinity of Site infrastructure, as illustrated in Figure 4.

A breach of the defences that provide the site with protection is considered to be of a very low probability taking in to account ongoing inspection and maintenance carried out by the EA.

Fluvial Flooding

The King's Lynn And West Norfolk SFRA[7] (Grids KL58 and KL59) provides mapping of areas at potential risk of fluvial flooding during a 1 in 100 (1%) annual probability event, including a climate change allowance of up to a 65% increase ion peak flows. The Site is shown to be outside of the extent of the 1 in 100 + 65% fluvial flood event.

5.6 Flood Defences

The Site is within a low lying area that could be at risk of tidal flooding from the Lower River Ouse (the Site is within the catchment of the Smeeth Lode Drain which discharges to the River Ouse), were defences not in place. EA geospatial records show the presence of raised defences on the River Ouse constructed to at least a 1 in 100 (1%) Standard of Protection (SoP). Additionally, a flood relief channel is present on the River Ouse to the east of the Site and flood levels on the river are managed by the release of waters to the flood plain at the Denver Sluice complex approximately 10km southeast of the Site.

Raised defences on the tidal River Nene provide a minimum 1 in 150 (0.75%) SoP and in the Wisbech area (the closest stretch of the Nene to the Site) are constructed to a 1 in 200 (0.5%)

[7] King's Lynn And West Norfolk SFRA, 2018. Available Online: https://www.west-norfolk.gov.uk/

SoP. The Wisbech SFRA[8] states that the EA has planned for upgrading/replacement of the defences located within Wisbech and a maintenance system has been implemented to ensure that the defences continue to provide protection against a 0.5% (1 in 200) AEP event, in line with sea level rises over the next 50 years.

Water levels of the surrounding drainage network are managed by the Kings Lynn IDB. Surface water from the agricultural drainage network flows in generally south easterly direction from the Site to the Smeeth Lode Drain. The Smeeth Lode flows in a generally north-easterly direction to Islington Pumping Station, where it is pumped to the tidal channel of the tidal River Great Ouse (a Main River) at Eau Brink approximately 9.7km northeast of the Site. King's Lynn IDB asset mapping (catchment ref CMT145P) confirms that the area in which the Site is located is drained via Smeeth Lode and the Islington Pumping Station. IDB documentation confirms that the pumping station was recently upgraded (commissioned in April 2022[9]) to provide at least a 1 in 100 (1%) standard of protection to the catchment served by Smeeth Lode (capacity of the pumping station was improved from 2,800 l/s to 16,000 l/s). It is also noted that, taking into account the distance of the Site from the Islington Pumping Station and the Ouse, there is a considerable storage capacity downstream of the Site that would provide further protection from the potential for fluvial flooding.

5.7 Surface Water and Sewer Drainage Flood Risk

According to the EA Risk of Flooding from Surface Water map[10], very limited, localised areas of the Site are assessed to be at a Low or Medium risk of surface water flooding. Were a medium probability 1 in 100 (1%) AEP rainfall event to occur EA mapping suggests that very small areas of surface water ponding, of less that 150mm in depth (on <1% of the open Site area) would occur. Were a low probability 1 in 1,000 (0.1%) AEP rainfall event to occur shallow surface water ponding (of less that 150mm could occur on very limited areas of the Site (comprising <5% of the total Site area). <1% of the Site (in the south) could be affected by surface water depths of between 150 and 300mm. Surface water accumulation in excess of 300 mm would be accommodated by the surrounding drainage network.

The Site comprises undeveloped agricultural land, not serviced by a piped drainage or sewerage network, and therefore sewer flooding is not considered to represent a risk to the Site.

5.8 Groundwater Flood Risk

The geology of the Site comprises clay and silt deposits underlain by mudstone, assessed by the EA to be of limited productivity. The limited productivity of the underlying geology and the level topography of the Site indicate that the emergence of groundwater leading to flooding at the Site is very unlikely.

Groundwater underlying the Site is likely to be highly dependent on water levels of the surrounding drainage network and, therefore, while waterlogging of soils could extend the duration of surface water flooding, groundwater flooding is highly unlikely to represent an independent source of flooding at the Site.

According to the King's Lynn and North Norfolk SFRA, groundwater levels on lower-lying Fen areas such as the Site are highly managed *"so it is reasonable to assume the pumping infrastructure operated by the IDB maintains a low water table. This would be reducing the probability of groundwater flooding. Nevertheless, there remains a residual risk of groundwater flooding due either a failure of the pumps of an exceedance of pump capacity."* Taking in to account the recent

[8] Wisbech Level 2 SFRA Fenland District Council June 2012
[9] https://www.wlma.org.uk/
[10] EA Risk of Flooding from Surface water Map. Available Online: https://www.gov.uk/check-long-term-flood-risk

upgrade of the Islington Pumping Station, a failure of the pumps or an exceedance of capacity is considered by Ramboll to be a very low probability event.

5.9 Risk from Reservoirs, Canal and other Artificial Sources

EA mapping of reservoir flood extents[11] shows that the Site is not within an area that could be at risk of flooding due to the failure of a reservoir dam.

There are no other artificial sources of flooding identified that could present a risk of flooding at the Site.

5.10 Historic Flooding

According to the EA's online geospatial data regarding historical flooding events[12], there are no records of historical flooding having occurred at the Site.

5.11 Flood Risk Summary

The primary source of flood risk at the Site is tidal flooding due to the proximity of the Site to the tidal River Nene. Were defences not in place, the Site could be affected by flooding from the River Nene during a 1 in 200 (0.5%) AEP flood. However, due to the presence of defences, the Site is not at risk of flooding during such an event also taking account of climate change induced sea level rise to the year 2115.

There is a very limited risk that an area of the Site could be affected by shallow flooding were a breach to defences to occur during a 1 in 200 (0.5%) AEP flood for the year 2115. Maximum depths of 0.3m could occur on the developable area of the Site and modelling suggests that peak flood velocities of 0-0.3m/s would occur at the Site. The maximum potential hazard as a result of flooding during such an event is 'Danger for Some' (classified as indicating that flooding could present a risk to *children, the elderly and the infirm*[13]).

The Islington Pumping Station is reported to provide capacity for at least a 1 in 100 (1%) AEP event. Taking into account the distance of the Site from the pumping station and downstream storage capacity within the channel of Smeeth's Lode, an additional degree of protection is provided to the Site which is approximately 8km upstream of the pumping station. There is a very low risk that were failure of the Islington Pumping Station to occur or were the capacity of pumps exceeded during a low-probability event, the Site could be affected by fluvial flooding. Taking in to account the recent upgrade that has been carried out to the Islington Pumping Station, such an event is considered to be of a very low probability.

Management of water levels in the surrounding area by the Kings Lynn IDB is such that the Site benefits from protection against fluvial flooding to at least a 1 in 100 (1%) SoP also taking account of future climate change.

Based on the limited productivity of the underlying geology and the level terrain of the Site, the Site is not considered to be at risk of flooding due to the emergence of groundwater.

The Site is not at risk of flooding from reservoirs or other artificial sources.

[11] EA Mapping of Reservoir Flood Extents. Available online via DEFRA Data Services: https://environment.data.gov.uk/

[12] EA Recorded Flood Extents. Available online via DEFRA Data Services: https://environment.data.gov.uk/

[13] Supplementary Note on Flood Hazard Ratings and Thresholds for Development Planning and Control Purpose: https://www.gov.uk/flood-and-coastal-erosion-risk-management-research-reports/flood-risk-assessment-guidance-for-new-development

6. ASSESSMENT OF FLOOD RISK

6.1 Flood Risk Vulnerability

According to Annex 3 of the NPPF (Flood Risk Vulnerability Classification)[14] Solar Farms are classified as Essential Infrastructure. The NPPF guidance states that Essential Infrastructure should only be permitted in this Flood Zone 3 if the Exception Test is passed and should be designed and constructed to remain operational and safe for users in times of flood.

6.2 Sequential Test

The Sequential Test is designed to ensure that areas at little or no risk of flooding from any source are developed in preference to areas at higher risk. Where it is not possible to locate development in low-risk areas, the Sequential Test should go on to compare reasonably available Sites:

- Within medium risk areas; and
- Then, only where there are no reasonably available Sites in low and medium risk areas, within high-risk areas.

As the Proposed Development is located within Flood Zone 3 the sequential test shall be applicable.

The Site represents a highly suitable location for the development of a solar farm, taking in to account the level and open topography of the Site. While the Site is located within Flood Zone 3, it is also within an area designated as an ABD and as such the SoP provided by defences is considered by the EA to be equivalent to at least the 1 in 200 (0.5%) annual probability tidal flood. Flood risk at the Site is therefore equivalent to Flood Zone 2 (Medium risk).

The regulatory classification of flood risk is the same as other potential fenland locations for solar farms within the surrounding area, with the extent of Flood Zone 3 covering a large geographical area. As such alternative Sites in the surrounding area which are comparably suitable for the development of a solar farm are unlikely to be at a lower risk of flooding.

The classification of agricultural land at the Site (predominantly Grade 3a and Grade 3b) is such that the Site shall be more suitable for the development of a solar farm than nearby agricultural land (of differing soil type and superficial geology).

6.3 Exception Test

As the Proposed Development is classified as Essential Infrastructure and is located within Flood Zone 3, the Exception Test is applicable to the Site.

Under the Exception Test it should be demonstrated that:

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

In regard to sustainability benefits, the Proposed Development will contribute to national objectives set out by the UK Government's Net Zero Strategy[15] and the identification in government policy that an increased contribution from solar generation will contribute to the Key

[14] GOV.uk (2022) National Planning Policy Framework, Annex 3: Flood risk vulnerability classification https://www.gov.uk/guidance/national-planning-policy-framework/annex-3-flood-risk-vulnerability-classification

[15] UK Government. Net Zero Strategy: Build Back Greener, 2021. Available Online: https://www.gov.uk/government/publications/net-zero-strategy

Policy that by 2035 the UK will be powered entirely by clean electricity, subject to security of supply.

Assessment of the suitability of the Proposed Development on agricultural land is provided in the Agricultural Land Classification Report and demonstrates that the Site would not significantly harm national agricultural interests.

There is the potential for enhanced biodiversity through the management of planting and land use under and around the solar array farm should increase biodiversity at the Site, meeting planning requirements for net biodiversity gain and providing the opportunity for ecological enhancement.

The Proposed Development would result in fewer vehicle movements on the Site compared to the current agricultural use which would result in lower levels of compaction allowing an improvement in the aeration of soil structure and improved infiltration rates. As a result of reduced soil disturbance for tillage there is the potential for improved soil structure and carbon sequestration as a result of less intensive land use.

This FRA has demonstrated that the Site is not at risk of flooding during present day 1 in 1,000 (0.1%) or the 1 in 200 (0.5%) annual probability flood, taking into account increases in flood risk due to climate change up to the year 2115. Therefore, the Site shall be safe for its lifetime and would satisfy the requirement that Essential Infrastructure remain operational during periods of flood.

Therefore, the Site meets the requirements of the Exception Test.

6.4 Mitigation Measures

As a precautionary measure, consideration shall be given to the use of flood resilient design where Site infrastructure is located within the extent of the climate change adjusted 1 in 200 (0.5%) AEP flood event, such that the Site would continue to operate during such a flood. Measures shall also include:

- The raising of Site infrastructure (including the substation and battery array) above modelled flood depths by 0.8 m above ground levels;
- The use of flood resilient design for switching and control kiosks (watertight design);
- Raising of PV arrays through integral stand design by 0.6 m above ground levels; and
- The use of sub-surface cabling that would be integrally resistant to any flooding.

The mounted PV panel system would be secured to prevent wind lifting. Therefore, taking in to account the very low modelled flood velocities on the Site PV system, footings would be suitable to prevent instability or movement during a flood.

Solar infrastructure at the Site shall be mounted on concrete plinth bases to meet design requirements for high-voltage transmission equipment, and additional protection from flooding shall be provided by this design feature. Where Site infrastructure is located outside of the potential flood extent, no further mitigation would be proposed.

6.5 Management of Residual Risk

Taking in to account the mitigation measures set out above, there are no residual risks of flooding identified at the Site.

7. IMPACT OF DEVELOPMENT ON SURFACE WATER RUNOFF

There is the potential for the Proposed Development to increase the risk of flooding due to increases in rates of surface water runoff through the addition of hard surfaces. Therefore, where applicable, the Proposed Development shall incorporate sustainable drainage systems in line with Paragraph 167 of the NPPF. Assessment of the potential for alterations in surface water runoff rates shall take into account paragraph 169 of the NPPF such that implementation of Sustainable Drainage Systems (SuDS) at the Site would:

- take account of advice from the lead local flood authority;
- have appropriate proposed minimum operational standards;
- have maintenance arrangements in place to ensure an acceptable standard of operation for the lifetime of the development; and
- where possible, provide multifunctional benefits.

7.1 Lead Local Flood Authority Guidance

Correspondence received from the Lead Local Flood Authority, Norfolk County Council (NCC), during pre-application consultation, provides guidance for the management of surface water on Site which specifically takes in to account the Proposed Development of the Site as a solar farm.

NCC pre-application guidance states that the design of PV panels means that the total surface area of the PV array is not considered to act as an impermeable area and the impact on surface water runoff *"is assumed to be nil"*. It is noted that NCC state that *"the nature of the underlying groundcover and antecedent conditions can have a demonstrable influence on the surface water run-off characteristics of a Site"*. In line with NCC guidance, areas under the PV array shall be planted with a suitable grass and wildflower seed mix which would increase interception and evapotranspiration rates, as well as preventing drying out and earth hardening. Therefore, no further SuDS measures are proposed on the main area of the PV array.

NCC pre-application guidance states that vehicular access tracks should be permeable (e.g. gravel medium) to mimic the existing surface conditions. Tracks on Site shall be constructed of a suitable granular material shall be used to match existing conditions (such as Type 3 aggregate). Therefore, proposed access tracks on the Site shall not increase runoff rates and will not affect runoff rates when compared to pre-development conditions.

NCC correspondence states that *"associated infrastructure like battery storage units, solar stations, substations, internal roads should be considered as fully impermeable"*. No sealed roads are proposed at the Site. The footprint of the substation and battery array shall be taken into account as fully impermeable. The surface of the solar infrastructure service area which shall be used for vehicle access and maintenance of Site infrastructure, shall comprise a permeable sub-base material (a Type 3 sub-base with reduced fines to allow water to free drain as a permeable sub base) such that outside of the building footprints the surface shall be permeable and replicate greenfield conditions.

NCC pre-application guidance states that no runoff should leave the Site up to the 1% AEP+CC storm, and this shall therefore be considered the appropriate proposed minimum operational standard for SuDS serving the solar infrastructure compound.

7.2 SuDS Hierarchy

For the lifetime of any development the effects of climate change have to be considered, and buildings must be designed to be resilient to a wider range of weather conditions. In accordance with the above the proposed surface water drainage strategy should follow the SuDS management train and discharge hierarchy as detailed in Part H of the Building Regulations[16]. The considerations given to the hierarchy are summarised in Table 7.1 below.

Table 7.1 : SuDS Management Train

Hierarchy	Reasoning
Infiltration to the ground	Guidance provided by NCC states that no runoff should leave the Site up to the 1% AEP+CC storm. This therefore necessitates that infiltration shall form the basis of the drainage strategy at the Site. The incorporation of open SuDS features shall support infiltration to ground, subject to ground investigation.
Discharge to surface water	Surface water drainage features are present around the Site boundary, and presently surface water runoff is to these features via shallow ground infiltration and surface runoff. SuDS features at the Site shall mimic the current flow of shallow groundwater and surface water runoff to boundary drainage features.
Discharge to surface water sewer, highway drain or another drainage system	N/A
Discharge to combined sewers	N/A

7.3 SuDS Options Appraisal

As stated in Table 7.2 current drainage of surface water from the Site is to the surrounding drainage network via shallow infiltration or surface water flows. It is preferable that SuDS employed at the Site shall mimic this natural drainage regime. Furthermore, in order to reduce ground disturbance and to reduce the carbon impact of engineering at the Site, soft engineering approaches incorporating Site won or natural materials shall be used where possible.

Table 7.2: Surface Water Drainage Techniques

Technique	Physical Constraints	Feasibility
Basins and Ponds • Constructed Wetlands • Balancing Ponds • Detention Basins • Retention Ponds	These are permanent ponds that provide storage above the resting water level in the pond or dry basins with a controlled outflow. Are appropriate for most Sites but require suitable space. Require impermeable soils, or can be lined.	**Feasible** Due to lack of gradient at the Site retention of surface water in an impermeable area would require pumping to outflow Would require outfall to drain (limited to surface water runoff rates)
Infiltration Basin	Shallow landscape features that store runoff before infiltration to the subsurface soils. Are appropriate for most Sites but require suitable infiltration capacity of underlying soils.	**Feasible** Suitable space available, exceedance route away from infrastructure available.
Swales (retention and infiltration)	Are widely applicable for attenuation and treatment of surface run-off by infiltration into the ground. Require slope of no more than 4-10% and can act as a substitute for soakaways where groundwater is shallow.	**Feasible** Shallow dry swales of deeper 'wet' swale could be accommodated at the Site
Permeable surfaces and filter drains • Gravelled areas • Solid paving blocks • Porous pavers	Ideally requires a level Site and favourable underlying ground conditions. Pervious material could be used for hard-surfaced areas in the Proposed Development. Filter drains are normally used adjacent to areas of car parking or roads and convey runoff via flow through an engineered substrate, may also be used to provide attenuation for very small rainfall events.	**Feasible in some areas** Earthing requirements on areas of infrastructure and high voltage equipment limit the suitability of permeable paving / surfaces. Gravelled surfaces may be used on areas where design standards allow (e.g. track surfaces, parking away from high voltage equipment)

[16] HM Government (2015) Building Regulations Part H: Drainage and Waste Disposal

Technique	Physical Constraints	Feasibility
Tanked systems • Over-sized pipes/tanks • Storm cells	On-line storage within the drainage network or off-line storage in a tank with outflow control.	**Feasible** Tanked storage may be feasible below ground level, incorporating a pumped outfall to an adjacent drain (limited to surface water runoff rates).
Discharge to combined sewers	N/A	N/A

In line with the most recent planning policy guidance[17], the choice of SuDS methods at the Site shall take in to account multifunctional benefits that the SuDS will provide. Therefore, preference shall be given to the use of an open SuDS system that would provide the potential for ecological enhancement, minimise ground disturbance and reduce the need for import of materials to the Site, thereby reducing carbon emissions from transportation and construction, and reducing embodied carbon of materials used at the Site.

In order to accommodate surface water runoff volumes anticipated at the Site, a combination of an open swale and a shallow infiltration basin adjacent to the solar infrastructure compound area shall accommodate surface water runoff from the compound area.

7.4 Calculation of Attenuation Volumes

Surface water attenuation volumes have been calculated in accordance with CIRIA publication C753 - The SUDS Manual[18], using Hydraulic Research (HR) Wallingford software (Appendix 1). An allowance of 40% for rainfall intensity to increase as a result of climate change has been applied.

Based on the underlying soil conditions (as defined by the Wallingford Procedure W.R.A.P[19] map), greenfield runoff rate at the Site is calculated to be very low at 2 l/s/hectare. The attenuation volumes required to accommodate the 100 year event whilst maintaining a greenfield runoff response is calculated to be 58m³ as detailed in Appendix 1: Greenfield Rates Runoff Calculation, for the minimum area (0.1ha) that may be applied in the software, this area is 20% larger than the likely area of hardstanding or impermeable structures (batteries and substation) that are proposed at the site.

Based on the required attenuation volumes, a maximum storage volume of 58m³ could be required to account for the increase in impermeable surface at the Site whilst maintaining the greenfield characteristics of the Site. This volume represents a conservative estimate based on a precautionary assessment significantly in excess of the actual area of hardstanding likely to be constructed at the site.

7.5 Drainage Strategy

A shallow swale adjacent to the solar infrastructure compound (Figure 5) shall accommodate any increase in surface water runoff. The design of the swale shall comprise a linear, trapezoidal channel. The swale would be dry under normal conditions and shall support infiltration to ground, to support the requirement by NCC that no extra runoff, beyond the very low greenfield characteristics, should leave the Site during storm events with up to the 1% AEP including an allowance for climate change. The base of the swale could comprise permeable gravels to support infiltration.

[17] https://www.gov.uk/guidance/flood-risk-and-coastal-change
[18] https://www.ciria.org/CIRIA/Memberships/The_SuDS_Manual_C753_Chapters.aspx
[19] Winter Rain Acceptance Potential

A shallow swale with a depth of 0.5 m (avoiding deeper excavations to take into account the potential for periods of shallow groundwater depths and in line with NCC recommendations), allowing for a 0.5 m wide base could provide attenuation of volumes as presented in Table 7.3. Sides of the swale should be designed with a maximum 1:3 gradient. A swale could be constructed at the north the boundary of the service area over a minimum length of 60 m, providing a 20% allowance for any vegetation growth. The exact position of the swale would be determined at the detailed design stage.

Table7.3: Swale Attenuation Volumes

Swale Position	Base Width (m)	Open Width (m)	Height (m)	Length (m)	Storage Volume (m^3)
Compound Perimeter	0.5	3.5	0.5	60	60

Were any increase in the area of impermeable surface proposed at the detailed design stage, the length of the swale could be extended to accommodate any additional runoff that could occur.

There is the potential that areas of the temporary construction compound may also be impermeable. Were this the case, SuDS measures would be implemented to the same specifications as set out above, with a swale designed to accommodate any potential increase in surface water runoff rates.

Were the capacity of SuDS features exceeded during a low probability rainfall event (in excess of the 1 in 100 + 40% event), flows would be distributed overland towards the north-western boundary of the Site, away from essential Site infrastructure.

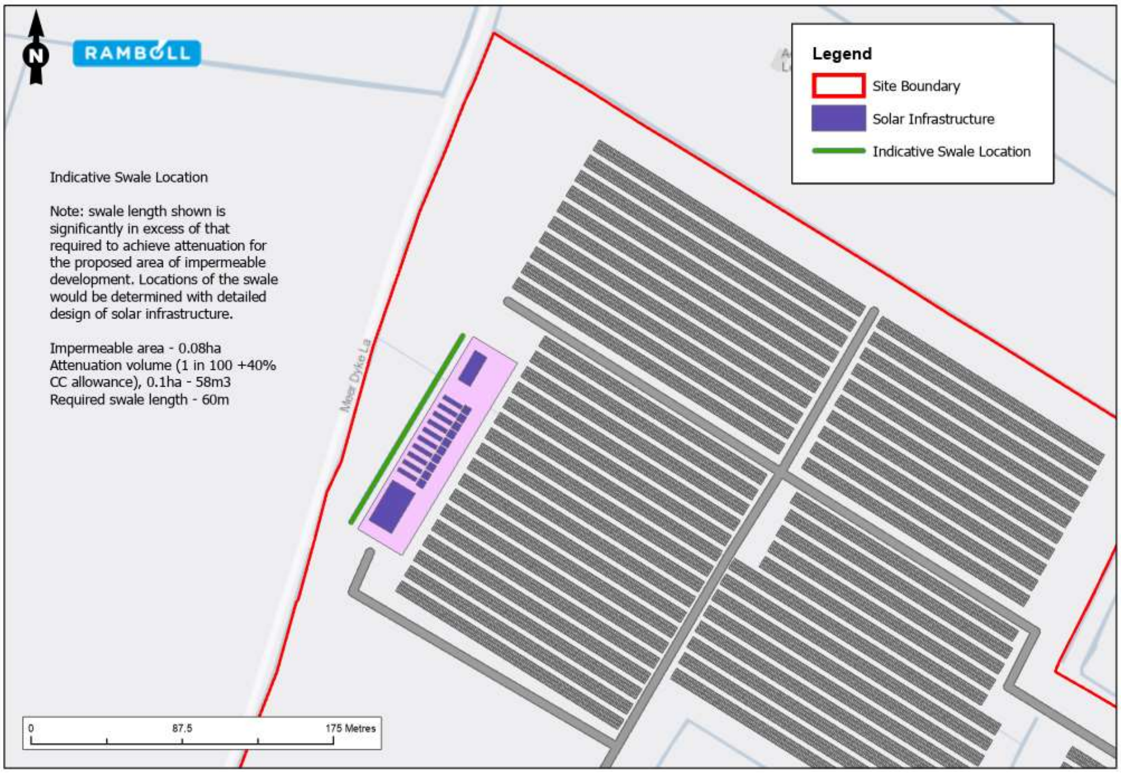

Figure 5: Indicative Swale Location

8. CONCLUSIONS

According to the EA's fluvial and tidal flood map for planning, the whole Site is located in Flood Zone 3 (High Probability) and is within an area classified by the EA as an ABD.

Due to the standard of defences protecting the Site, EA hydraulic modelling shows that tidal flooding would not affect the Site during tidal flood events up to and including the 1 in 1,000 (0.1%) AEP event.

Taking in to account the potential for increases in sea levels due to climate change (up to the year 2115), were defences maintained to their current standard the Site would also remain not affected by the 1 in 200 (0.5%) AEP flood for its anticipated lifespan.

Were a breach to defences to occur, the majority of the Site would not be affected by flooding during a 1 in 200 (0.5%) AEP flood even taking account of potential climate change. A limited area in the northwest of the Site could be at risk of shallow flooding. Such an event is considered to be of a very low probability, taking in to account ongoing inspection and maintenance of defences by the EA. Raising of infrastructure on concrete footings (a concrete slab in the case of the substation and concrete pads in the case of batteries) would provide suitable mitigation against such an event.

The surrounding drainage network provides at least a 1 in 100 (1%) SoP to the Site from fluvial flooding, following the very recent redevelopment of the Islington Pumping Station which serves the area. The Site is shown to be outside of the extent of the 1 in 100 AEP fluvial event, also considering a 65% increase in peak flows to account for climate change. Raising of infrastructure on concrete footings (a concrete slab in the case of the substation and concrete pads in the case of batteries) would provide suitable mitigation against the very low probability events which exceed the climate change adjusted 1 in 100 AEP fluvial flood.

Mitigation measures that shall be implemented at the Site include:

- The raising of Site infrastructure (including the battery array and substation) above modelled flood depths through the use of open water compatible footings by 0.8 m above ground levels;
- The use of flood resilient design for switching and control kiosks (watertight design);
- Raising of PV arrays through integral stand design by 0.6 m above ground levels; and
- The use of sub-surface cabling that would be integrally resistant to any flooding.

There is the potential that the development of a solar infrastructure compound area could lead to increased rates of surface water runoff from the Site. The implementation of SuDS at the Site, incorporating the use of a swale and shallow detention basin to support infiltration to shallow groundwater (in line with existing conditions at the Site) would ensure that, during events with up to a 1 in 100 (1%) AEP, no runoff would leave the Site in excess of greenfield conditions. The detailed design of the drainage measures would seek for all discharge during events up to the climate change adjusted 1 in 100 (15) AEP event to be to ground.

Based on the findings of this FRA and in consideration of the recommendations made, it is concluded that any flood risk is appropriately managed by the development proposals over the lifetime of the development, taking climate change into account and the proposed land use is considered suitable at this location. Taking account of the vulnerability of proposed users. No further flood risk assessment is deemed necessary.

APPENDIX 1
GREENFIELD RATES RUNOFF CALCULATION

Surface water storage requirements for sites

www.uksuds.com | Storage estimation tool

Calculated by:	Christopher Day
Site name:	Meredyke
Site location:	Meredyke

Site Details

Latitude:	52.67229° N
Longitude:	0.22067° E
Reference:	469578346
Date:	Oct 14 2022 15:46

This is an estimation of the storage volume requirements that are needed 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). It is not to be used for detailed design of drainage systems. It is recommended that hydraulic modelling software is used to calculate volume requirements and design details before finalising the design of the drainage scheme.

Site characteristics

Total site area (ha):	0.1
Significant public open space (ha):	0
Area positively drained (ha):	0.1
Impermeable area (ha):	0.1
Percentage of drained area that is impermeable (%):	100
Impervious area drained via infiltration (ha):	0
Return period for infiltration system design (year):	10
Impervious area drained to rainwater harvesting (ha):	0
Return period for rainwater harvesting system (year):	10
Compliance factor for rainwater harvesting system (%):	66
Net site area for storage volume design (ha):	0.1
Net impermable area for storage volume design (ha):	0.1
Pervious area contribution to runoff (%):	30

* where rainwater harvesting or infiltration has been used for managing surface water runoff such that the effective impermeable area is less than 50% of the 'area positively drained', the 'net site area' and the estimates of Q_{BAR} and other flow rates will have been reduced accordingly.

Design criteria

Climate change allowance factor:	1.4
Urban creep allowance factor:	1.1
Volume control approach	Use long term storage
Interception rainfall depth (mm):	5
Minimum flow rate (l/s):	2

Methodology

esti	IH124
Q_{BAR} estimation method:	Calculate from SPR and SAAR
SPR estimation method:	Calculate from SOIL type

Soil characteristics

	Default	Edited
SOIL type:	2	2
SPR:	0.3	0.3

Hydrological characteristics

	Default	Edited
Rainfall 100 yrs 6 hrs:	--	63
Rainfall 100 yrs 12 hrs:	--	94.71
FEH / FSR conversion factor:	1.25	1.23
SAAR (mm):	573	573
M5-60 Rainfall Depth (mm):	20	20
'r' Ratio M5-60/M5-2 day:	0.4	0.4
Hydological region:	5	5
Growth curve factor 1 year:	0.87	0.87
Growth curve factor 10 year:	1.65	1.65
Growth curve factor 30 year:	2.45	2.45
Growth curve factor 100 years:	3.56	3.56
Q_{BAR} for total site area (l/s):	0.14	0.14
Q_{BAR} for net site area (l/s):	0.14	0.14

Site discharge rates	Default	Edited	Estimated storage volumes	Default	Edited
1 in 1 year (l/s):	2	2	Attenuation storage 1/100 years (m^3):	59	58
1 in 30 years (l/s):	2	2	Long term storage 1/100 years (m^3):	0	0
1 in 100 year (l/s):	2	2	Total storage 1/100 years (m^3):	59	58