Technical Appendix 4: Flood Risk and Drainage Impact Assessment

Derril Water Solar Farm

01/03/2021

Neo Environmental Ltd	
Head Office - Glasgow: Wright Business Centre, 1 Lonmay Road, Glasgow. G33 4EL T 0141 773 6262 E: info@neo-environmental.co.uk	
Warrington Office: Cinnamon House, Crab Lane, Warrington, WA2 0XP. T: 01925 661 716 E: info@neo-environmental.co.uk	**Rugby Office:** Valiant Suites, Lumonics House, Valley Drive, Swift Valley, Rugby, Warwickshire, CV21 1TQ. T: 01788 297012 E: info@neo-environmental.co.uk
Ireland Office: Johnstown Business Centre, Johnstown House, Naas, Co. Kildare. T: 00 353 (0)45 844250 E: info@neo-environmental.ie	**Northern Ireland Office:** Unit 3, the Courtyard Business Park, Galgorm Castle, Ballymena, Northern Ireland, BT42 1HL. T: 0282 565 04 13 E: info@neo-environmental.co.uk

Prepared For:

Renewable Energy Systems (RES) Ltd

Prepared By:

Michael McGhee BSc TechIOA

Tom Saddington BEng MSc

	Name	Date
Edited By:	Michael McGhee	01/03/2021
Checked By:	Nicole Beckett	01/03/2021
	Name	**Signature**
Approved By	Paul Neary	

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EXECUTIVE SUMMARY

4.1. This Flood Risk and Drainage Impact Assessment has been carried out for the Proposed Development consisting of a 42MW solar farm and associated infrastructure on lands circa 1.2km southwest of the village of Pyworthy, Devon.

4.2. The EA Flood Map for Planning shows that the Application Site is mostly located in Flood Zone 1, an area described as "*Low probability*" of flooding. However, there is a small part of the Application Site within Flood Zone 2 and 3, towards the eastern boundary of Field 16.

4.3. The proposed type of development is classed as 'Essential Infrastructure' and therefore development in Flood Zone 1 is deemed appropriate. The small area of Flood Zone 2 and 3 has been avoided in the design iteration process.

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 very marshy land next to watercourses, however a 5m buffer has been kept free of development from all field drains/watercourses within the site.

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 puddling would form and surface water levels would likely reach a maximum of 0.3m deep before feeding into the existing field drain network. The only infrastructure which is located within the areas of surface water will be solar panels, which will be raised at least 0.6m Above Ground Level (AGL) and therefore, above the surface water level of approximately 0.3m with a suitable freeboard.

4.6. It has been demonstrated that the Proposed Developments impact on surface water runoff is minimal due to the small amount of impermeable infrastructure proposed for the Application Site (109.0m^2).

4.7. The extent of impermeable area created is due to the buildings associated with the Proposed Development. The 1 in 100 year plus climate change discharge limit of 2.9l/s was used.

4.8. This soil class has a Standard Percentage Runoff (SPR) of 0.47 which suggests that they provide poor opportunity for infiltration. However, soil infiltration testing should be conducted at the detailed design stage before ruling out infiltration completely.

4.9. It is proposed to construct a series of filter drains / infiltration trenches and swales across the Application Site in order to maintain greenfield run off rates as well as reducing the risks of soil erosion and limiting any impacts on downstream receiving watercourses or agricultural land. The location of the filter drains / infiltration trenches and swales have been chosen within fields with the steeper gradients, near to the site boundaries, where overland flow will be directed. In total, there will be a storage volume of approximately 405.8m^3. This is greater than the volume of additional runoff generated as a result of the impermeable buildings (109.0m^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 improvement.

4.10. 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, 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: 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.

4.11. The FRA and DIA has therefore demonstrated 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

4.12. Neo Environmental Ltd has been appointed by Renewable Energy Systems (RES) Ltd (the "Applicant") to complete a flood risk and drainage impact assessment for a proposed 42MW solar farm and associated infrastructure (the "Proposed Development") on lands circa 1.2km southwest of the village of Pyworthy, Devon (the "Application Site").

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

Development Description

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

4.15. 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

4.16. The Application Site is located on lands circa 1.2km southwest of the village of Pyworthy and c. 1.8km southeast of Bridgerule in Torridge, Devon; the approximate centre point of which is Grid Reference E229936, N101914. Comprising 28 agricultural fields, the Application Site measures 66.33 hectares (ha) in total. See **Figure 1 of Volume 2: Planning Application Drawings** for details.

4.17. Land within the Application Site itself is gently undulating, ranging between 95 - 125m AOD and consists of fields typically of medium scale and generally well enclosed by a mixture of dense treelines, hedgerows and woodland shelter belt, limiting visibility for local settlements and receptors (See **Figure 3 of Volume 2: Planning Application Drawings** for field numbers).

4.18. The Application Site is in an area with existing electricity infrastructure, with a solar farm present c. 0.3km southeast and another c. 1.2km to the southwest. Additionally, the electrical Pyworthy Substation is located c. 75m from the northern parcel's eastern boundary, adjacent to Field 16, where the Proposed Development will connect.

4.19. The local area is generally agricultural in nature, punctuated by individual properties and farmsteads; the nearest residential areas are Hopworthy and Yeomadon, located 0.7km northeast and southeast respectively. Recreational Routes include two Public Rights of Way

(PRoW); one which passes the southeastern boundary of the Application Site (linking Crinacott Farm and Northmoor Farm, both outside the Application Site) and another which passes east of the adjacent substation.

4.20. While there are a number of drains and water courses throughout the Application Site, it is mostly contained within Flood Zone 1, an area described as having a "Low probability" of flooding. The exception to this is a small part of the Application Site within Flood Zone 2 and 3, towards the eastern boundary of Field 16. These areas have been avoided within the Proposed Development footprint.

4.21. The Application Site will be accessed from four existing entrance points on the unnamed minor road which splits the site into northern and southern parcels. From the western boundary of the site, the road runs in a southwestern direction for c. 0.5km before turning in a general east-northeast direction through the eastern section of the Application Site.

Scope of Report

4.22. 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.

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

4.24. 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: Risk of Flooding from Rivers and Sea
  - Figure 4.4: Outline Drainage Design
- Appendix 4B: Photo Appendix
- Appendix 4C: Flow Output for Solar Farm Drainage Design

Statement of Authority

4.25. This Flood Risk Assessment (FRA) has been produced by Michael McGhee of Neo Environmental. Having completed a civil engineering degree in 2012, Michael has worked on over 800MW of renewable development flood risk assessments across the UK and Ireland whilst working towards becoming a Chartered Engineer. Michael has over 8 years of environmental consultancy experience, mainly producing technical assessments for energy projects.

Consultation

4.26. A pre-application request was submitted to the Council on the 1st September 2020 and a response was received on the 10th November 2020. The Environment Agency commented on the Proposed Development and stated:

"From a brief review of the information provided it appears that, while the majority of the site lies within Flood Zone 1, there is a watercourse and associated floodplain running through the site. The report indicates that development in this area will be avoided in the final layout. It is important that the floodplain is kept free from development and that a buffer zone is maintained between the river and development".

4.27. In addition, The County Council's Flood Risk Management Officers commented on the Proposed Development raising concerns about the potential for soil erosion from the Application Site during the construction phase and the likely adverse impacts that this would cause on water quality downstream from the site. In addition, the run off from access tracks and the ancillary buildings would need to be carefully considered. The Flood Risk Officers recommend the inclusion of a cross-contour perimeter swale to limit surface water run-off from the site. In addition, guidance is provided in relation to vegetation planting on the site to further reduce surface water run-off and the need for crossing points to be added into the site to allow works to take place on both sides of Derril Water.

LEGISLATION

4.28. 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), 2019[7]

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[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] UK Government, National Planning Policy Framework, 2012 (Updated 2019), Available at https://www.gov.uk/government/publications/national-planning-policy-framework--2

Review of Local Plan Policy

North Devon and Torridge Local Plan

4.29. The North Devon and Torridge Local Plan Strategy 2018[8] (the "LP") is the adopted plan at present.

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

Planning Policy/Objective	Comment
Policy ST03 *"Development should be designed and constructed to take account of the impacts of climate change and minimise the risk to and vulnerability of people, land, infrastructure and property by:* *(a) locating and designing development to minimise flood risk through:* *(i) avoiding the development of land for vulnerable uses which is or will be at risk from flooding, and* *(ii) managing and reducing flood risk for development where that has wider sustainability or regeneration benefits to the community, or where there is no reasonable alternative site;* *(b) reducing existing rates of surface water runoff within Critical Drainage Areas;* *(c) upgrading flood defences and protecting key transport routes from risks of flooding;* *(d) re-establishing functional flood plains in accordance with the Shoreline Management Plan, Flood Risk Management Plan and Catchment Action Plan;* *(e) locating development to avoid risk from current and future coastal erosion;*	A detailed FRA has been undertaken to determine the flood risk. A Drainage Impact Assessment has been undertaken in order to design a SuDS scheme and will take into account the impact of Climate Change on flood risk.

8 North Devon and Torridge Local Plan 2018. Available at https://consult.torridge.gov.uk/portal/planning/localplan/adoption/interactive?pointId=5051463

(f) adopting effective water management including Sustainable Drainage Systems, water quality improvements, water efficiency measures and the use of rainwater; *(g) ensuring development is resilient to the impacts of climate change through making effective use of renewable resources, passive heating and cooling, natural light and ventilation;* *(h) ensuring risks from potential climate change hazards, including pollutants (of air and land) are minimised to protect and promote healthy and safe environments;* *(i) conserving and enhancing landscapes and networks of habitats, including cross-boundary green infrastructure links, strengthening the resilience of biodiversity to climate change by facilitating migration of wildlife between habitats and improving their connectivity;* *(j) protecting and integrating green infrastructure into urban areas, improving access to natural and managed green space; and* *(k) promoting the potential contribution from ecosystem services that support adaptation to climate change."*	

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

4.30. In accordance with the requirements of the Flood Risk Regulations (2009), Devon 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 risk where the Application Site is located.

4.31. The PFRA also included groundwater flood maps and this shows that the Application Site is within an area which has less than a 25% chance of groundwater flooding.

[9] Devon County Council (2011). Preliminary Flood Risk Assessment for Devon Available at https://devoncc.sharepoint.com/sites/PublicDocs/Planning/FloodRisk/Forms/AllItems.aspx?id=%2Fsites%2FPublicDocs%2FPlanning%2FFloodRisk%2FDevon%20Preliminary%20Flood%20Risk%20Assessment%2Epdf&parent=%2Fsites%2FPublicDocs%2FPlanning%2FFloodRisk&p=true&originalPath=aHR0cHM6Ly9kZXZvbmNjLnNoYXJlcG9pbnQuY29tLzpiOi9zL1B1YmxpY0RvY3MvUGxhbm5pbmcvRWNuRXFDbExDYkpGbHZZREU0THpITFFCc3dIWHJfNWlJbEg5eVh2TDhjVWRjZz9ydGltZT10S1UyMEdEQjJFZw

Strategic Flood Risk Assessment (SFRA)[10]

4.32. North Devon and Torridge Council undertook a joint level 1 SFRA. 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.

[10] North Devon and Torridge Council (2009), Strategic Flood Risk Assessment, Available at https://northdevon.gov.uk/media/266924/sfra_part-1_feb_09.pdf

METHODOLOGY

4.33. 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"*

4.34. 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.

4.35. 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.*

4.36. 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.

4.37. 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?

4.38. 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.

4.39. 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.

4.40. 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

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

4.42. 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

4.43. A topographical survey was undertaken at the Application Site (**see Figure 4.2 Appendix 4A**). The lowest point within the Application Site (95m AOD) is in the southeast corner of Field 25 (**See Figure 3 of Volume 2: Planning Application Drawings**). The high point at 122.5m AOD is located in a northeast section of Field 18 (**See Figure 3 of Volume 2: Planning Application Drawings**).

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

Geology & Soil

4.45. The geological conditions of the Application Site were identified utilising the British Geological Society ("BGS") Spatial Resources online geological mapping[11] system. It is underlain by; Bude Formation – Mudstone and Siltstone, Bude Formation – Sandstone and Crackington Formation – Mudstone and Siltstone.

4.46. Bude Formation – Mudstone and Siltstone and Bude Formation – Sandstone formed approximately 310 to 319 million years ago in the Carboniferous Period.. Crackington Formation – Mudstone and Siltstone formed approximately 318 to 328 million years ago in the Carboniferous Period. The local environment previously dominated by sub-aqueous slopes.

4.47. There are three boreholes located approximately 200, 550 and 900m southeast of Field 27. However, these boreholes are where the National Grid have tested the land for where the pylons are located and subsequently are classified with no information available. Additionally, another borehole is located approximately 850m east of Field 16. Again, this is where the

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

National Grid have tested the land for where the pylon is located and subsequently are classified with no information available.

Soil

4.48. 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 *'Slowly permeable seasonally wet acid loamy and clayey soils'* and *'Freely draining slightly acid loamy soils'*.

4.49. 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. However, soil infiltration testing should be conducted at the detailed design stage before ruling out infiltration completely.

Hydrology

4.50. According to the Environment Agency Catchment Data Explorer[14], the Application Site lies within the South West River Basin District. Within this, the site lies in the Tamar Management catchment which is rural by majority until Plymouth is reached in the south. Furthermore, the Application Site lies within the Tamar Upper Operational Catchment. This catchment contains the Upper River Tamar and its tributaries including; the Ottery, Kensey, Carey, Claw and Deer.

Local River Network

4.51. The Application Site itself has drains which lead into the Derril Water River (see **Photo 26: Appendix 4B**) which has an overall classification of "Bad" under the Water Framework Directive (WFD). This river leads into the Tamar River approximately 3km south of the Application Site. Following this, the River Tamar flows into the Hamoaze, which is where the river converges with the River Lynher, to then lead into the Plymouth Sound which is a bay of the English Channel.

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

[13] UK Sustainable Drainage and Guidance Tools. Greenfield Runoff Estimation for the Sites. Available at: http://www.uksuds.com/greenfieldrunoff_js.htm

[14] Environment Agency, Catchment Data Explorer, Available at https://environment.data.gov.uk/catchment-planning/RiverBasinDistrict/8

Internal Watercourses

4.52. The drains that run through the Application Site between fields will drain all surface water of the Proposed Development to the Derril Water River, which eventually converges with the River Tamar. **Photo 11: Appendix 4B** shows an example of the field drains within the Application Site.

Flood Zone Classification

4.53. The Environment Agency Flood Map for Planning[15] shows that the Application Site is mostly 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*". However, there is a small part of the Application Site within Flood Zone 2 and 3, towards the eastern boundary of Field 16.

4.54. 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

4.55. The Environment Agencies 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 Bridgerule to the northwest of the Application Site.

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

Hydrogeology

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

Groundwater Vulnerability

4.58. Groundwater Vulnerability refers to the intrinsic geological and hydrogeological characteristics that determine the ease at which groundwater may be contaminated by

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

human activities. The more vulnerable the groundwater is, the more easily it can be contaminated by surface water.

4.59. According to the Environment Agency Groundwater Vulnerability Maps, the Application Site has got areas of 'High', 'Medium-High' and 'Medium' groundwater vulnerability. The mapping is based on kilometre squares so it is difficult to make out precisely which areas have High vulnerability; however it is likely that these will be in low lying areas near to watercourses.

FLOOD RISK ASSESSMENT

Sequential Test

4.60. 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, local planning authorities 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

4.61. The EA Mapping shows that only the eastern boundary of Field 16 within the Application Site is identified as being at risk of flooding from fluvial or coastal events. A 10m buffer from Derril Water has been incorporated into the design of the Proposed Development. There is also a 5m buffer from the panels to fence line, meaning that the panels will be at least 15m away from this watercourse. In addition, the flood zone was overlaid onto the topographical survey and it showed that the areas of Flood Zone 2 and 3 extended to approximately 110.25 Above Sea Level (ASL) contour. All infrastructure is above this level, with the panels having a freeboard of at least 300mm.

4.62. Therefore, no infrastructure will be built where the land is deemed to be Flood Zone 2 or 3. The remainder of the Application Site is situated within Flood Zone 1. See **Figure 4.3: Appendix 4A**.

4.63. 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

4.64. 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 very marshy land next to watercourses, however a 5m buffer has been kept free of development from all field drains/watercourses within the Application Site.

4.65. **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 before feeding into the existing field drain network. See **Photo 7: Appendix 4B** which is within an area of surface water flooding according to the EA mapping.

4.66. The only infrastructure which is located within the areas of surface water will be solar panels, which will be raised at least 0.6m AGL and 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

4.67. 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.

4.68. 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 **Appendix 4B**.

4.69. In addition, the main impacts to groundwater include the contamination risk during the construction phase. These impacts will be managed and outlined within the Construction and Traffic Management Plan (CTMP): **Technical Appendix 5 of Volume 3** and 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 vulnerability is presumed to be **Low**.

Access/Egress

4.70. There are no areas of fluvial or coastal flooding which would block off access to the 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.

4.71. There are four access points being constructed off the public road network, using existing field entrances. These will be constructed so that surface water flows into the Application Site and not onto the public road.

DRAINAGE IMPACT ASSESSMENT

Introduction

4.72. 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.

4.73. 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

4.74. 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

4.75. 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

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

4.77. 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

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

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

4.79. 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

4.80. 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.

4.81. 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.

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

4.83. 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	Total Area (m^2)
14 x Inverter Substations (16.0m(L) x 6.0m(W))	1,344.0
1 x Grid Substation (25m(L) x 24.1m(W)= 602.5m2). Most of this area consists of permeable laydown area. The area considered permeable consists of the buildings only.	128.4
Total Impermeable Area	1,472.4
Site Area (m^2)	663,327.4

4.84. 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 1,472.4m^2 or 0.2% of the total site area.

Existing Drainage Arrangements

Existing Runoff Rates

4.85. 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	Green Field
Greenfield Method	IH124
Positively Drained Area (ha)	0.147
SAAR (mm)	1105

Soil Index	4
Standard Percentage Runoff	0.47
Region	8
	Runoff rate (l/s)
1 year	0.9
1 in 30 year	2.4
1 in 100 year	2.9

4.86. The limiting discharge should be calculated as the flow rates from the pre-developed site, as detailed in **Table 4-4**.

Post Development Runoff Volume

4.87. 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.

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

4.89. Using this approach, the runoff volume for the 1-in-100-year event, inclusive of the 40% climate change allowance and a 360-minute storm event, would be **79.0m^3.**

Proposed Drainage Arrangements

4.90. 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.

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

- Regional Control - Designing a system that can efficiently manage the runoff from a site, or several sites.

4.91. 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).

4.92. 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 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.

4.93. 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.

4.94. 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;

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

- 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

4.95. 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.** 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	
Return Period (years)	100 years
Climate Change (%)	40
Impermeable Area (ha)	0.147
Peak Discharge (l/s)	2.9
Total storage Requirement (m^3)	109m^3

4.96. Using the approach outlined in the methodology, the storage requirement to be attenuated from the critical storm 100-year return period (including 40% for climate change) from the Proposed Development would be **109.0m^3**.

Proposed Drainage Strategy

4.97. It is proposed to construct a series of filter drains / infiltration trenches and swales across the Application Site in order to maintain greenfield run off rates as well as reducing the risks of soil erosion and limiting any impacts on downstream receiving watercourses or agricultural land. The location of the filter drains / infiltration trenches and swales have been chosen within fields with the steeper gradients, near to the site boundaries, where overland flow will be directed.

4.98. The proposed filter drains / infiltration trenches will have an overall combined length of approximately 1,515m, with a base width of 0.5m, a 0.5m design depth and a 0.15m freeboard. They will be filled with crushed rock with a void ratio of 20%. They will provide a total storage volume of approximately 75.8m^3

4.99. The proposed swales will be of an overall length of approximately 330m, with a base width of 500mm, a 500mm design depth, 150mm freeboard and a maximum side slope of 1 in 3. They will provide a total storage volume of approximately 330m^3.

4.100. In total, proposed drainage strategy will provide a storage volume of approximately 405.8m^3. This is greater than the volume of additional runoff generated as a result of the impermeable buildings (109.0m^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, butprovides improvement.

4.101. 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.

4.102. The proposed discharge points vary throughout the Application Site, but will generally be located at the closest field drain or watercourse.

4.103. 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, 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: 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.

Designing for Exceedance Events

4.104. 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).

4.105. 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

4.106. 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

4.107. 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.

4.108. 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.

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

4.110. 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.

4.111. 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.

4.112. With regard to the Proposed Development, a lot of the northern fields of the Application Site is relatively flat with only a gentle gradient across most of the fields. 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 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

4.113. The FRA and DIA requirements are set out by the National Planning Policy Framework and guidance.

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

4.115. The EA Flood Map for Planning shows that the Application Site is mostly located in Flood Zone 1, an area described as "*Low probability*". However, there is a small part of the Application Site within Flood Zone 2 and 3, towards the eastern boundary of Field 16.

4.116. The proposed type of development is classed as 'Essential Infrastructure' and therefore development in Flood Zone 1 is deemed appropriate. The small area of Flood Zone 2 and 3 has been avoided in the design iteration process.

4.117. 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 very marshy land next to watercourses, however a 5m buffer has been kept free of development from all field drains/watercourses within the site.

4.118. 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 before feeding into the existing field drain network. The only infrastructure which is located within the areas of surface water will be solar panels, which will be raised at least 0.6m AGL and therefore, above the surface water level of approximately 0.3m with a suitable freeboard.

4.119. It has been demonstrated that the Proposed Developments impact on surface water runoff is minimal due to the small amount of impermeable infrastructure proposed for the Application Site (109.0m^2).

4.120. The extent of impermeable area created is due to the buildings associated with the Proposed Development. The 1 in 100 year plus climate change discharge limit of 2.9l/s was used.

4.121. This soil class has an SPR of 0.47 which suggests that they provide poor opportunity for infiltration. However, soil infiltration testing should be conducted at the detailed design stage before ruling out infiltration completely.

4.122. It is proposed to construct a series of filter drains / infiltration trenches and swales across the site in order to maintain greenfield run off rates as well as reducing the risks of soil erosion and limiting any impacts on downstream receiving watercourses or agricultural land. The location of the filter drains / infiltration trenches and swales have been chosen within fields with the steeper gradients, near to the site boundaries, where overland flow will be directed. In total, a storage volume of approximately 405.8m^3. This is greater than the volume of additional runoff generated as a result of the impermeable buildings (109.0m^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 also provides improvement.

4.123. 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, 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: 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.

4.124. The FRA and DIA has therefore demonstrated 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.