Technical Appendix 4: Flood Risk and Drainage Impact Assessment

Kingston Solar Farm

07/01/2022

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Contents

EXECUTIVE SUMMARY

4.1. This Flood Risk and Drainage Impact Assessment (FRA-DIA)has been carried out for the Proposed Development consisting of a 49.9MW solar farm and associated infrastructure on lands circa 1.3km south of Gotham and c. 0.75km northwest of East Leake, Nottinghamshire.

4.2. The Environment Agency (EA) Flood Map for Planning shows that the Application Site is wholly located in Flood Zone 1, an area described as "*Low probability*".

4.3. The proposed type of development is classed as 'Essential Infrastructure' and therefore development in Flood Zone 1 is deemed appropriate.

4.4. In addition to fluvial and coastal flood risk, the EA also provide surface water flood maps. This indicates multiple areas of surface water flooding within the Application Site. Each of these areas was assessed during the site visit and they were mostly confined to the existing small watercourses and field drains. There were some areas of marshy land next to watercourses, however a 2m buffer has been kept free of development from all field drains/watercourses within the Application Site. 5m buffers have also been left around the site perimeter and from hedgerows, where the ditches are generally located, so there will be 5m buffers from ditches in most locations.

4.5. In addition to the site visit assessment, the topographical survey and aerial maps were studied to determine what likely depth of surface water could be possible in a storm event. It was found that it would be unlikely that any major ponding would form, and surface water levels would likely be a maximum of 0.3m deep in all fields, except along the western edge of Field 6 which would likely be a maximum of 0.9m deep, before feeding into the existing field drain network. This area has been avoided from development.

4.6. The level the solar panels will be raised above ground will vary depending on ground conditions; however, they will generally be at least 0.6m AGL. Therefore, above the surface water level of approximately 0.3m with a suitable freeboard. The surface water levels have been based off the 'Medium Risk Scenario' which correlates to a 1 in 100 chance of flooding, with onsite and topographic checks for accuracy.

4.7. It has been demonstrated that the Proposed Developments impact on surface water runoff is minimal due to the small amount of impermeable infrastructure (0.6% of the overall Application Site Area) proposed for the Application Site. However, drainage in the form of Sustainable urban Drainage Systems (SuDS) has been proposed so the operational site discharges surface water at the greenfield run off rate (QBar). Due to the large area of the Grid Substation, and the dispersed nature of the impermeable development of the rest of the Proposed Development, drainage schemes for these have been designed separately.

4.8. The soils encountered beneath the site, found during on-site infiltration testing, were predominately clay and these were dug within Fields 3 and 5. There are 11 boreholes located

within the Application Site. However, nine of these boreholes are associated with BPB Industries Ltd, are classified with no information. The other two boreholes have got a depth of 65.83m and 69.95m respectively, and both suggested that clay was encountered beneath the Application Site. Another borehole, located just to the east of the Application Site, shows that there was also clay found beneath the surface. This suggests that across the site, the soils beneath will be predominately clay. This is consistent with the soil class which has a Standard Percentage Runoff (SPR) of 0.47 and suggests that they provide poor opportunity for infiltration.

4.9. The soakage rates obtained during the investigation were found to be practically impermeable. Given the data from the test, it is considered that infiltration drainage is not suitable across the Application Site.

4.10. The extent of impermeable area created is due to the buildings associated with the Proposed Development. The QBar greenfield rate is used as the limiting discharge rate.

Proposed Drainage Strategy (Solar Farm)

4.11. It is proposed to construct multiple filter drains / soakaways and swales within the Application Site. The location of the schemes have been chosen on the downward slope, near to the existing watercourse which runs through the Application Site. The idea is to capture any overland flow in the Sustainable Drainage System (SuDS) device, prior to releasing into the natural surface water system.

4.12. The proposed filter drains / soakaways will have an overall length of approximately 970m, with a base width of 0.5m, a 0.5m design depth and a 0.15m freeboard. It will be filled with crushed rock with a void ratio of 20% and will provide a total storage volume of approximately 48.5m^3.

4.13. The proposed swales will be of an overall length of approximately 360m, with a base width of 0.5m, a 0.5m design depth, 0.15m freeboard and a maximum side slope of 1 in 3. It will provide a total storage volume of approximately 360m^3.

4.14. In total, the proposed drainage strategy will provide a storage volume of approximately 408.5m^3. This is significantly greater than the volume of additional runoff generated as a result of the impermeable buildings (114.0m^3). It is therefore considered that this not only adequately mitigates the increase in flow rates as a result of the minor increase in impermeable area, but provides significant improvement.

4.15. The SuDS features will be implemented during the construction phase of the Proposed Development and the swales will be planted with vegetation to protect against soil erosion. They will be maintained throughout the lifespan of the Proposed Development, generally in accordance with the recommendations in the appropriate guidance.

4.16. The proposed discharge points are into various existing field drains.

Proposed Drainage Strategy (Grid Substation)

4.17. It is proposed that surface run-off will be collected and conveyed by the provision of filter drains to a detention basin. A notional freeboard level of 0.15m shall be incorporated into the detailed detention basin for the 1 in 100-year storm event plus 40% climate change with the final design of the pond being submitted to the Local Planning Authority (LPA), Rushcliffe Borough Council, prior to the construction period. The design volume of the detention basin will be a minimum of 179m^3.

4.18. As stated previously, the grid substation area is underlain by clays which exclude infiltration techniques for surface water disposal. QBar discharge rate restriction satisfies the requirements of the SuDS Manual '*Designing for Long Term Storage*'. Final discharge is restricted at the pond by the provision of a Hydro-Brake® vortex flow control device, or a device of similar quality.

4.19. Due to very infrequent site attendance that is required during the operational phase of the development, the pollution risk is deemed negligible. On-plot surface water treatment is provided in the form of filter drains wrapped to intercept the conveyance of any silts within the drainage system. Further downstream, water quality polishing is provided within the detention basin prior to discharge from the Application Site.

4.20. The discharge point will be into the existing site field drainage to the northeast of the detention basin.

4.21. Additional drainage measures to be implemented on-site include the following:

- Solar Panels: Current grass cover is to be retained or reinstated adjacent to and under panels in order to maximise bio-retention;
- Access Tracks: Access tracks are to be unpaved and constructed from local stone. Swales or similar shall be utilised to collect runoff from access tracks, where required, however these will be designed at the detailed design stage. Where swales are utilised, check dams formed from gravels and other excavated material shall be placed in the swale at frequent intervals; and,
- Inverter Substations, Spare Part Containers, etc: Filter strips will surround the concrete bases of the ancillary buildings to capture any runoff from the roofs. This will be discharged to a percolation area or into the sites drainage network where it is close enough. Should surface water accumulate around any of these locations then a simple soakaway can be constructed to allow water soak into the underlying subsoils.

4.22. A permanent toilet is proposed within the substation compound which will be utilised by maintenance staff of both the solar farm and the substation as well as tour groups and visiting

members of the local authority. This will either be a composting toilet, or a tank based one which is emptied as and when required by an approved contractor.

4.23. This FRA and DIA demonstrates that the Proposed Development will not increase flood risk away from the Application Site during the construction, operation and decommissioning phases. The Proposed Development is therefore considered to be acceptable in planning policy terms.

INTRODUCTION

Background

4.24. Neo Environmental Ltd has been appointed by Renewable Energy Systems (RES) Ltd (the "Applicant") to complete a Flood Risk ("FRA") and Drainage Impact Assessment ("DIA") for a proposed 49.9MW solar farm and associated infrastructure (the "Proposed Development") on lands circa 1.3km south of Gotham and c. 0.75km northwest of East Leake, Nottinghamshire (the "Application Site").

4.25. Please see **Figure 4 of Volume 2: Planning Application Drawings** for the layout of the Proposed Development.

Development Description

4.26. The Proposed Development will consist of the construction of a 49.9MW solar farm with bi-facial solar photovoltaic (PV) panels mounted on metal frames, new access tracks, underground cabling, perimeter fencing with CCTV cameras and access gates, two temporary construction compounds, substation and all ancillary grid infrastructure and associated works.

4.27. The Proposed Development will result in the production of clean energy from a renewable energy resource (daylight) and will also involve additional landscaping including hedgerow planting and improved biodiversity management.

Site Description

4.28. The Application Site is located on lands circa 1.3km south of Gotham and c. 0.75km northwest of East Leake, Nottinghamshire; the approximate centre point of which is Grid Reference E453185, N328739. Comprising 16 agricultural fields and additional ancillary areas, the Application Site measures c. 80.65 hectares (ha) in total, with only c. 55.65 hectares accommodating the solar arrays themselves. See **Figure 1 of Volume 2: Planning Application Drawings** for details.

4.29. The Proposed Development Site is split into two sections, north and south, by an area of woodland, Leake New Wood. Both sections lie on elevated, gently undulating land ranging between 87 – 96m AOD. The northern section extends across several rectilinear agricultural fields largely contained by existing mixed woodland providing good screening for the wider area. These include Gotham Wood to the north, Cuckoo Bush to the east, Leake New Wood to the south and Crownend Wood to the west. The southern section is also surrounded by pockets of woodland including Oak Wood, Crow Wood and Ash Spinney.

4.30. The Application Site is in an area with an existing industrial presence with a telecoms mast located on the southwestern boundary of Field 7, a wood pole line along the boundary

between Fields 7 and 8 and within the southern section of Fields 4 and 5 and overhead lines located along the southern boundary of Field 16 and the eastern boundary of Field 15 (See **Figure 3 of Volume 2: Planning Application Drawings** for field numbers).

4.31. The surrounding area is semi-rural in nature with the site being surrounded by agricultural fields and woodland in most directions. The area is however punctuated by individual farmsteads and Rushcliffe Golf Club is located on the eastern boundary of Field 15 in the southern section of the site. There are also various industrial brownfield sites within the locality including Charnwood Truck Services located directly southwest of Field 4. Additionally, there is a large-scale power station located beyond the A453, circa 1.58km north of the site which can currently be seen from Bridleway 12.

4.32. Recreational routes include a number of Bridleways (BW) which cross or abut the Site providing connectivity to the wider Kingston Estate. These include Gotham BW No. 10, 11 and 12 and West Leake BW's No. 5 and 13.West Leake BW No. 5, also known as the Midshires Way, is also a Long-Distance Walking Association (LDWA) Route bordering the southern boundary of Fields 15 and 16. While there are several field drains throughout the Application Site, it lies entirely within Flood Zone 1, an area described as having a "Low probability" of flooding.

4.33. The Application Site will be accessed from Wood Lane, which is an unadopted road. Delivery vehicles will exit the M1 at junction 24, signposted A453 Nottingham (S), onto the A453 and travel in a northeast direction for approximately 4.3km, before taking the exit onto West Leake Lane. This road will be travelled on in a southern direction for approximately 1.5km, before turning left onto Kegworth Road. Vehicles will travel northeast along this road for approximately 1.3km before turning right into Wood Lane.

Scope of Report

4.34. The aim of this assessment is to identify the baseline geological and hydrological conditions of the site and surrounding area; to assess the potential impacts of the Proposed Development during the construction, operation and decommissioning phases; to identify the risk of flooding at the proposed Application Site; and to recommend mitigation measures where appropriate.

4.35. This Flood Risk Assessment has been prepared in accordance with National Planning Policy Guidelines.

4.36. This report is supported by the following figures and appendices:

- Appendix 4A Figures:
  - Figure 4.1: Watercourses with Photo Locations;
  - Figure 4.2: Topographical Survey

  - Figure 4.3: Planning Flood Map
  - Figure 4.4: Outline Drainage Design (Solar West)
  - Figure 4.5: Outline Drainage Design (Solar East)
  - Figure 4.6: Outline Drainage Design (Grid)
- Appendix 4B: Photo Appendix
- Appendix 4C: Flow Output (Solar Farm)
- Appendix 4D: Flow Output (Grid Substation)
- Appendix 4E: BRE 365 Test and Report

Statement of Authority

4.37. This Flood Risk Assessment (FRA) has been produced by Michael McGhee, David Thomson and Tom Saddington of Neo Environmental. Having completed a civil engineering degree in 2012, Michael has worked on over 1GW of renewable development flood risk and drainage impact assessments across the UK and Ireland whilst working towards becoming a Chartered Engineer. Michael has over 10 years of environmental consultancy experience, mainly producing technical assessments for energy projects. Tom has an undergraduate degree in Bioengineering and graduated with an MSc in Environmental and Energy Engineering in January 2020. He has been working on various technical assessments including flood risk assessment reports for numerous renewable developments in Ireland and the UK. David has an undergraduate degree in physics, as well as a MSc in sensor design and a MSc in nanoscience. He is an Environmental Engineer currently being trained in Hydrology assessments.

Consultation

4.38. A pre-application request was submitted to Rushcliffe Borough Council on the 18th December 2020 and a response was received on the 1st September 2021 from the Principal Flood Risk Management Officer. The response stated:

"Any FRA or drainage strategy should include following information:

- *The provided layout plan shows no provision for above ground sustainable drainage systems as such we request that any surface water scheme submitted at a later date includes provision for above ground SuDS features.*

- *With regards to an acceptable surface water management scheme for the site we would offer the following comments and recommendations;*
- *Provide evidence of a proven outfall from site in accordance with the drainage hierarchy the follows options should be considered, in order of preference; infiltration, discharge to watercourse, discharge to surface water sewer or discharge to combined sewer.*
- *The maximum discharge should be set to the QBar Greenfield run-off rate for the positively drained area of development.*
- *The site drainage system should cater for all rainfall events up to and including the 1 in 100-year event including a 40% allowance for climate change.*
- *Details of who will manage and maintain all drainage features for the lifetime of the development will be required prior to construction".*

4.39. All these points were taken into account in this report.

LEGISLATION

4.40. A review of relevant legislation has been conducted to ensure the Proposed Development complies with the following:

- EU Directive on the Assessment and Management of Flood Risks [2007/60/EC][1] implemented in England via the Flood and Water Management Act 2010[2] and the Flood Risk Regulations 2009[3];
- The Water Framework Directive [2000/60/EC][4] as implemented in England via the Water Environment (Water Framework Directive) (England and Wales) Regulations 2017[5];
- The Groundwater Directive (GWD) (2006/118/EC)[6] as implemented by the Groundwater (Water Framework Directive) (England) Direction 2016 and Environmental Permitting (England and Wales) Regulations 2016.
- National Planning Policy Framework (NPPF), 2021[7]

[1] European Parliament (2007). Directive 2007/60/EC of the European Parliament and of the Council establishing a framework for the assessment and management of flood risks. Available at https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=celex:32007L0060

[2] UK Government (2010). Flood Water a Management Act 2010. Available at https://www.legislation.gov.uk/ukpga/2010/29/contents

[3] UK Government (2009). The Flood Risk Regulations 2009. Available at http://www.legislation.gov.uk/uksi/2009/3042/contents

[4] European Parliament (2000). Directive 2000/60/EC of the European Parliament and of the Council establishing a framework for the Community action in the field of water policy ("The Water Framework Directive"). Available at: https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:32000L0060.

[5] UK Government (2017). The Water Environment (Water Framework Directive) (England and Wales) Regulations 2017. Available at http://www.legislation.gov.uk/uksi/2017/407/contents/made

[6] European Parliament (2006). Directive 2006/118/EC of the European Parliament and of the Council establishing a framework for the protection of groundwater against pollution and deterioration ("The Water Framework Directive"). Available athttps://www.eea.europa.eu/policy-documents/groundwater-directive-gwd-2006-118-ec

[7] https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/1005759/NPPF_July_2021.pdf

Review of Local Plan Policy

Rushcliffe Local Plan

4.41. The Rushcliffe Local Plan Part 2: Land and Planning Policies[8] (the "LAPP") is the adopted plan at present.

Table 4 - 1: Local Plan Flood Management Policies/Objectives (key points summarised)

Planning Policy/Objective	Comment
Policy 17: Managing Flood Risk *"1. Planning permission will be granted for development in areas where a risk of flooding or problems of surface water disposal exists provided that:* *a. the sequential test and exception test are applied and satisfied in accordance with the National Planning Policy Framework and National Planning Policy Guidance; or* *b. where the exception test is not required, for example change of use applications, it has been demonstrated that the development and future occupants will be safe from flood risk over the lifetime of the development; or* *c. the development is for minor development where it has been demonstrated that the Environment Agency's flood risk standing advice has been followed, including: i. an industrial or commercial extension of less than 250 square metres; ii. alterations to buildings that do not increase the size of the building; iii. householder development including sheds, garages within the curtilage of the dwelling; and* *d. development does not increase the risk of flooding on the site or elsewhere, including through increased run-off due to areas of hardstanding, or reduction in ground water storage as a result of basements.* *2. Development proposals in areas of flood risk will only be considered when accompanied by a site specific flood risk assessment. Proposals will be expected to include*	A detailed FRA has been undertaken to determine the flood risk. A Drainage Impact Assessment has been undertaken to ensure the run-off rate matches or betters the pre-development greenfield run off rates.

8 Rushcliffe Local Plan Part 2: Land and Planning Policies. Available at https://www.rushcliffe.gov.uk/planningpolicy/localplan/localplanpart2landandplanningpolicies/

mitigation measures which protect the site and manage any residual flood risk, such as flood resistance/resilience measures and the provision of safe access and escape routes."	
Policy 18: Surface Water Management *"1. To increase the levels of water attenuation, storage and water quality, and where appropriate, development must, at an early stage in the design process, identify opportunities to incorporate a range of deliverable Sustainable Drainage Systems, appropriate to the size and type of development. The choice of drainage systems should comply with the drainage hierarchy.* *2. Planning permission will granted for development which:* *a) is appropriately located, taking account of the level of flood risk and which promotes the incorporation of appropriate mitigation measures into new development, such as sustainable drainage systems;* *b) reduces the risk to homes and places of work from flooding;* *c) delivers a range of community benefits including enhancing amenity (ensuring a safe environment) and providing greater resistance to the impact of climate change;* *d) contributes positively to the appearance of the area;* *e) accommodates and enhances biodiversity by making connections to existing Green Infrastructure assets; and* *f) retains or enhances existing open drainage ditches."*	A Drainage Impact Assessment will include the design of SuDS. This will seek to incorporate features which enhance the biodiversity of the site using SuDS.

Preliminary Flood Risk Assessment (PFRA) for Nottinghamshire County Council[9]

4.42. In accordance with the requirements of the Flood Risk Regulations (2009), Nottinghamshire County Council prepared a Preliminary FRA. This constitutes a high-level screening exercise to identify significant flood risk areas associated with flooding from surface water, groundwater and ordinary watercourses. The assessment identified surface water flooding approximately 0.5km north of the Application Site, however there is no impacts on the Proposed Development.

Strategic Flood Risk Assessment (SFRA)[10]

4.43. Nottingham City Council instructed AECOM to undertake a Level 1 SFRA in 2017 for the Greater Nottingham Area. The assessment is based upon historic flood records, hydraulic modelling data and the Environment Agency's (EA) Flood Map for Planning. The Application Site could not be discovered in the assessment; therefore, EA's mapping has been used.

[9] Nottinghamshire County Council (2011). Preliminary Flood Risk Assessment for Nottinghamshire Available at https://www.nottinghamshire.gov.uk/media/1598/pfra-1.pdf

[10] Nottingham City Council (2017), Greater Nottingham Strategic Flood Risk Assessment, Available at https://www.nottinghamcity.gov.uk/information-for-business/planning-and-building-control/planning-policy/greater-nottingham-strategic-flood-risk-assessment-addendum/

METHODOLOGY

4.44. Flood planning policy and guidance for England is contained within the National Planning Policy Framework and in relation to flood risk it states:

"A site-specific flood risk assessment should be provided for all development in Flood Zones 2 and 3. In Flood Zone 1, an assessment should accompany all proposals involving:

- *sites of 1 hectare or more;*
- *land which has been identified by the Environment Agency as having critical drainage problems;*
- *land identified in a strategic flood risk assessment as being at increased flood risk in future;*
- *land that may be subject to other sources of flooding, where its development would introduce a more vulnerable use"*

4.45. As this Proposed Development is over 1 hectare in size then a site-specific FRA is necessary. The objectives of a site-specific FRA are to establish:

- whether a proposed development is likely to be affected by current or future flooding from any source;
- whether it will increase flood risk elsewhere;
- whether the measures proposed to deal with these effects and risks are appropriate;
- the evidence for the local planning authority to apply (if necessary) the Sequential Test, and;
- whether the development will be safe and pass the Exception Test, if applicable.

4.46. The Guidelines provide five vulnerability categories, based on the type of proposed development, which are detailed as follows:

- 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.

- 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

- 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, cafes and hot food takeaways; offices; general industry, storage and distribution; non-residential institutions not included in the 'more vulnerable' class; 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.

• 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 defence installations.
- 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.

Table 4 - 2: Flood Risk Vulnerability Classification

Flood Zone	Essential Infrastructure	Highly Vulnerable	More Vulnerable	Less Vulnerable	Water Compatible
Zone 1	Appropriate	Appropriate	Appropriate	Appropriate	Appropriate
Zone 2	Appropriate	Exception Test Required	Appropriate	Appropriate	Appropriate
Zone 3a	Exception Test Required [x]	Not Appropriate	Exception Test Required	Appropriate	Appropriate
Zone 3b	Exception Test Required *	Not Appropriate	Not Appropriate	Not Appropriate	Appropriate*

[x] *In Flood Zone 3a essential infrastructure should be designed and constructed to remain operational and safe in times of flood.*

[*] *In Flood Zone 3b (functional floodplain) essential infrastructure that has to be there and has passed the Exception Test, and water-compatible uses, should be designed and constructed to:*

- *remain operational and safe for users in times of flood;*
- *result in no net loss of floodplain storage;*
- *not impede water flows and not increase flood risk elsewhere.*

4.47. The sequential test compares the Application Site with other available sites, with the aim to develop on areas of land which are at a lower risk of flooding.

4.48. When applying the sequential test, should the site still be located within Flood Zones 2 and 3 then any flood risk assessment should consider the following:

- What other locations with a lower risk of flooding have you considered for the proposed development?
- If you have not considered any other locations, what are the reasons for this?
- Explain why you consider the development cannot reasonably be located within an area with the lowest probability of flooding (flood zone 1); and, if your chosen site is within flood zone 3, explain why you consider the development cannot reasonably be located in flood zone 2.

- As well as flood risk from rivers or the sea, have you taken account of the risk from any other sources of flooding in selecting the location for the development?

4.49. Where a proposed development requires an Exception Test, this must be undertaken to determine if the development can be justified. The application of the exception test should be informed by a site-specific FRA. For the exception test to be passed it should be demonstrated that:

- the development would provide wider sustainability benefits to the community that outweigh the 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.

4.50. Development should only be allowed in areas at risk of flooding where, in the light of the site-specific FRA (and the sequential and exception tests, as applicable) it can be demonstrated that:

- within the site, the most vulnerable development is located in areas of lowest flood risk, unless there are overriding reasons to prefer a different location;
- the development is appropriately flood resistant and resilient;
- it incorporates sustainable drainage systems, unless there is clear evidence that this would be inappropriate;
- any residual risk can be safely managed; and
- safe access and escape routes are included where appropriate, as part of an agreed emergency plan.

4.51. Site specific FRA's should also provide surface water management arrangements at the site using sustainable drainage systems wherever appropriate, to ensure there is no increase in flood risk to others off-site. The following questions should be answered in all proposals:

- What are the existing surface water drainage arrangements for the site?
- If known, what (approximately) are the existing rates and volumes of surface water run-off generated by the site?
- What are the proposals for managing and discharging surface water from the site, including any measures for restricting discharge rates? For major developments (eg of 10 or more homes or major commercial developments), and for all developments in

areas at risk of flooding, sustainable drainage systems should be used, unless demonstrated to be inappropriate.

- How will you prevent run-off from the completed development causing an impact elsewhere?
- Where applicable, what are the plans for the ongoing operation and/or maintenance of the surface water drainage systems?

BASELINE CONDITIONS

4.52. This section presents the information gathered on the existing topographical, geological, hydrological and hydrogeological conditions of the Application Site and its immediate surroundings.

4.53. A site walkover survey was also undertaken in order to identify hydrological, geological, flood risk and drainage features within the Application Site. A photographic record of drainage features is contained within **Appendix 4B** and the photo locations can be seen in **Figure 4.1 of Appendix 4A**.

Topography

4.54. A topographical survey was undertaken at the Application Site (**see Figure 4.2 Appendix 4A**). The lowest point within the Application Site (57.9m AOD) is in the southern corner of Field 2. The high point at 96.33m AOD is in northwest section of Field 15. The eastern part of the site contains a gentle gradient, for the most part, from the high points within Field 12 and 15. However these gradients become steeper in places, particularly to the south western part of Field 13. The area where the land starts to this fall away has been avoided. The western fields again contain gentle gradients, however they become steeper within the southern segments of Fields 1, 2, 4 and 6. Again these areas have been avoided.

4.55. **Appendix 4B** shows various pictures of the drains that run along the boundaries and within the Application Site.

Geology & Soil

4.56. The geological conditions of the Application Site were identified utilising the British Geological Society ("BGS") Spatial Resources online geological mapping[11] system. This indicated that the site has no superficial drift deposits recorded and bedrock deposits were recorded as the Barnstone Member - Mudstone and Limestone, Interbedded.

4.57. Barnstone Member - Mudstone and Limestone formed approximately 199 to 210 million years ago in the Jurassic and Triassic Periods. Local environment previously dominated by shallow lime-mud seas.

[11] BGS Geology of Britain Map., Available at http://mapapps.bgs.ac.uk/geologyofbritain/home.html

Soil

4.58. Different soil types have different capabilities of soaking up water, the efficiency of which is dependent upon the structure and infiltration capacity. The Soilscapes[12] map has been utilised to obtain soil data. It classes the soil at the Application Site as *'Lime-rich loamy and clayey soils with impeded drainage'* and *'Slightly acid loamy and clayey soils with impeded drainage'.*

4.59. According to the Wallingford Procedure 'Winter Rain Acceptance Potential' (WRAP) map[13], the soil classification for the site is Class 4. This soil class has a Standard Percentage Runoff (SPR) of 0.47 and will likely not provide good infiltration opportunities.

4.60. The soils encountered beneath the Application Site, found during the infiltration testing, were predominately clay. These were dug within Fields 3 and 5 and the results can be found in the report provided in **Appendix 4E**. There are 11 boreholes located within the Application Site. However, nine of these boreholes are associated with BPB Industries Ltd and are classified with no information. The other two boreholes have got a depth of 65.83m and 69.95m, respectively, and both suggested that clay was encountered beneath the site. Another borehole, located just to the east of the Application Site, shows that there was also clay found beneath the surface. This suggests that across the site, the soils will be predominately clay.

4.61. The soakage rates obtained during the investigation were found to be practically impermeable. Given the data from the test, it is considered that infiltration drainage is not suitable across the site.

Hydrology

4.62. According to the Environment Agency Catchment Data Explorer[14], the Application Site lies predominately within the Humber River Basin District. Within this, the site lies in the Soar Management catchment and within the Soar River Operational Catchment. The small section of the site that does not lie within the Soar Management Catchment, Field 5 and the northern part of Field 6, is in the Trent Lower and Erewash Management Catchment. Furthermore, this area is within the Nottinghamshire South B Operational Catchment.

[12] Cranfield Soil and Agrifood Institute, Soilscapes website. Available at http://www.landis.org.uk/soilscapes/

[13] HR Wallingford. Greenfield Runoff Estimation for the Sites. Available at: https://www.uksuds.com/tools/greenfield-runoff-rate-estimation

[14] Environment Agency, Catchment Data Explorer, Available at https://environment.data.gov.uk/catchment-planning/RiverBasinDistrict/4

Local River Network

4.63. The Application Site is predominately within the catchment of the Kingston Brook which has an overall classification of "Poor" under the Water Framework Directive (WFD). The Kingston Brook leads into the Soar River approximately 3km southwest of the Application Site. Following this, the Soar River converges with the River Trent, which joins the River Ouse to form the Humber Estuary and empty into the North Sea.

4.64. Some small areas to the north of the site are in the catchment of the Fairham Brook, which leads to the River Trent approximately 7.5km to the north. The Fairham Brook has an overall classification of "Moderate" under the Water Framework Directive (WFD).

Internal Watercourses

4.65. The drains that run through the Application Site between fields will drain all surface water of the Proposed Development to the Long Whatton Brook or the Kingston Brook, which eventually converge with the Soar River. **Photo 9: Appendix 4B** shows an example of the field drains within the Application Site.

Flood Zone Classification

4.66. The Environment Agency Flood Map for Planning[15] shows that the Application Site is wholly located in Flood Zone 1, an area described as "*Low probability*" of flooding in **Table 1: Flood Zones** of the "*Planning Practice Guidance to the National Planning Policy Framework*".

4.67. Flood Zone 1 is categorised as being the lowest flood risk and comprises land assessed as having less than 1 in 1,000 annual probability of river or sea flooding. (See **Figure 4.3: Appendix 4A**).

Historic Flooding

4.68. The Environment Agency's historic flood map[16] is a GIS layer showing the maximum extent of individual recorded flood outlines from rivers, the sea and groundwater springs that meet a set criterion. It shows areas of land that have previously been subject to flooding in England. The map shows that no part of the Application Site has been included within this historic flood extents, with the closest area of historic flooding occurring in Kingston on Soar to the west of the Application Site.

[15] Environment Agency Flood Map for Planning, Available at https://flood-map-for-planning.service.gov.uk/

[16] Environment Agency, Historic Flood Outlines, Available at https://environment.data.gov.uk/DefraDataDownload/?mapService=EA/HistoricFloodMap&Mode=spatial

4.69. A review of the Strategic Flood Risk Assessments covering the area has identified that there are no specific records of flooding for the Application Site.

Hydrogeology

4.70. The Application Site is not located within any source protection zones (SPZs).

Groundwater Vulnerability

4.71. Groundwater Vulnerability refers to the intrinsic geological and hydrogeological characteristics that determine the ease at which groundwater may be contaminated by human activities. The more vulnerable the groundwater is, the more easily it can be contaminated by surface water.

4.72. According to the Environment Agency Groundwater Vulnerability Maps, the Application Site has got areas of 'High' and 'Medium-High' groundwater vulnerability. The 'High' risk dominates the northwest fields of the Proposed Developments, meanwhile 'Medium-High' risk dominates the south east fields of the Proposed Development.

FLOOD RISK ASSESSMENT

Sequential Test

4.73. The Sequential Test ensures that a sequential approach is followed to steer new development to areas with the lowest probability of flooding. The flood zones, as refined in the Strategic Flood Risk Assessment for the area, provide the basis for applying the Test. The aim is to steer new development to Flood Zone 1 (areas with a low probability of river or sea flooding). Where there are no reasonably available sites in Flood Zone 1, LPA's in their decision making should take into account the flood risk vulnerability of land uses and consider reasonably available sites in Flood Zone 2 (areas with a medium probability of river or sea flooding), applying the Exception Test if required. Only where there are no reasonably available sites in Flood Zones 1 or 2 should the suitability of sites in Flood Zone 3 (areas with a high probability of river or sea flooding) be considered, taking into account the flood risk vulnerability of land uses and applying the Exception Test if required.

Fluvial and Coastal Flood Risk

4.74. The EA Mapping shows that the Application Site is wholly within Flood Zone 1 which comprises land assessed as having less than 1 in 1,000 annual probability of river or sea flooding. Therefore, there will be no infrastructure built where land is deemed to be Flood Zone 2 or 3.

4.75. The proposed type of development is classed as '*Essential Infrastructure*' and therefore development in Flood Zone 1 is deemed '*appropriate*' (See Table 4-2).

Pluvial Flood Risk

4.76. In addition to fluvial and coastal flood risk, the EA also provide surface water flood maps. This indicates multiple areas of surface water flooding within the Application Site. Each of these areas was assessed during the site visit and they were mostly confined to the existing small watercourses and field drains. There were some areas of marshy land next to watercourses, however a 2m buffer has been kept free of development from all field drains/watercourses within the Application Site. 5m buffers have also been left around the site perimeter and from hedgerows, where the ditches are generally located, so there will be 5m buffers from the ditches in most locations.

4.77. Figure 4.2 of Appendix 4A shows the topographical survey of the Application Site. In addition to the site visit assessment, the topographical survey and aerial maps were studied to determine what likely depth of surface water could be possible in a storm event. It was found that it would be unlikely that any major ponding would form, and surface water levels would likely be a maximum of 0.3m deep in all fields, except along the western edge of Field 5 which would likely be a maximum of 0.9m deep, before feeding into the existing field drain network. This area has been avoided from development. See Photo 6: Appendix 4B taken within Field

6, which is an area of surface water flooding according to the EA mapping. This was taken on a site visit in March 2021 after a period of heavy rain, although it was dry on the day.

4.78. The level that solar panels will be raised above ground will vary depending on ground conditions; however, they will generally be at least 0.6m AGL. Therefore, above the surface water level of approximately 0.3m with a suitable freeboard. The surface water levels have been based off the 'Medium Risk Scenario' which correlates to a 1 in 100 chance of flooding, with onsite and topographic checks for accuracy.

Groundwater Flood Risk

4.79. Groundwater flooding is a "hidden" risk that is often difficult to distinguish from other types of flooding. For example, rising groundwater often forms in low-lying areas which are also susceptible to the accumulation of surface water.

4.80. The PFRA showed that there is less than a 25% chance of groundwater flooding where the Application Site is located. As discussed previously, it's likely that the higher vulnerability of groundwater flooding is near to the watercourses and within low lying areas of the Application Site. During the site visit, various areas of marshy land were noted and development within these areas was avoided during the design iteration process. See **Photo 7 and 12: Appendix 4B**.

4.81. In addition, the main impacts to groundwater include the contamination risk during the construction phase. These impacts will be managed and outlined in the Pollution Prevention chapter of the Outline Construction Environmental Management Plan (OCEMP)**: Technical Appendix 8 of Volume 2**, both being submitted in conjunction with this report to form the planning application. Therefore, the groundwater flood risk is presumed to be **Low**.

Access/Egress

4.82. There are no areas of fluvial or coastal flooding which would block off access to the Application Site. Even though the risk of maintenance staff being stuck onsite due to flooding within the site is low, an emergency plan will be in place in case of flash flooding and any staff members who are to visit the site will be appropriately briefed prior to the visit.

4.83. There is one access point being constructed off the private road network, which is not adopted, using an existing field entrance. This will be constructed so that surface water flows into the Application Site and not onto the private road. There will also be upgrades to the junction of Kegworth Road and Wood Lane which will be constructed so that surface water flows into the Application Site and not onto the public road.

DRAINAGE IMPACT ASSESSMENT

Introduction

4.84. There is a requirement in the NPPG for proposals to incorporate surface water drainage measures that have a neutral or beneficial effect on the risk of flooding both on and off the Application Site.

4.85. Surface water arising from a developed site should, as far as is practicable, be managed to mimic the surface water flows arising from the site prior to the Proposed Development, while reducing the flood risk at the site itself and elsewhere.

Methodology

Catchment Characteristics

4.86. Catchment characteristics were obtained from the Flood Studies Report[17]. Catchment sizes were measured using ArcGIS and catchment boundaries were produced based on the site-specific topographical survey.

Greenfield Runoff and Stormwater Storage

4.87. Greenfield runoff rates and stormwater storage requirements have been obtained using the following tools:

- HR Wallingford UK Sustainable Drainage Greenfield Runoff Estimation Tool (using IH124[18] methodology due to the small-scale nature of the catchment).
- Flow – Causeway Drainage design software (using IH124 methodology due to the small-scale nature of the catchment).
- The areas of permeable and impermeable surfaces have been estimated and are based upon the Proposed Development layout (**Figure 4 of Volume 2: Planning Application Drawings** for the layout of the Proposed Development).

[17] Institute of Hydrology, Flood Studies Report (1975)

[18] Institute of Hydrology (1994). *Flood estimation for small catchments. Report No IH124*, Wallingford.

Greenfield Runoff rates

4.88. The IH24 methodology is used for calculating the Greenfield runoff rates. This is recommended by the Institute of Hydrology for catchments below 200ha.

4.89. The IH124 equation estimates Qbar with the following equation:

$$Qbar - rural = 0.00108\ x\ (0.01\ x\ AREA)0.89\ x\ SAAR1.17\ x\ SPR2.17, m3/s$$

where:

- Qbar-rural is the mean annual flood flow from a rural catchment (approximately 2-3-year return period).
- AREA is the area of the catchment in ha.
- SAAR is the standard average annual rainfall for the period 1961 to 1990, available from the Flood Studies Report
- SPR is Standard Percentage Runoff coefficient for the SOIL category.

Calculating storage estimates

4.90. The storage estimates are calculated using the inputs below:

- Return Period
- Climate Change
- Impermeable Area
- Peak Discharge

4.91. The return period and climate change are combined with the Flood Studies Report (FSR) parameters and storm durations to generate the rainfall used. The result from these calculations is the attenuation storage required for the Application Site as a result of the additional runoff generated by the Proposed Development.

Site and Project Descriptions

4.92. The Proposed Development will have a very limited extent of impermeable ground cover. The area beneath the solar panels will remain as grassland and the post-development site infiltration rate will not change.

4.93. Rainwater falling onto each panel will drain freely onto the ground beneath the panels and infiltrate the ground at the same rate as it does in the site's existing greenfield state. Thus, the total surface area of the photovoltaic array is not considered an impermeable area.

4.94. Similarly, any rainwater falling onto the permeable access tracks will soak into the ground beneath at the same rate that it presently does.

4.95. The extent of impermeable area created as a result of the Proposed Development is summarised in Table 4-3.

Table 4 - 3: Extent of less permeable areas created by the Proposed Development

Building	Solar Farm Total Area (m^2)	Grid Substation (m^2)
20 x Inverter Substations (16.0m(L) x 6.0m(W))	1,920.0	NA
2 x Equipment Containers (2.4m(L) x 12.2m(W))	58.6	NA
Grid Substation Area (62m(L) x 49.5m(W))	NA	3,069.0
Total Impermeable Area (m^2)	1,978.6	3,069.0
Total Impermeable Area (m^2)	5,047.6	
Site Area (m^2)	806,525.5	

4.96. In its current greenfield state, the Application Site is considered to be 100% undeveloped. As a result of the Proposed Development, the extent of impermeable hardstanding introduced will be approximately 5,047.6m^2 or 0.6% of the total site area.

4.97. Due to the small size of the inverter substations and equipment containers, and the widespread nature of their locations across the Application Site, it is impractical to connect them into a drainage scheme. Water runoff from these buildings will slowly drain into the underlying geology through infiltration and the impact of this will be **Negligible**. Should surface water accumulate around any of these locations, a simple soakaway can be constructed to allow water soak into the underlying subsoils.

Existing Drainage Arrangements

Existing Runoff Rates

4.98. The existing runoff rates and hydrological characteristics of the Proposed Development are detailed in **Table 4-4** below (there are no hardstanding areas on the site at present).

Table 4 - 4: Pre-Development Greenfield runoff rates.

Site Make Up	Solar Farm Green Field	Grid Green Field
Greenfield Method	IH124	IH124
Positively Drained Area (ha)	0.20	0.31
Seasonally Adjusted Annual Rate (SAAR) (mm)	597	597
Soil Index	4	4
Standard Percentage Runoff	0.47	0.47
Region	4	4
	Runoff rate (l/s)	**Runoff rate (l/s)**
QBar	0.8	1.2
1 year	0.7	1.1
1 in 30 year	1.6	2.4
1 in 100 year	2.0	3.1

4.99. The limiting discharge rate will be the QBar greenfield rate, as detailed in **Table 4-4**.

Post Development Runoff Rate

4.100. The surface water runoff rate resulting from the Proposed Development has been based on the areas of hardstanding introduced, which will have a lower permeability than the existing greenfield composition.

4.101. Surface water runoff was derived using the Modified Rational Method as outlined within the methodology.

4.102. Using this approach, the runoff rate for the 1-in-100-year, 360-minute storm event, inclusive of the 40% climate change allowance would be a combined **114m^3**, across the three site areas, if left unmanaged.

Proposed Drainage Arrangements

4.103. The SuDS Manual[19] is the current best practice guidance on the use of SuDS. It promotes the use of a hierarchical approach to managing runoff. This approach is outlined below:

- Prevention - Preventing runoff by reducing impermeable areas.
- Source Control - Effective control of runoff at or very near its source.
- Site Control- Planned management of water in a local area or site.
- Regional Control - Designing a system that can efficiently manage the runoff from a site, or several sites.

4.104. The use of SuDS is generally accepted to have greater benefits than conventional drainage systems and these include[20]:

- Managing runoff volumes and flow rates from hard surfaces, reducing the impact of urbanisation on flooding;
- Providing opportunities for using runoff where it falls;
- Protecting or enhancing water quality (reducing pollution from runoff);
- Protecting natural flow regimes in watercourses;
- SuDs are sympathetic to the environment and the needs of the local community;
- Providing an attractive habitat for wildlife in urban watercourses;
- Providing opportunities for evapotranspiration from vegetation and surface water; and
- Encouraging natural groundwater/aquifer recharge (where appropriate).

4.105. The surface water drainage strategy for the Proposed Development seeks to provide a sustainable and integrated surface water management scheme for the whole Application Site

19 CIRIA (2015). Report C753, The SuDS Manual

20 Susdrain. Sustainable drainage. Accessed http://www.susdrain.org/delivering-suds/using-suds/background/sustainable-drainage.html

and aims to ensure no increase in downstream flood risk by managing discharges from the Proposed Development to the local water environment in a controlled manner.

4.106. To comply with current policies, guidance and best practice, the volume and quality of surface water runoff discharged off-site from the Proposed Development at this Application Site will need to be controlled using SuDS.

4.107. In compliance with the above, the drainage strategy has been developed to meet the following key principles;

- Mimic existing (greenfield) drainage arrangements as far as possible;
- Avoid increases in the greenfield rate, volume and frequency of offsite discharge;
- Avoid significant deterioration in water quality of discharges and no detrimental impact in downstream water quality;
- Achieve the above criteria for all storms up to and including the 100-year event; and,
- Incorporate an allowance for climate change (40%).

Indicative Surface Water Storage Requirements

4.108. Indicative storm water storage volumes have been estimated using Causeway's Drainage Design Flow software. The storage calculations include up to the critical storm 100-year return period event (including a 40% allowance for climate change) and the design limits discharge rates back to greenfield runoff rates. The results are enclosed in **Appendix 4C and 4D.** These are estimated from the new surfaces added to the Proposed Development.

- Attenuation storage limits the rate of surface runoff discharge from the Proposed Development to match the pre-development greenfield runoff rates; and,
- All storage calculations have been given a climate change allowance factor of 40% that has been added to the rain depths.

Table 4 - 5: Storage Estimates

Storage Estimates		
	Solar Farm	Grid Substation
Return Period (years)	100 years	100 years
Climate Change (%)	40	40

Impermeable Area (ha)	0.033	0.163
QBar Peak Discharge (l/s)	0.1	0.4
Total storage Requirement (m^3)	114.0	179.0

Proposed Drainage Strategy (Solar Farm)

4.109. It is proposed to construct multiple filter drains / soakaways and swales within the Application Site. The location of the schemes have been chosen on the downward slope, near to the existing watercourse which run through the Application Site, see **Figure 4.4 and 4.5: Appendix 4A**. The idea is to capture any overland flow in the SuDS device, prior to releasing into the natural surface water system. Calculations are included in **Appendix 4C. The drainage design is in outline form and are indicative only at this stage and subject to detailed design.**

4.110. The proposed filter drains / soakaways will have an overall length of approximately 970m, with a base width of 0.5m, a 0.5m design depth and a 0.15m freeboard. It will be filled with crushed rock with a void ratio of 20% and will provide a total storage volume of approximately 48.5m^3

4.111. The proposed swales will be of an overall length of approximately 360m, with a base width of 500mm, a 500mm design depth, 150mm freeboard and a maximum side slope of 1 in 3. It will provide a total storage volume of approximately 360m^3.

4.112. In total, proposed drainage strategy will provide a storage volume of approximately 408.5m^3. This is significantly greater than the volume of additional runoff generated as a result of the impermeable buildings (114.0m^3). It is therefore considered that this not only adequately mitigates the increase in flow rates as a result of the minor increase in impermeable area but provides significant improvement.

4.113. The SuDS features will be implemented during the construction phase of the Proposed Development and the swales will be planted with vegetation to protect against soil erosion. They will be maintained throughout the lifespan of the Proposed Development, generally in accordance with the recommendations in the appropriate guidance.

4.114. The proposed discharge points are into various existing field drains and can be viewed on **Figure 4.4: Appendix 4A**.

Proposed Drainage Strategy (Grid Substation)

4.115. It is proposed that surface run-off will be collected and conveyed by the provision of filter drains to a detention basin as shown in **Figure 4.5: Appendix 4A**. A notional freeboard level of 150mm shall be incorporated into the detailed detention basin for the 1 in 100-year storm event plus 40% climate change with the final design of the pond being submitted to the

council prior to the construction period. Calculations are included in Appendix 4D and the design volume of the detention basin will be a minimum of 179m^3.

4.116. As stated previously, the grid substation area is underlain by clays which exclude infiltration techniques for surface water disposal. QBar discharge rate restriction as noted in Table 4-5 satisfies the requirements of the SuDS Manual '*Designing for Long Term Storage'*. Final discharge is restricted at the pond by the provision of a Hydro-Brake® vortex flow control device, or a device of similar quality.

4.117. Due to very infrequent site attendance that is required, the pollution risk is deemed negligible. On-plot surface water treatment is provided in the form of filter drains wrapped to intercept the conveyance of any silts within the drainage system. Further downstream, water quality polishing is provided within the detention basin prior to discharge from site.

4.118. The discharge point will be into the existing site field drainage to the north east of the detention basin.

4.119. Additional drainage measures to be implemented on-site include the following:

- Solar Panels: current grass cover is to be retained or reinstated adjacent to and under panels in order to maximise bio-retention;
- Access Tracks: access tracks are to be unpaved and constructed from local stone. Swales or similar shall be utilised to collect runoff from access tracks, where required, however these will be designed at the detailed design stage. Where swales are utilised, check dams formed from gravels and other excavated material shall be placed in the swale at frequent intervals; and,
- Inverter Substations, Spare Part Containers, etc: Filter strips will surround the concrete bases of the ancillary buildings to capture any runoff from the roofs. This will be discharged to a percolation area or into the sites drainage network where it is close enough. Should surface water accumulate around any of these locations then a simple soakaway can be constructed to allow water soak into the underlying subsoils.

Foul Drainage

4.120. A permanent toilet is proposed within the substation compound which will be utilised by maintenance staff of both the solar farm and the substation as well as tour groups and visiting members of the local authority. This toilet will be one of the following:

- Composting toilet which is waterless and chemical free. The composting toilet uses a dehydration process resulting in an odour free compost which is collected annually for further processing off-site.

- Off grid toilet with water tank which is refilled as and when required. Will also have a foul tank which will be emptied when required by an approved contractor.

Designing for Exceedance Events

4.121. Overland flow routes will not be altered by the construction of the Proposed Development as it is not proposed to significantly vary ground levels. The outline drainage has been designed so that flooding will not occur for up to and including the 1-in-100-year storm event (including 40% climate change consideration).

4.122. Should an exceedance of this 1 in 100-year critical storm event occur, surface water will flow the same way as at present, into the surrounding field drains and watercourses. There are no sensitive receptors between the Application Site and the field drains.

Long Term Maintenance of SuDS

4.123. The long-term management and maintenance of the proposed SuDS will be the responsibility of the site owner and/or operators. These responsibilities include:

- Periodic cutting or grazing of vegetation;
- Observation of infiltration performance;
- If poor infiltration is observed then any accumulated silt/litter will be removed and aeration of the soil will be undertaken to improve permeability; and
- Maintain the structural integrity of the infiltration trenches/ attenuation structure.

Potential for Soil Erosion

4.124. The key to avoiding increased runoff and the transport of 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.

4.125. Soil compaction will be limited during construction and operation of the solar farm. During construction, only light machinery will be required to install the solar arrays. Any Heavy Goods Vehicles (HGVs) delivering components will be restricted to site access tracks and the temporary construction compounds.

4.126. To alleviate the effects of any limited compaction during the construction process any affected areas will be harrowed prior to being reseeded.

4.127. The risks of runoff and soil erosion are lowest on land with a gradual gradient with cohesive soils and are highest on dry, sandy and steeply sloping soil surfaces. Furthermore, the slope aspect of the land can also have an effect on runoff rates and soil erosion. The aspect of static solar panels in England will mostly always be south-facing and, therefore, north or south facing slopes will result in runoff flowing in a parallel direction to that of the runoff from the panels; thereby remaining relatively diffuse and unlikely to result in concentrated flows that could cause soil erosion, apart from where very steep slopes occur.

4.128. East or west facing slopes will result in runoff flowing in a perpendicular direction to that of runoff from the panels; this will result in runoff becoming concentrated along the drip-line of each row, which could lead to increased soil erosion.

4.129. With regard to the Proposed Development, most of the fields of the Application Site are relatively flat with only a gentle gradient. The orientation of the solar panels could concentrate surface water flow in some areas of the Application Site and increase the risk of soil erosion. However, due to the low gradient across these fields, the likelihood of increased overland flow or soil erosion occurring is considered to be Low. The addition of the filter drains / infiltration trenches and swales on the downstream boundary of the fields with the steeper gradients will reduce the risk of soil erosion on these fields and reduce any risk of water quality issues on any downstream watercourses or agricultural land.

SUMMARY & CONCLUSIONS

4.130. The FRA and DIA requirements are set out by the National Planning Policy Framework and Planning Policy Guidance.

4.131. The Guidance aims to avoid inappropriate development in flood zones and instead direct it to areas of low risk by adopting a sequential approach.

4.132. The EA Flood Map for Planning shows that the Application Site is wholly located in Flood Zone 1, an area described as "*Low probability*". The proposed type of development is classed as 'Essential Infrastructure' and therefore development in Flood Zone 1 is deemed appropriate.

4.133. In addition to fluvial and coastal flood risk, the EA also provide surface water flood maps. This indicates multiple areas of surface water flooding within the Application Site. Each of these areas was assessed during the site visit and they were mostly confined to the existing small watercourses and field drains. There were some areas of marshy land next to watercourses, however a 2m buffer has been kept free of development from all field drains/watercourses within the Application Site. 5m buffers have also been left around the site perimeter and from hedgerows, where the ditches are generally located, so there will be 5m buffers from ditches in most locations.

4.134. In addition to the site visit assessment, the topographical survey and aerial maps were studied to determine what likely depth of surface water could be possible in a storm event. It was found that it would be unlikely that any major ponding would form, and surface water levels would likely be a maximum of 0.3m deep in all fields, except along the western edge of Field 6 which would likely be a maximum of 0.9m deep, before feeding into the existing field drain network. This area has been avoided from development.

4.135. The level the solar panels will be raised above ground will vary depending on ground conditions; however, they will generally be at least 0.6m AGL. Therefore, above the surface water level of approximately 0.3m with a suitable freeboard. The surface water levels have been based off the 'Medium Risk Scenario' which correlates to a 1 in 100 chance of flooding, with onsite and topographic checks for accuracy.

4.136. It has been demonstrated that the Proposed Developments impact on surface water runoff is minimal due to the small amount of impermeable infrastructure (0.6% of the overall Application Site Area) proposed for the Application Site. However, drainage in the form of SuDS has been proposed so the operational site discharges surface water at the greenfield run off rate (QBar). Due to the large area of the Grid Substation, and the dispersed nature of the impermeable development of the rest of the Proposed Development, drainage schemes for these have been designed separately.

4.137. The soils encountered beneath the site, found during on-site infiltration testing, were predominately clay and these were dug within Fields 3 and 5. There are 11 boreholes located

within the Application Site. However, nine of these boreholes are associated with BPB Industries Ltd, are classified with no information. The other two boreholes have got a depth of 65.83m and 69.95m respectively, and both suggested that clay was encountered beneath the Application Site. Another borehole, located just to the east of the Application Site, shows that there was also clay found beneath the surface. This suggests that across the site, the soils beneath will be predominately clay. This is consistent with the soil class which has a SPR of 0.47 and suggests that they provide poor opportunity for infiltration.

4.138. The soakage rates obtained during the investigation were found to be practically impermeable. Given the data from the test, it is considered that infiltration drainage is not suitable across the Application Site.

4.139. The extent of impermeable area created is due to the buildings associated with the Proposed Development. The QBar greenfield rate is used as the limiting discharge rate.

Proposed Drainage Strategy (Solar Farm)

4.140. It is proposed to construct multiple filter drains / soakaways and swales within the Application Site. The location of the schemes have been chosen on the downward slope, near to the existing watercourse which runs through the Application Site. The idea is to capture any overland flow in the SuDS device, prior to releasing into the natural surface water system.

4.141. The proposed filter drains / soakaways will have an overall length of approximately 970m, with a base width of 0.5m, a 0.5m design depth and a 0.15m freeboard. It will be filled with crushed rock with a void ratio of 20% and will provide a total storage volume of approximately 48.5m^3.

4.142. The proposed swales will be of an overall length of approximately 360m, with a base width of 0.5m, a 0.5m design depth, 0.15m freeboard and a maximum side slope of 1 in 3. It will provide a total storage volume of approximately 360m^3.

4.143. In total, the proposed drainage strategy will provide a storage volume of approximately 408.5m^3. This is significantly greater than the volume of additional runoff generated as a result of the impermeable buildings (114.0m^3). It is therefore considered that this not only adequately mitigates the increase in flow rates as a result of the minor increase in impermeable area but provides significant improvement.

4.144. The SuDS features will be implemented during the construction phase of the Proposed Development and the swales will be planted with vegetation to protect against soil erosion. They will be maintained throughout the lifespan of the Proposed Development, generally in accordance with the recommendations in the appropriate guidance.

4.145. The proposed discharge points are into various existing field drains.

Proposed Drainage Strategy (Grid Substation)

4.146. It is proposed that surface run-off will be collected and conveyed by the provision of filter drains to a detention basin. A notional freeboard level of 0.15m shall be incorporated into the detailed detention basin for the 1 in 100-year storm event plus 40% climate change with the final design of the pond being submitted to the LPA, Rushcliffe Borough Council, prior to the construction period. The design volume of the detention basin will be a minimum of 179m^3.

4.147. As stated previously, the grid substation area is underlain by clays which exclude infiltration techniques for surface water disposal. QBar discharge rate restriction satisfies the requirements of the SuDS Manual '*Designing for Long Term Storage*'. Final discharge is restricted at the pond by the provision of a Hydro-Brake® vortex flow control device, or a device of similar quality.

4.148. Due to very infrequent site attendance that is required during the operational phase of the development, the pollution risk is deemed negligible. On-plot surface water treatment is provided in the form of filter drains wrapped to intercept the conveyance of any silts within the drainage system. Further downstream, water quality polishing is provided within the detention basin prior to discharge from the Application Site.

4.149. The discharge point will be into the existing site field drainage to the northeast of the detention basin.

4.150. Additional drainage measures to be implemented on-site include the following:

- Solar Panels: Current grass cover is to be retained or reinstated adjacent to and under panels in order to maximise bio-retention;
- Access Tracks: Access tracks are to be unpaved and constructed from local stone. Swales or similar shall be utilised to collect runoff from access tracks, where required, however these will be designed at the detailed design stage. Where swales are utilised, check dams formed from gravels and other excavated material shall be placed in the swale at frequent intervals; and,
- Inverter Substations, Spare Part Containers, etc: Filter strips will surround the concrete bases of the ancillary buildings to capture any runoff from the roofs. This will be discharged to a percolation area or into the sites drainage network where it is close enough. Should surface water accumulate around any of these locations then a simple soakaway can be constructed to allow water soak into the underlying subsoils.

4.151. A permanent toilet is proposed within the substation compound which will be utilised by maintenance staff of both the solar farm and the substation as well as tour groups and visiting

members of the local authority. This will either be a composting toilet, or a tank based one which is emptied as and when required by an approved contractor.

4.152. This FRA and DIA demonstrates that the Proposed Development will not increase flood risk away from the Application Site during the construction, operation and decommissioning phases. The Proposed Development is therefore considered to be acceptable in planning policy terms.

APPENDICES

Appendix 4A Figures:

- Figure 4.1: Watercourses with Photo Locations;
- Figure 4.2: Topographical Survey
- Figure 4.3: Planning Flood Map
- Figure 4.4: Outline Drainage Design (Solar West)
- Figure 4.5: Outline Drainage Design (Solar East)
- Figure 4.6: Outline Drainage Design (Grid)

Appendix 4B: Photo Appendix

Appendix 4C: Flow Output (Solar Farm)

Appendix 4D: Flow Output (Grid Substation)

Appendix 4E: BRE 365 Test and Report

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